UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF NORTH DAKOTA
NORTHWESTERN DIVISION

David Monson **-and-** **Wayne Hauge,** **Plaintiffs,** **v.** **Drug Enforcement Administration** **-and-** **United States Department of Justice,** **Defendants.**	**Civ. No. 4:07-cv-00042 (DLH/CSM)** **Affidavit of** **Dr. T. Randall Fortenbery, Ph.D.**

STATE OF WISCONSIN)
) ss.
COUNTY OF_____)

Dr. T. Randall Fortenbery, Ph.D, being first duly sworn on oath, deposes and says:

Background and Qualifications

1. I am of legal age and a citizen of the United States and a resident of Wisconsin with my principal residence in Middleton, Wisconsin. I make this affidavit upon personal knowledge.

2. I hold a Ph.D. in Agricultural Economics from the University of Illinois-Urbana/Champaign (1988), a M.S in Applied Economics from Montana State University

EXHIBIT
tabbies
C

(1984), and a B.S. in Natural Resource Economics from Montana State University (1982). I have served as the Renk Chair of Agribusiness and Director of the Renk Agribusiness Institute at the University of Wisconsin's Department of Agriculture and Applied Economics and School of Business since 2002. From 1999 to 2002, I served as the Director of Graduate Studies Department of Agriculture and Applied Economics at the University of Wisconsin and as an Associate Professor in the Department of Agriculture and Applied Economics at the University of Wisconsin. Prior to that I served as Director of Research for Frontier Risk Management, a commodity marketing and risk management firm in Chicago. A copy of my current C.V. is attached hereto as Exhibit A.

3. In 2004, I co-authored a scholarly article entitled "Opportunities for Commercial Hemp Production," Review of Agricultural Economics 26(Spring 2004):97-117. Which found that:

- hemp production has been nonexistent in the United States since the 1950s;
- low prices for traditional crops have piqued interest in commercial hemp production;
- While the current state of harvesting and processing technology for hemp fiber makes its production labor and resource intensive, oilseed crushing facilities capable of processing hemp seed already exist in the United States, including North Dakota; and
- estimated returns for hemp compare well with most other traditional row crops, though they are not as competitive as some specialty crops including tomatoes for processing, irrigated potatoes and tobacco.

A copy of this study is attached as Exhibit B.

The Market for Industrial Hemp

4. Industrial hemp is a commonly used term for genetically distinct non-psychoactive, non-drug varieties of the species *Cannabis sativa L.* that are cultivated for industrial rather than drug purposes. Industrial hemp plants grown in Canada and Europe contain less than 0.3% and 0.2% by weight of tetrahydrocannabinol ("THC"), in the upper portion of the flowering plant, respectively, versus drug marijuana varieties which typically contain 3 to 15% THC in its flowers.

5. Hemp can be grown as a fiber and/or seed crop. The statutory exclusion of hemp stalk, fiber, sterilized seed, and seed oil from the scope of the CSA has enabled U.S. individuals and businesses to legally import, purchase, use, and trade in sterilized hemp seeds, oil, stalk and fiber, and products made from those exempt parts of the plant. Hemp food, oil and fiber products are available throughout the U.S., Canada, the European Union, Australia, Eastern Europe, Russia and Asia. Industrial hemp is currently cultivated by farmers in more than 30 countries including Canada, England, France, Germany, Hungary, Russia and China.

6. Companies currently selling hemp fiber, seed and oil products in the U.S. generally either import hemp fiber, seed and oil from Canada, Asia or Europe, for use in manufacturing these products in the U.S., or import already finished products from Canada or Europe.

7. Hemp farming has been legal in Canada for approximately ten years. In 2006, more than 48,000 acres of hemp were planted in Canada, most of it in Manitoba and Saskatchewan, provinces that border North Dakota. According to the Canadian

Hemp Trade Alliance, an association of businesses, farmers and researchers, farmers in Canada are averaging $250 CDN per acre in profit.

8. According to a study by the U.S. Dept. of Agriculture, "Hemp seeds can be used as a food ingredient or crushed for oil and meal. The seed contains 20 percent high-quality digestible protein, which can be consumed by humans . . . The oil can be used both for human consumption and industrial applications." U.S. Dept. of Agriculture, "Industrial Hemp in the United States: Status and Market Potential" p. 15 (Jan. 2000)("USDA Study"). Hemp seed and oil, along with flax seed, are one of the few significant alternative sources of the omega-3 essential fatty acid ("EFA") found in certain types of fish. The U.S. Food and Drug Administration has cited supportive research showing that consumption of omega-3 may help reduce the risk of coronary heart disease. At the same time, FDA has warned consumers, especially pregnant and nursing women and children, to limit their intake of wild fish and fish oil supplements due to mercury and other environmental contaminants. Consumption of hemp seed products and supplements has thus increased substantially over the past ten years as consumers seek alternative sources to fish for omega-3.

9. The U.S. market for industrial hemp stalk and fiber, while less developed than that in Europe and China, is still very substantial and would provide U.S. industrial hemp farmers significant business opportunities that are currently enjoyed by Canadian, Asian and European farmers. The use of industrial hemp fiber in the automotive industry as an alternative to fiberglass is well established. There are an estimated 3 million vehicles in North America today that contain interior panels molded from hemp fiber bio-

composite material. Johnson Controls, FlexForm, and Composites America are three U.S. companies that use hemp fiber in this way.

10. Worldwide, as fiber raw material markets weather price-hikes and shortages, there is increasing demand for, and interest in developing additional uses for, industrial hemp. A fast growing, high-yielding and mechanically strong plant, industrial hemp is also finding a niche in the plastics and composite, automotive, furniture, building, paper and textile industries.

11. In the largest hemp producing country, China, hemp hurds are processed into lightweight boards and hemp fibers, already used in the paper and automotive industry, and are finding new uses as reinforcement in plastics for window frames and interior and exterior floor coverings (which will be used on a large scale at the Olympic Games 2008 in Beijing according to news reports). In Europe, Swedish companies IKEA, Volvo and Saab have shown interest in hemp fibers and hurds for vehicle interiors and furniture. In Italy, Germany and the Netherlands, considerable investments are being made to reintroduce hemp fibers to the textile industry to compete with cotton textiles in feel and price. Canadian, German and Japanese businesses are investigating reinforcing Polylactide (PLA) with hemp fibers to widen the field of applications for the plastic elements.

North Dakota Regulatory Regime

12. In 2005, the state of North Dakota enacted a law permitting a person within the State to plant, grow, harvest, possess, process, sell and buy industrial hemp upon meeting certain requirements and obtaining a license from the Agriculture Commissioner. N.D.C.C. § 4-41-01. The law defines "industrial hemp" to mean

Cannabis sativa L. "having no more than three tenths of one percent tetrahydrocannabinol." N.D.C.C. § 4-41-01

13. The state law requires that, in order to obtain a license, a person must submit to the Agriculture Commissioner an application on a form prescribed by the Commissioner, including the legal description of the land area to be used to produce industrial hemp, and must undergo a criminal background check. N.D.C.C. § 4-41-02. Each license is valid for a period of one year. N.D.C.C. § 4-41-02.

14. Each licensee is required to file with the Agriculture Commissioner documentation indicating that the seeds planted were certified to produce plants with no more than three tenths of one percent of THC in the dried flowering tops, and must notify the Commissioner of the sale or distribution of any industrial hemp fiber and seed grown by the licensee and the names of the persons to whom the hemp was sold or distributed. N.D.C.C. § 4-41-02. The Agriculture Commissioner is required to adopt rules for the testing of industrial hemp plants during growth and for supervision of the crop during its growth and harvest. N.D.C.C. § 4-41-02.

15. In December 2006, the Agriculture Commissioner issued regulations to implement the statute. N.D. Admin. Code, Article 7-14. The regulations require that the applicant list all individuals who will be involved in any manner in handling or producing the industrial hemp; and that the applicant must provide GIS field location information along with an official aerial USDA farm service agency map. N.D. Admin. Code § 7-14-02-02(1)(d) & (e).

16. N.D. Admin. Code. § 7-14-02-04(1) requires that all industrial hemp seed be covered during transport to avoid the inadvertent dissemination of industrial hemp;

that all volunteer plants not located in a licensed field be destroyed before reaching the seed producing stage; and that all nonexempt plant material be exported or sold to a DEA registered processor. The state regulations thus ensure that there will not be diversion of any parts of the industrial hemp plant other than those exempt from federal law.

Growth of Industrial Hemp under North Dakota Regulatory Regime: No Effect on Market for Marijuana

17. I have reviewed the Affidavits of David Monson and Wayne Hauge and both farmers intend to grow industrial hemp in compliance with North Dakota laws. Specifically, after harvesting the industrial hemp plants, each farmer plans to remove the seeds on the premises of his farm. Rep. Monson will use a commercial grade oil press on his own premises to press seed into oil, and ship the oil directly to customers. In addition, Rep. Monson may sterilize a portion of the harvested and removed seed using an infrared sterilization process (heat), and ship the sterilized seed to commercial seed pressers located in North Dakota and in neighboring states. Mr. Hauge plans to clean the removed viable seed on the premises of his farm, using a portable cleaner, and transport the viable seed, after testing by Commissioner Johnson and using secure transport methods approved by Commissioner Johnson, to other farmers in North Dakota who have been licensed to cultivate industrial hemp.

18. I have reviewed the Declaration of Dr. Gero Leson and, for purposes of this affidavit, rely on his conclusion that industrial hemp, as defined by North Dakota law, would not be fungible with illegal marijuana because "industrial hemp with a THC content of less than 0.3% has no practical potential as a crude marijuana substitute for personal consumption or the commercial illegal conversion to high-potency drug use." Dec. of Dr. Gero Leson, Para. 9.

19. The growth of industrial hemp as defined by North Dakota law by Rep. Monson and Mr. Hauge pursuant to the regulatory regime found in North Dakota poses no risk of swelling the market for illegal marijuana.

20. The growth of industrial hemp as defined by North Dakota law by Rep. Monson and Mr. Hauge pursuant to the regulatory regime found in North Dakota will have no effect on the trade in or price of illegal marijuana.

Dated this 17 day of September, 2007

Dr. T. Randall Fortenbery, Ph.D.

Subscribed and sworn to before me this 17th day of September, 2007.

(SEAL) PHILIP E. HARRIS NOTARY PUBLIC STATE OF WISCONSIN

568177

Notary Public

My commission is permanent

CURRICULUM VITAE

T. RANDALL FORTENBERY

Department of Agricultural and Applied Economics
427 Lorch Street
University of Wisconsin - Madison
Madison, WI 53704
Voice (608) 262-4908
Fax (608) 262-4376

I. POSITIONS HELD

2002-present	University of Wisconsin – Madison Renk Chair of Agribusiness, and Director Renk Agribusiness Institute Dept. of Agricultural and Applied Economics, and School of Business
2002-2003	University of Wisconsin - Madison Director of Graduate Studies, Department of Agricultural and Applied Economics
2001-present	Advanced Technology Group, LLC Board of Directors
1999-2002	University of Wisconsin - Madison Associate Professor in the Department of Agricultural and Applied Economics, and Associate Director, Renk Agri-business Institute
1999-2000	FoodUSA.com Board of Advisors
1998-1999	Frontier Risk Management, Chicago Ill. Director of Research - Frontier Risk Management is a commodity trading company managing both speculative and hedging accounts
1992-1997	University of Wisconsin-Madison Assistant Professor in the Department of Agricultural Economics Promoted to Associate Professor with Tenure September 19, 1996, effective July 1, 1997.
1988-1992	North Carolina State University. Assistant Professor in the Department of Agricultural and Resource Economics (formerly called the Department of Economics and Business).
1984-1988	University of Illinois-Urbana/Champaign. Graduate Research Assistant in the Department of Agricultural Economics with responsibilities in agricultural marketing.
1982-1984	Montana State University. Graduate Research Assistant in the Department of Agricultural Economics and Economics with responsibilities in transportation economics.
1982	Montana State University. Research Associate in the Department of Agricultural Economics and Economics with responsibilities for evaluating and preparing a report on transportation financing alternatives for the Montana State Legislature.

II. HONORS AND AWARDS

EXHIBIT
tabbies
A

Renk Chair in Agribusiness, University of Wisconsin – Madison, August 2002

John S. Donald Excellence in Teaching Award, University of Wisconsin - Madison. February 1996.

Sigma Xi, Scientific Honor Society, 1987.

III. PUBLICATIONS

A. Refereed Journal Articles

Fortenbery, T. Randall and Hector O. Zapata. "Developed Speculation and Underdeveloped Markets – The Role of Futures Trading on Export Prices in Less Developed Countries," European Review of Agricultural Economics, December 2004, p. 451-471.

Fortenbery, T. Randall and Michael Bennett. "Looking for Alternative: Economic Opportunities of Hemp," Review of Agricultural Economics, Spring 2004, p. 97-117

Chavas, Jean-Paul, Paula M. Despins, and **T. Randall Fortenbery**. "Inventory Dynamics under Transactions Costs," American Journal of Agricultural Economics, May 2000, p. 260-270.

Fortenbery, T. Randall, Robert Cropp, and Hector Zapata. "Analysis of Expected Price Dynamics Between Fluid Milk Futures Contracts and Cash Prices for Fluid Milk," Journal of Agribusiness, Fall 1997.

Fortenbery, T. Randall and Hector O. Zapata. "An Evaluation of Price Linkages Between Futures and Cash Markets for Cheddar Cheese," Journal of Futures Markets, May 1997, p. 279-301.

Zapata, Hector O. and **T. Randall Fortenbery**. "Stochastic Interest Rates and Price Discovery in Selected Commodity Markets." Review of agricultural Economics, October 1996, p. 643-654 .

Fortenbery, T. Randall and Hector O. Zapata. "An Examination of Cointegration Relations between Futures and Local Grain Market," Journal of Futures Markets. December 1993, p. 921-932.

Fortenbery, T. Randall and Daniel A. Sumner. "The Effects of USDA Reports in Futures and Options Markets." Journal of Futures Markets. April 1993, p. 157-174.

Fortenbery, T. Randall and Hector O. Zapata. "Evaluating Stochastic Properties of Systematic Risk." Review of Futures Markets. Spring 1993.

Fortenbery, T. Randall and Robert Hauser. "An Examination of Futures Contract Investment Potential." American Journal of Agricultural Economics, August 1990, p. 721-726.

Garcia, Philip, Raymond M. Leuthold, **T. Randall Fortenbery**, and Gboroton F. Sarasoro. "Pricing Efficiency in the Live Cattle Futures Markets: Measurement and Interpretation." American Journal of Agricultural Economics, February 1988, p. 162-169.

Fortenbery, T. Randall and Harley R. Harris. "Public Participation, the Forest Service, and NFMA: Hold the Line," Public Land Law Review, University of Montana Law School, Spring 1983, p. 51-87.

B. Publications in Review at Refereed Journals

Fortenbery, T. Randall "Understanding Soybean Basis: An empirical Investigation." Journal of Agricultural and Resource Economics

Zapata, Hector O. and **T. Randall Fortenbery.** "Price Impacts of Sugar Futures," Agribusiness – An International Journal

C. Publications in Progress

Lin, Hau and **T. Randall Fortenbery.** "Risk Premiums and the Storage of Agricultural Commodities."

Fortenbery, T. Randall. "Impacts of Elevator Concentration on Local Basis: An Indirect Measure of Transportation Policy on Farm Price."

Fortenbery, T. Randall. "Impact of Packer Concentration on Hog Prices: An Evaluation of the 1998 Price Debacle."

Fortenbery, T. Randall. "Understanding the Basis for Corn"

Fortenbery, T. Randall. "Impact of Futures Market Speculation on Cash Market Volatility"

C. Other Peer Reviewed Papers (reviewed for presentation prior to publication)

Armstrong, Delroy, Hector O. Zapata and **T. Randall Fortenbery** "Price Discovery in the Futures and Cash Market for Sugar." Abstract in Agricultural and Applied Economics , August 2003.

Fortenbery, T. Randall. "Outlook for Corn and Soybeans, 1992/93 Marketing Year," Invited paper presented at the Extension Outlook Symposium at the 1992 American Agricultural Economics Association Annual Meeting, Abstract in American Journal of Agricultural Economics, December 1992.

Zapata, Hector O. and **T. Randall Fortenbery.** "Specification Tests in Risk Premium Analyses." Presented at the 1991 Southern Agricultural Economics Association Annual Meeting. Abstract published in Southern Journal of Agricultural Economics, July 1991.

D. Proceedings -(* abstracts were peer reviewed prior to presentation)

Fortenbery, T. Randall and Hector O. Zapata. "Causality in Mean and Variance for Coffee Futures-Cash Markets." Proceedings of the Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management. St. Louis. April 2004.

Fortenbery, T. Randall and Hector O. Zapata "Developed Speculation and Under Developed Markets – The Role of Futures Contracts on Export Prices in Less Developed Countries." Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management, St. Louis. April 2003.

Fortenbery, T. Randall. "New Evidence on the Value of Public Information in Commodity Markets: Commentary," Published in the Research Symposium Proceedings, Chicago Board of Trade, Fall 1995, p. 39-42. This was an invited paper.

Fortenbery, T. Randall, Hector O. Zapata, and Eugene Kunda. "Impacts of Elevator Concentration on Local Basis." Published in the Proceedings of the 1993 N.C.R. 134 Conference on Applied Commodity Price Analysis, Forecasting and Market Risk Management, Chicago, IL; p. 149-156.

Fortenbery, T. Randall and Hector O. Zapata. "An Examination of Cointegration in Storable Commodities," Published in the Proceedings of the 1992 N.C.R. 134 Conference on Applied Commodity Price Analysis, Forecasting and Market Risk Management, Chicago, IL, p. 310-322.

Strobl, Maximilian, T. **Randall Fortenbery**, and Paul Fackler. "An Examination of Spatial and Intertemporal Aspects of Basis Determination," Published in the Proceedings of the 1992 N.C.R. 134 Conference on Applied Commodity Price Analysis, Forecasting and Market Risk Management, Chicago, 111, p. 394-406.

Fortenbery, T. Randall. "Using Options to Price International Soymeal Sales," Published in the Proceedings of the 17th Annual Poultry Nutrition Conference, December 1990, Charlotte, NC, p. 1-8.

Fortenbery, T. Randall and Daniel A. Sumner. "The Effects of USDA Reports in Futures and Options Markets," Published in the Proceedings of the 1990 N.C.R. 134 Conference on Applied Commodity Price Analysis, Forecasting and Market Risk Management, Chicago, IL, p. 114-124.

Fortenbery, T. Randall and Hector O. Zapata. "Sensitivity of Risk Premium Analyses to Violations of Distributional Assumptions," Published in the Proceedings of the 1990 N.C.R. 134 Conference on Applied Commodity Price Analysis, Forecasting and Market Risk Management, Chicago, IL, p. 104-113.

Fortenbery, T. Randall. "International Events and their Effects on Prices of Soybeans and Other Feed Ingredients," Published in the Proceedings of the 15th Annual Carolina Poultry Nutrition Conference, December 1988, p. 76-79.

Hudson, Michael, Robert Hauser, and **T. Randall Fortenbery**. Analysis of Price Risk Management Strategies for Commercial Cattle Feeders," Published in the Proceedings of the 1985 N.C.R. 134 Conference on Applied Commodity Price Analysis, Forecasting and Market Risk Management, Chicago, IL.

E. Other Presented Papers

Fortenbery, T. Randall. "Soybean Outlook: 1995/96 Marketing Year," Presented at the 1995 Midwest Outlook Conference, University of Kentucky, Lexington KY, August 16, 1995. Invited Paper.

Zapata, Hector O. and T. **Randall Fortenbery**. "Stochastic Interest Rates and Price Discovery in Selected Commodity Markets." Presented at The Second International Conference on Financial Econometrics, Queenstown, New Zealand, December 1993.

Fortenbery, T. Randall and Hector O. Zapata. "Evaluating Stochastic Properties of Systematic Risk," presented at the Chicago Board of Trade Spring Research Seminar, May 1991.

Fortenbery, T. Randall. "Situation and Outlook for Soybeans and Soybean Meal: 19901991," presented to the Southern Regional Outlook Conference, Atlanta, GA, October 1990.

F. Staff Papers, Newsletters and Departmental Mimeos

Fortenbery, T. Randall "Biodiesel Feasibility Study: An Evaluation of Biodiesel Feasibility in Wisconsin." Renk Agribusiness Institute, UW-Madison. August 2004.

Fortenbery, T. Randall and Michael Bennet. "Is Industrial Hemp Worth Further Study in the US? A Survey of the Literature," Department of Agricultural and Applied Economics Staff Paper Series, No. 443, July 2001.

Fortenbery, T. Randall. "A Study of Costs of Compliance Related to Non-Point Pollution Rules for Wisconsin Crop Producers," Department of Agricultural and Applied Economics Staff Paper Series, No. 442 , February 2001.

Schnitkey, Gary D., Michael E. Salassi, G. Grant Giesler, Hector O. Zapata, Robert E. Coats, Jr., and **T. Randall Fortenbery** "The Rice-Farm Financial-Policy Simulation Model" A.E.A. Information Series No. 146, Agricultural Center, Louisiana State University, September 1996.

Fortenbery, T. Randall and Hector O. Zapata. "An Evaluation of Price Linkages Between Futures and Cash Markets for Cheddar Cheese," Center for Food Policy Research, Working Paper #108, March 1995.

Zapata, Hector O. and **T. Randall Fortenbery.** "Stochastic Interest Rates and Price Discovery in Selected Commodity Markets," Department of Agricultural Economics Staff Paper Series, No. 383, March 1995.

Fortenbery, T. Randall. "Feed Grain, Oilseeds and Wheat Outlook," Status of Wisconsin Farming Department of Agricultural Economics, UW- Madison, February, 1994. 4 pages. Also served as co-editor, total document 54 pages.

Fortenbery, T. Randall. "Feed Grain, Oilseeds and Wheat Outlook," Status of Wisconsin Farming, Department of Agricultural Economics, UW-Madison, February, 1993. 6 pages. Also served as co-editor, total document 51 pages:

Fortenbery, T. Randall. "Understanding Grain Marketing: Basis, Cash Contracting, and Using Futures Options," Managing the Farm, Vol. 25, No. 9, Department of Agricultural Economics, UW-Madison, November, 1992. 7 pages.

Fortenbery, T. Randall. "Corn and Soybeans Outlook," Managing the Farm, Vol. 25, No. 6, Department of Agricultural Economics, UW-Madison, September, 1992. 3 pages.

Ferguson, J. M., W. T. Fike, and **T. Randall Fortenbery.** "Canola," Agricultural Communications Publication, AG-465, North Carolina State University, August 1992. 4 pages.

Fortenbery, T. Randall. "The Futures Markets: Why?," N.C. State Economist, Department of Agricultural and Resource Economics, N.C. State University, June 1992.1 page.

Fortenbery, T. Randall. "Situation and Outlook for Small Grains: 1991-1992," Small Grains AG-464, North Carolina Cooperative Extension Service, North Carolina State University, February 1992. 6 pages.

Fortenbery, T. Randall and W. D. Eickhoff. "Economic Outlook and Marketing Options," 1991 Cotton Information, AG-417, North Carolina Cooperative Extension Service, North Carolina State University, January 1992.9 pages.

Fortenbery, T. Randall and Charles L. Moore. "1992 Agricultural Outlook," N.C. State Economics, January 1992. 4 pages.

Eickhoff, W. D., Allen M. Beals, and **T. Randall Fortenbery.** "Issues Related to North Carolina Cotton Production, North Carolina State Economist, October 1991. 4 pages.

Waller, Mark L. and **T. Randall Fortenbery.** "U.S. and World Coarse Grain Trade," SRDC No. 148, August 1991. 2 pages.

Fortenbery, T. Randall. "A Look at North Carolina Basis," Agricultural Communications Publication, AG-45 1, North Carolina State University, June 1991. 12 pages.

Fortenbery, T. Randall. "Issue on 1990 Farm Bill," N. C. State Economist, January 1991. 4 pages.

Fortenbery, T. Randall. "Small Grain Production Guide: Marketing," Agricultural Communications Publication, AG-419-6, North Carolina State University, January 1990. 5 pages.

Fortenbery, T. Randall. "Basis Tables for Corn, Soybeans, and Wheat in Selected North Carolina Markets - 1984-1988," Economic Information Report No. 79, Department of Economics and Business, North Carolina State University, July 1989. 32 pages.

Fortenbery, T. Randall. "International Agricultural Markets: The U.S. Share," North Carolina State Economist, North Carolina State University, May 1989.1 page.

Fortenbery, T. Randall and Robert J. Hauser. "Examining the Investment Potential of Agricultural Futures Contract," Faculty Working Paper No. 135, North Carolina State University, November 1988. 24 pages.

Fortenbery, T. Randall. "Dairy Farmers Facing Increased Costs," Dairy Extension Newsletter, NCSU, August 1988. 1 page.

Monthly corn and soybean articles in Agricultural and Resource Economics monthly newsletter, Market Pointer, North Carolina State University. 1988 – 1992.

Fortenbery, T. Randall and Merle D. Faminow. "Changes in Regulatory Policy and Montana Railroads," Montana Cooperative Extension Service Report, Montana State University, January 1984. 9 pages.

Faminow, Merle D. and **T. Randall Fortenbery.** "A Brief Description of Constrained Market Pricing," Montana Cooperative Extension Service Report, Montana State University, October 1983. 3 pages.

Fortenbery, T. Randall, Gail L. Cramer, and Bruce R. Beattie. "Highways and Railroads in Montana: Problems and Opportunities," Montana Agricultural Economics Experiment Station Special Report, December 1982. 22 pages.

G. Electronic Materials

Fortenbery, T. Randall. *Grain Market Outlook 2005.* 45 minute video. UW-Madison, Renk Agribusiness Institute and UW-Extension, February 2005.

Fortenbery, T. Randall. *Developing and Implementing a Marketing Plan.* 50 Minute video, divided into two different sections. UW-Madison, Renk Agribusiness Institute and UW-Extension, February 2005.

Fortenbery, T. Randall. RAI Forecasting System. Strand alone computer program for forecasting local grain basis levels. July 2004.

Fortenbery, T. Randall. *Grain Outlook for 2004.* 45 minute video. UW-Madison, Renk Agribusiness Institute and UW-Extension, February 2004

Monthly E-mail to all University of Wisconsin - Extension faculty on grain market outlook, 1993-1998, 1999-2001 .

Fortenbery, T. Randall. "Market Stratigizer, ver. 95.1," Stand-alone software to help agricultural producers determine optimal market strategy given current market conditions, October 1995.

Fortenbery, T. Randall. "Agricultural Investment Analyzer," Stand-alone software to help agricultural business evaluate investment decisions based on an approximation to Quadratic Programming solutions to a portfolio allocation problem, October 1995.

Monthly radio program on agricultural outlook, 1990-1992. Broadcast over 72 radio stations across North Carolina.

Fortenbery, T. Randall. "1991 Feedgain and Cotton Program." This computer program is menu driven, stand alone software. It was distributed to all 100 North Carolina counties and helped producers determine their optimal level of participation in the 1991 government farm program.

Fortenbery, T. Randall. "1990 Wheat, Feedgain, and Cotton Program." This computer program is menu driven, stand alone software. It was distributed to all 100 North Carolina counties and helped producers determine their optimal level of participation in the 1990 government farm program.

Fortenbery, T. Randall and Duane Newman. "1989 Wheat, Feedgain, and Cotton Program." Multi-plan computer programs distributed to all 100 North Carolina counties to help producers determine their optimal level of participation in the 1989 government farm program.

Fortenbery, T. Randall and Duane Newman. "1988 Wheat, Feedgain, and Cotton Program." Multi-plan computer program distributed to all 100 North Carolina counties to help producers determine their optimal level of participation on the 1988 government farm program.

IV. Research and Extension Support

"Biodiesel Feasibility Study," Badger AgVest, $15,000, 2004.

"Measurement Tools for Evaluating Impacts of Ethanol Plant Development on Wisconsin Communities," Wisconsin Department of Energy, $15,000, 2003-2005.

"Measurement of Local and National Impacts Associated with an Expanded Bio-Fuels Industry: An Economic Analysis," HATCH Grant, $77,220, 2003-2006.

"Development of Basis Forecasting Tools for Wisconsin Agricultural Markets," HATCH Grant, $68,907, 2000-2003.

"Development of Optimal Hedge Strategies for Wisconsin Cheese Producers," HATCH Grant $49,408, 1997-1998.

"Use of Dairy Based Futures Markets to Improve the Competitive Position of the Wisconsin Dairy Industry," Industry and Economic Development Research Award, University-Industry Relations, University of Wisconsin System, $35,861, 19971998.

"Student Trading Program." Auditrack, $2,586 grant, 1994.

"Development of Optimal Hedge Strategies for Wisconsin Grain Producers." UW System Applied Research Grant Program, $16,615 grant, 1994-1995.
"Impact of Grain Elevator Concentration on Local Price Basis." The Graduate School of UW-Madison, $11,357 grant, 1993.

"Factors Affecting Spatial and Temporal Relations Between Futures and Cash Prices for Corn and Soybeans." HATCH grant, $19,666/year, .1993-1997.

"Analysis of the Structure, Efficiency, and Competitiveness of the Southern U.S. Grain Marketing Systems." HATCH grant, $1,200/year, 1990-1992.

"Measuring Hedging Benefits to Small Grain Farmers." Agricultural Foundation, North Carolina, $4,000, 1989.

"Master Marketer Pilot Program." North Carolina Small Grain Growers Association, $1,600, 1989, with Jack Ward.

"The Use of Soybean Basis in Determining Local Fair Price and Optimal Marketing Strategies." North Carolina Soybean Producers Association, $3,500, 1989, with Paul Fackler.

V. Professional Activities and Service

A. Reviewer

American Journal of Agricultural Economics, Land Economics, Southern Journal of Agricultural Economics, Canadian Journal of Agricultural Economics, Journal of Futures Markets, Journal of Agribusiness, Contemporary Economics, Review of Agricultural Economics *(Member Editorial Council,* 1994-2001), John Wiley Publishers.

American Agricultural Economics Association Selected Papers Topic Committee Marketing and Commodities, (1990 *(Chair),* 1991, 1996, 2005).

Southern Agricultural Economics Association Selected Papers Committee (1990, 1996).

Editorial Council - Review of Agricultural Economics, Member 1994-2001.

B. Regional Committees and Task Forces

Southern Regional Research Committee 231, Member 1989-1992 *(Secretary* 1991-1992).

American Soybean Association Economists Round Table, Member 1991-1993.

North Central Regional Extension Committee on Producer Marketing, Member 1992 - 1995 *(Secretary* 1993, *Chair* 1994-1995).

C. Professional Service

AAEA Quality of Communications Committee 1999, 2000
Chairman 2001

Moderator of session at NAFTA conference sponsored by Agricultural Technology Family Farm Institute, University of Wisconsin - Madison, 1993.

Selected Sessions Paper Moderator, American Agricultural Economics Association annual meetings, 1990.

C. Public Service (invited presentations)

Invited Speaker at Wisconsin Corn/Soy Expo, 1993-2005.

"Future Demand for Corn as an Industrial Input," Wisconsin Fertilizer, Aglime and Pest Management Conference, Madison, WI, January 2005.

"Commodity Market Outlook," Dane County Farm Bureau Annual Meeting, Madison, WI, January 2005.

"Use of weather forecasts in financial market management," AOS Predictability Conference, Atmospheric, Ocean, and Space Sciences, University of Wisconsin – Madison, March 15-17, 2004.

"Improving Forecasting and Hedging in Volatile Times," 52nd Annual Midwest Milk Marketing Conference, Madison, WI, March 1997.

"Outlook for Corn and Soybeans," Dane County Farm Bureau Annual Meeting, Montrose, WI, January 1997.

"Soybean Outlook: 1995/96 Marketing Year," Presented to the Midwest Outlook Conference, University of Kentucky, Lexington, KY, August 16 1995.

"New Evidence on the Value of Public Information in Commodity Markets: Commentary," Presented at the Chicago Board of Trade Fall Research Seminar, Chicago, IL, December 1994.

"Commencement Address," 1994 Short Course Graduation, University of Wisconsin Madison, March 1994. The commencement speaker at this event is elected by the graduating seniors to provide the address.

"Grain Market Issues," Wisconsin Corn Soy Expo, Madison, Wisconsin, February 1994.

"Grain Market Issues," Wisconsin Corn Soy Expo, Madison, Wisconsin, February 1993.

"Outlook for Corn and Soybeans, 1992/93 Marketing Year," Extension Outlook Symposium at the 1992 American Economics Association Annual Meeting, Baltimore, Maryland, August 1992.

"Managing Price Volatility," Master Farm Management Seminar, North Carolina State University; Raleigh, North Carolina, January 1992.

"Global Marketing and the Corn Trade," North Carolina Grain Growers Annual Membership Meeting, Raleigh, North Carolina, January 1992.

"Using Basis Information as a Decision Aid," Master Farm Management Seminar, North Carolina State University, Raleigh, North Carolina, January 1991.

"Evaluating Market Opportunities," North Carolina Grain Growers Annual Membership Meeting, Raleigh North Carolina, January 1991.

"Using Options to Hedge International Soymeal Sales," Presented to the 17th Annual Carolina Poultry Nutrition Conference, Charlotte, North Carolina, December 1990'.

"Situation and Outlook for Soybeans and Soybean Meal: 1990-1991.;" Presented to the Southern Regional Outlook Conference, Atlanta, Georgia, October 1990.

"Importance of Basis," Presented to the Southeastern Bankers School, Clemson, South Carolina, May 1990

"Grain Market Update," North Carolina Society of Rural Appraisers, Raleigh, North Carolina, February 1990.

Hedging Opportunities in Agricultural Markets," Presented to the Southeastern Bankers School, Clemson, South Carolina, July 1989.

"Developing and Using Outlook Information," Presented to Directors of the North Carolina Farm Bureau, Raleigh, North Carolina, February 1989.

"Importance of Developing a Marketing Plan," Master Farm Management Seminar, North Carolina State University, Raleigh, North Carolina, February 1989.

"Market Opportunities for 1989," Presented to the North Carolina Soybean Producers Association annual meeting, Raleigh, North Carolina, January 1989.

"International Events and their Effects on Prices of Soybeans and other Feed Ingredients," Presented to the 15th Annual Carolina Poultry Nutrition Conference, Charlotte, North Carolina, December 1988.

"Soybean Prospects for the Coming Marketing Year," Presented to the Board of Directors, North Carolina Soybean Association, Raleigh, North Carolina, June 1988.

Review of Agricultural Economics—Volume 26, Number 1—Pages 97–117
DOI:10.1111/j.1467-9353.2003.00164.x

Opportunities for Commercial Hemp Production

T. Randall Fortenbery and Michael Bennett

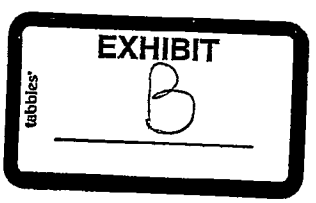
Hemp production has been nonexistent in the United States since the 1950s. However, low prices for traditional crops have peeked interest in commercial hemp production. The current literature on hemp suggests that it may compete on the margin with traditional crops, but is not likely to generate sizeable profits. Hemp appears slightly more profitable than traditional row crops, but less profitable than other specialty crops. An important constraint to a viable commercial hemp industry is the current state of harvesting and processing technologies, which are quite labor intensive, and result in relatively high per unit costs.

Over the past decade, industrial hemp has generated a great deal of interest from the general public, various state governments, private researchers, and segments of the U.S. business community. Those advocating its legalization have cited environmental benefits—low pesticide and herbicide requirements and adaptability to a wide range of agronomic conditions—and an array of current and potential uses as evidence of its value as an alternative cash crop for U.S. farmers. They claim that industrial hemp could be profitable if it were allowed to develop like any other commercial agricultural enterprise.

Opponents of commercial hemp production suspect a hidden agenda—the legalization of marijuana—or argue that estimates of profitability are insufficient to justify the licensing and increased drug monitoring costs associated with its cultivation.

Recently several state legislatures have initiated efforts focused on hemp legalization. State-sponsored studies on the economic viability of industrial hemp have been produced for Arkansas, Hawaii, Illinois, Kentucky, Missouri, North Dakota, Oregon, Vermont, and Wisconsin. USDA published a report in 2000 on prospects for commercial hemp production, the Congressional Research Service published

■ *T. Randall Fortenbery is Renk Chair Professor in the Department of Agricultural and Applied Economics, University of Wisconsin–Madison.*
■ *Michael Bennett is former graduate student in the Department of Agricultural and Applied Economics, University of Wisconsin–Madison.*



industry continued in Wisconsin until 1958. Since then, fiber hemp production in the United States has been negligible (Wright, Dempsey, Ehrensing).

Plant Characteristics, Cultivation, Harvesting, and Processing

Plant Characteristics

Industrial hemp and marijuana are different varieties of the same species, *Cannabis sativa* L. Though often associated with each other and generally identical in appearance, they differ significantly in their content of the psychoactive ingredient delta-9-tetrahydrocannabinol (THC). Whereas marijuana contains 3–15% THC on a dry-weight basis, industrial hemp contains less than 1% (Vantreese 1997).

Industrial hemp can be grown for its fiber, seed, or as a dual-purpose crop. It is a bast or long-fiber plant, similar to flax, kenaf, and jute, ranging in height from 3 to 19 feet. It has a rigid, herbaceous stalk with a hollow core, surrounded by an inner pith layer of short woody fibers called hurds, and an outer phloem or parenchyma layer, where the bast fibers are primarily found (Kraenzel et al.). Both the hurd and bast fibers can be processed for use. Hemp is an annual plant that is normally dioecious, with the species divided into male and female plants, the females producing the seeds. Monoecious (unisex) varieties have been developed through breeding and selection in a number of countries (Ehrensing, Dempsey).

Cultivation

Cultivation techniques depend on desired output. There are specific varieties for seed and fiber production, and a tradeoff exists between the production and quality of the two. Most fiber varieties reach 10–12 feet in height in three or four months, with minimal foliage. The optimal harvest time for fiber is before the seeds are fully mature, generally seventy to ninety days after seeding. If left beyond this time, the fiber becomes too course for textile applications. When grown for fiber, industrial hemp is planted in narrow rows to reduce branching, increase stalk height, and increase the percentage of the bast fibers that are the very long primary fibers (the bast fiber component also includes many shorter secondary fibers) (Meijer et al.).

Harvesting for seed usually occurs four to six weeks later than that for fiber (Ministry of Agriculture and Food, British Columbia; Kraenzel et al.; Vantreese 1997). When grown for seed, hemp is planted farther apart to encourage branching and greater seed development. Seeding rates are recommended at one-fifth of those for fiber production (Kraenzel et al., Vantreese).

Industrial hemp is well adapted to the temperate zone and can grow in a wide range of environmental conditions. However, higher yields require a rich supply of nutrients and abundant moisture throughout the growing season, so fertilizer is generally required. It grows best on loose, well-drained loam soils that have abundant organic matter. Optimal mean daily temperature for cultivation ranges between 60 and 80°F (13–22°C), though hemp will endure both colder and warmer conditions. Both seedlings and mature plants are resistant to light frosts of short duration (Ehrensing, Kraenzel et al.). Hemp needs ample moisture for optimum

Once retted, dried and bailed, stalks are delivered to a processing mill for scrutching (breaking the woody core of the stems into short pieces) and decortication (separating bast fiber from the hurds). Some processes convert all of the bast fiber into tow (tow refers to the short broken fibers used for yarn, twine, and stuffing), which results in higher throughput and lower skilled labor requirements. European researchers are currently trying to increase throughput capacity and reduce labor costs by bypassing traditional retting and scrutching techniques using steam explosion and ultrasound (USDA 2000, Ehrensing). Processing hemp seed involves hulling or pressing and crushing, depending upon the desired output.

Markets for Hemp Fiber and Seed

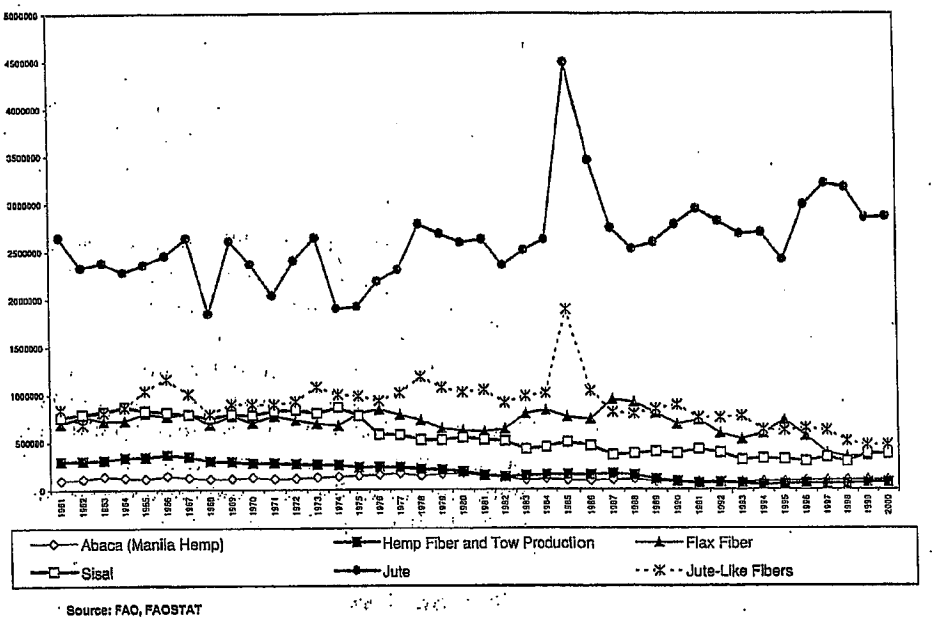
The market potential for industrial hemp is a critical consideration in assessing the long-term feasibility of developing a domestic industry. Numerous sources in the literature have cited hemp's current and potential uses, a variety of which are summarized in figure 1 relative to their processing requirements (Gardner Pinfold Consulting Economists Ltd. and White; Thompson, Berger, and Allen.). The USDA (2000) report, however, points out that for the many potential uses of hemp to translate into concrete market opportunities, they need to be competitive with current well-established sources of bast fiber, hurds and seeds, in terms of characteristics, quality and price.

Fiber Markets

Current markets for bast fibers include specialty textiles, paper, and composites. As a rough look at available supply, figures 2 and 3 document world production of various bast fiber plants and industrial hemp, respectively, from 1961 to 2000. Hemp made up a very small share of world bast fiber plant production, averaging only 8% of jute production and 27% of flax production. Flax has been described as similar to hemp in terms of fiber quality and processing requirements (USDA 2000). Overall, world production of bast plant fibers has changed little over time. Jute, abaca, and jute-like fibers have all had positive average annual growth rates, with jute having the highest rate at 1.6% per annum. Hemp fiber and tow production, flax fiber and sisal have all had negative average annual growth rates, ranging from −0.7% per annum for flax fiber, to −2.9% per annum for hemp fiber and tow. As shown in figure 3, hemp fiber and tow production has steadily decreased over the past three decades, from about 300,000 metric tons in 1961 to 74,000 metric tons in 2000.

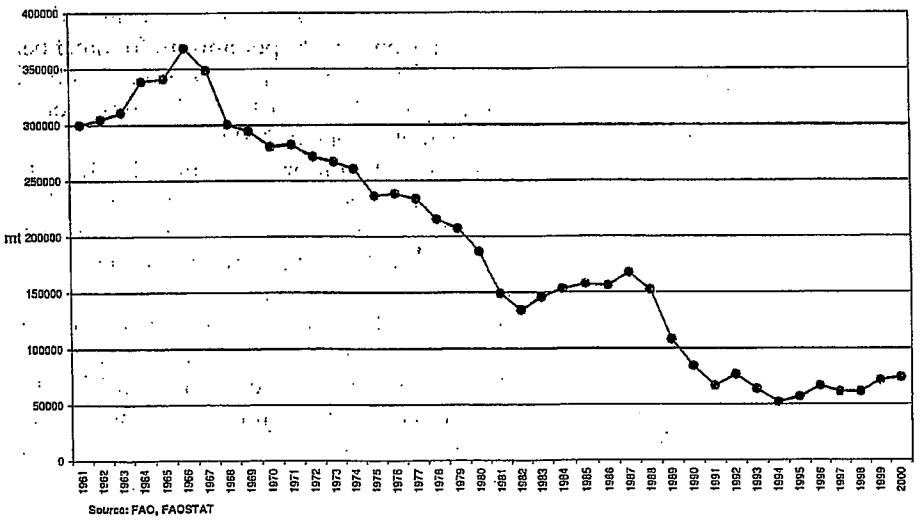
Recent U.S. imports of hemp fiber have been small (table 1). Using hemp fiber and linen imports as lower and upper bound indicators of short-term market potential for domestically cultivated hemp, USDA (2000) estimates a potential 2,0000–250,000-acre production-equivalent range for U.S. hemp (linen from flax is hemp's closest competing fiber). However, USDA suggests that near-term market potential is likely to be at the low end of this range (which could be supplied by only a few farms, given average U.S. farm size of about 500 acres) because hemp fiber imports have generally been 0.5% or less of linen imports, and no textile flax is produced in the United States despite a lack of restrictions on its cultivation. This suggests that domestic production of crops similar to flax, such as hemp, are unprofitable.

Figure 2. World production of selected bast plant fibers (mt), 1961–2000



Aggregate demand for domestic hemp textile is likely constrained by the need to further develop technology for spinning hemp into fine yarns, since its variable fiber quality can damage current high-speed processing machinery (Gardner Pinfold Consulting Economists and White). In addition, both hemp and linen are

Figure 3. World hemp fiber and tow production (mt), 1961–2000



Thompson, Berger, and Allen conclude that hemp hurds appear price-competitive with current sources of animal bedding such as wood chips, fine wheat straw, and other types of premium bedding. These materials are favored for their water absorbency, which reduces illnesses. Companies in England, France, and the Netherlands make horse bedding from hurds, and some members of the racehorse industry have expressed interest in using hemp hurds (Patton). Hemp hurd-based cat litter is being sold in England, France, and Germany (Gardner Pinfold Consulting Economists and White). Studies suggest that since hurds are a joint product with bast fiber in hemp, finding markets for hurds could mean the difference between profitability and loss for industrial hemp producers (USDA 2000, Gardner Pinfold Consulting Economists and White).

Other potential markets for hemp fiber include molded car parts, fiberglass substitutes, and composites. Domier reports that several car companies have investigated the use of nonwood fibers, such as hemp and kenaf, in the manufacture of molded car parts because they are lighter and easier to recycle than current feedstock. Several BMW models have trunk liners and press-molded airbag parts that use hemp fibers. Kenex Ltd. has developed prototype molded car parts, and transit buses are being retrofitted in Florida with molded hemp parts for use in Orlando (Thompson, Berger, and Allen). However, to gain in these markets hemp would have to compete with other sources of nonwood fiber, and would have to be supplied in sufficient quantities throughout the year. According to USDA (2000), use of nonwood fibers such as hemp in composites is still largely in research and development stages, or in the early stages of commercialization in North America.

Wheat straw, flax, kenaf, jute, and hemp, in combination with various resins, can be used to make composite board, with wheat straw being the dominant non-wood fiber in these applications (Glaser and Van Dyne). Hemp fiber could be desirable in this market because of its length and strength. Gardner Pinfold Consulting Economists and White identify a number of factories using non-wood fibers that operate in Manitoba and Alberta. They produce nonstructural fiberboard and strawboard, and hemp could be a potential feedstock in their production process given sufficiently low price.

Hemp and other non-wood fibers could also replace fiberglass in some applications (Thompson, Berger, and Allen). The use would be limited, however, to replacing chopped fiberglass and in applications where moisture is not a problem.

Seed Markets

Hempseed can be used as a food ingredient, or crushed for oil and meal. As a food ingredient, hempseed has been shown to be highly nutritious, containing 20% high-quality digestible proteins. The seed is approximately 29–34% oil by weight, and the oil can be used for both human consumption and industrial applications (USDA 2000). The oil contains roughly the same ratio of linoleic and linolenic acids found in a nutritionally balanced diet (Marshall). However, hemp oil is fairly unstable and becomes rancid quickly. Hemp meal contains 25–30% protein and can be used in food or animal feed (Vantreese 1998). Various food products containing hempseed include nutrition bars, tortilla chips, pretzels, and beer. At least two breweries in the United States, as well as some in Canada,

on the market between 1986 and 1991, increasing world export volume by three to five times of previous levels, world prices dropped by nearly half. After China stopped exporting hempseed in 1991, prices nearly doubled in 1992 and increased further after that. Such price fluctuations, Vantreese adds, would be difficult for many farmers to weather, and is an important factor to consider when examining the possibilities of reviving industrial hemp cultivation in the United States (note, however, that significant price variability existed for most domestic crops in the late 1990s).

Canada's experience suggests hemp producers will face significant market uncertainty. Canada produced its first hemp crop in 1994, after fifty years of prohibition. In 1995, seven groups were granted production licenses, including joint efforts between academia, government and private industry (Vantreese 1997). By 1998, Health Canada permitted 259 farmers to grow hemp on 6,180 acres, primarily in Ontario and Manitoba. In June 1999, 674 hemp production licenses were issued for cultivation on about 35,000 acres. More than half of this acreage was in Manitoba, followed by Saskatchewan and Ontario. However, actual acreage under cultivation was less than allowed because of planting delays associated with a wet spring in western Canada (Health Canada 1998, 1999; Hanson-Trip 1999; Hanks). The number of commercial licenses issued in 2000 dropped to 213 as a result of fewer applications. These allowed for cultivation on about 13,560 acres, more than half of which was again in Manitoba. One of the major reasons cited for the drop in license applications was that the major contractor buying industrial hemp in Manitoba closed its doors, leaving contracting farmers uncertain as to existing and future demands (Hanson-Trip 2000). In fact, the general manager of Kenex Ltd., a company that specializes in industrial hemp research, production and processing in Southwestern Ontario, indicated that the 1999 supply of Canadian hemp fiber and seed oversupplied the North American hemp market (von Sternberg). Canada's experience highlights the economic challenges facing the development of an industrial hemp industry in the United States.

Viability of U.S. Cultivation and Processing

Yields

Yield is a key parameter in assessing the viability of any crop. The literature on industrial hemp documents a wide range of yield estimates. The range of varieties cultivated, the scale of cultivation, the different growing locations and climatic conditions, and differences in reporting standards, all complicate comparison across studies. Many European authors report all above-ground dry matter for fiber hemp, which also includes leaves and seed, instead of the dry-stem yields reported by other authors (Ehrensing). To put this into perspective, both Dempsey and Wright estimate that 1 pound of dry retted stems contains 0.2 pounds of fiber (which is comprised of the long, "line" fiber and the tow), whereas 1 pound of dry retted stems and leaves contains about 0.13 pounds of fiber. Ehrensing reports that research trials for fiber hemp in Europe over the last four decades showed dry-matter yields ranging from 2.6 to 8.7 tons per acre. Research trials in the Netherlands during the late 1980s reported dry-stem yields of 4.2–6.1 tons per

sampling and THC testing to be around $27 per acre for Ontario (this estimate was reported in Canadian dollars, and has been adjusted to an U.S. dollar equivalent). All seed production estimates assume that the residual hemp stalks are processed for fiber or pulp. As mentioned above, fiber from dual production is lower quality than from fiber-only cultivation, and authors have given lower price estimates for fiber produced in the dual production scenarios. The prices for seed stock and seed and fiber output are the most speculative parts of earlier estimates, and will be most affected by future developments in technology, market access and domestic sources of certified seed. Since China and France are currently the two major world producers of certified seed, the development of North American supplies of seed stock could significantly reduce the transportation component in seed costs. All of the studies assume the existence of local processing facilities, so transportation costs are relatively low.

Thompson, Berger, and Allen estimate seed and fiber prices based on the price of hemp imports into the United States in 1998. They use cost estimates from the University of Kentucky College of Agriculture updated to 1997 values based on the increases in costs from growing corn and the results of research in Canada. Their yield estimates come from German agricultural data (Nova Institute). Ehrensing used estimated typical costs associated with irrigated field corn in the Pacific Northwest to derive the hemp fiber price of $75/dry-weight ton based on discussions with an Oregon hemp composite manufacturer and on current trends in the price for wood chips. Moes uses cost estimates derived from 1994–1997 research trials in Manitoba, Canada, and does not include estimates of market price for fiber and seed. Baxter and Sheifele and Ministry of Agriculture and Food, British Columbia, Canada do not explicitly indicate the source for their estimates, but it is assumed that these come from the combined results of research from trial crops and commercial experience in Canada.

Overall, profitability estimates from these studies range from −$241.30 to $605.91 per acre. Estimated hemp fiber prices used range from $75–$200 per ton for fiber-only crops, and $90.50–$200 per ton for fiber produced from dual production crops. Produced seed prices range from $0.30 to $1.20 per pound, depending on whether it is for grain or certified seed. The input price of seed stock in these estimates ranges from $0.81 to $3.32 per pound. Generally, fiber yields are similar, ranging from 3.4 to 5 tons per acre for fiber-only production, and 0.5–2.5 tons per acre for dual production crops. Seed yields range from 300 to 1,069 pounds per acre. Estimates for variable costs range from $121.45 to $378.39, and where given, fixed cost estimates ranged from $36.44 to $245.

In addition to estimating the profitability of industrial hemp itself, some authors have compared hemp with other cash crops. Table 4 is a compilation of various estimates of profitability for other crops used as a basis of comparison to hemp from these studies. Thompson, Berger, and Allen conclude that estimated returns to hemp compare well with other field crops in Kentucky, though fall below estimates for tobacco. Vantreese 1997 estimates a range of returns to hemp of $5.33–$141.65 per acre, with an average of $73.49 per acre, and concludes that hemp is generally comparable to other cash crops in Kentucky, though not as competitive as tomatoes for processing, or tobacco. Kraeznel et al. uses hemp profit estimates from both Vantreese 1997 and Thompson, Berger, and Allen and finds that only irrigated potatoes compare favorably with industrial hemp. The general

Operator Labor/Acre				
Tillage and Planting		$40.00	$33.92	$13.96
Irrigation		$62.00		
Forage Chopper		$15.00		
Raking		$7.50		
Cutting & Swathing			$16.63	
Retting			$16.63	
Bailing		$49.00	$43.23	
Harvest and Haul				$35.91
Total Labor Cost/Acre	$56.00	$173.50	$110.39	$49.87
Total Variable Costs	$313.28	$371.30	$378.39	$121.45
Fixed Costs/Acre				
Land Rent		$150.00		
Insurance—Machinery & Equipment		$3.00		
Irrigation System—Depreciation & Interest		$44.00		
Machinery and Equipment		$48.00		
Total Fixed Costs	$50.27	$245.00	–	–
Total Enterprise Costs	$363.55	$616.30		
Yield (Tons/Acre)	3.4	5.0	3.86	3.6
Price (/Ton)	$200.00	$75.00	$119.70	
Total Revenue/Acre	$680.00	$375.00	$462.04	
Profit/Acre	$316.45	–$241.30	$40.57[b]	–

Note: Assumptions and definitions of cost vary considerably across estimates, and should thus be viewed with caution.
[a]All values have been converted to US$ from Canadian dollars by the current rate, as of Jan 30, 2001, of 0.665 US$ to Can $.
[b]Does not include fixed costs.

Combining			$46.55	
Cutting and Swathing			$16.63	
Retting			$16.63	
Baling			$26.60	
Seed Drying for Storage		$1.42–$2.37		
Grain Cleaning		$1.99–$3.33		$13.30
General Labor	$56.00/$70.00/$63.00	$19.95		
Harvest and Haul				$75.14
Total Labor Cost/Acre	$56.00/$70.00/$63.00	$37.32–$39.61		$102.40
Total Variable Costs	$211.76/$223.36/$328.44	$132.16–$169.27	$354.46	$139.40
Fixed Costs/Acre				
Land Investment Costs		$11.84		
Machinery Depreciation & Investment		$24.60		
Total Fixed Costs	$45.00/$70.73/$75.05	$36.44	–	–
Total Enterprise Costs	$256.76/$294.09/$403.49	$168.60–$205.71		
Residual Stalk Yield (Tons/Acre)	0.5/0.5/2.25	1.5–2.5	2.2	1.8
Stalk Price (/Ton)	$120/$120/$200		$90.50	
Seed Yield (Lbs/Acre)	1069/700/700	300–500	300–1500	800
Seed Price (/lb)	$0.39/$1.20/$0.39		$0.30	
Total Revenue/Acre	$536.91/$900/$723		$289.10–$649.10	
Profit/Acre	$220.15/$605.91/$319.51	–$65.36–$294.64[c]	–	–

Note: Assumptions and definitions of cost vary considerably across estimates, and should thus be viewed with caution.
[a]All values have been converted to US$ from Canadian dollars by the current rate, as of Jan 30, 2001, of 0.665 US$ to Canadian $.
[b]Does not include grain storage.
[c]Does not include fixed costs.

In the past, DEA has granted no registrations for the cultivation of hemp for industrial purposes, and under the Controlled Substances Act determination needs to be made that such production is in the public interest (Industrial Hemp Investigative and Advisory Task Force). Consequently, any lifting of restrictions on cultivation of industrial hemp will most certainly be accompanied by strict regulations governing licensing and certification, cultivation, testing and monitoring of hemp cultivation (this is currently the case in Canada). Compliance costs will likely be born by individual producers.

Conclusions

Although research on the development and cultivation of varieties of fiber and seed hemp better suited to North American climatic and soil conditions would be a necessary part of developing industrial hemp production in the United States, the literature generally concludes that agronomic considerations are of relatively minor concern. Lack of innovation in both harvesting and processing technology—reducing labor and resource costs and improving fiber quality and yield—is continually cited as a major barrier to the economic feasibility of industrial hemp in the United States. This observation is highlighted by the fact that today's major world suppliers are generally countries with low labor and resource costs, as well as European producers that have benefited from government subsidies. Such innovations would not only improve farm gate profitability, but would also improve the prospects for the profitable development of local processing facilities for hemp fiber and seed, which is key to making industrial hemp cultivation feasible in North America.

It appears hemp production would be marginally profitable for U.S. producers assuming relatively low compliance costs and the development of local processing capacity. In general, hemp is found to be slightly more profitable than traditional row crops, but less profitable than other specialty crops. Importantly, previous studies do not account for the potential price impact associated with a significant increase in the market supply of hemp. Based on the Canadian experience, current demand could be quickly satiated with only a small amount of commercial production. As such, short-run opportunities may be limited to the few producers who are able to contract directly with processors serving small niche markets.

A strong argument in favor of hemp's commercialization is its relatively low environmental impact. Recent research on hemp has confirmed its potential as an attractive rotational crop (with minimal pesticide and herbicide use) that is well suited to a wide range of growing conditions. However, the degree to which such characteristics make it a desirable industrial crop greatly depend on the overall costs—both environmental and otherwise—of its harvesting and processing as a raw material. Industrial hemp generally needs to be grown on prime agricultural land with ample fertilizer use and moisture for good yields, and current processing techniques for its fiber and pulp remain relatively resource and labor intensive and may be as environmentally damaging as competitive sources of raw materials (Johnson). Furthermore, Cochran, Windham, and Moore point out that if hemp were to be intensively cultivated, increased incidence of pest problems should be anticipated, which could compromise the longer-term impacts of its environmental benefits.

Johnson, P. "Industrial Hemp: A Critical Review of Claimed Potentials For Cannabis Sativa." *Tappi Journal* (July 1999):113–23.

Kessler, R.W., and R. Kohler. 1996. "New Strategies for Exploiting Flax and Hemp." *Chemtech* (December 1996):34–42.

Kraenzel, D.G., T. Petry, B. Nelson, M.J. Anderson, D. Mathern, and R. Todd. *Industrial Hemp as an Alternative Crop in North Dakota: A White Paper Study of the Markets, Profitability, Processing, Agronomics and History*. Ag. Econ. Rep. 402, Inst. Nat. Res. Econ. Dev., North Dakota State University, 1998.

Louie, E. "Cannabis Beer? Not What You Think." *New York Times*, September, 1998.

Low, I. "UK Hemp Production,"*1995 Bioresource Hemp Symposium Proceedings*. Frankfurt: Germany, 1995, pp. 106–8.

Mackie, G. "Hemp: The Acceptable Face of Cannabis." *Textile Month* October 1995, pp. 49–50.

Marshall, T. "Is There a Market for Hemp Oil?" *Alberta Hemp Symposium Proceedings*. Edmonton, Alberta: Alberta Agriculture, Food and Rural Development, 1998.

McPartland, J.M. "Cannabis Pests." *J. Int. Hemp Assoc.* 3(December 1996):52–55.

Meijer, W.J.M., H.M.G. van der Werf, G.J. van Roekel, E.P.M. de Meyer, and W. Huisman. *Fibre Hemp: Potentials and Constraints*. Edmonton, Alberta: Alberta Agriculture, Food and Rural Development, 1996.

Ministry of Agriculture and Food, British Columbia, Canada. *Specialty Crops Factsheet: Industrial Hemp*. 1999.

Moes, J. "Hemp Research in Manitoba—1995–1997." *Alberta Hemp Symposia Proceedings*. Edmonton, Alberta: Alberta Agriculture, Food and Rural Development, 1998.

Nova Institute. *The Hemp Produce Line Project*. Koln, Germany: The Nova Institute, 1996.

Patton, J. "Founder of the Body Shop Sees Hemp as Viable Kentucky Crop." *Lexington-Herald Leader*. Lexington, KY, 1999.

Rawson, J.M. *Growing Marijuana (Hemp) for Fiber: Pros and Cons*. Washington DC: Congressional Research Service, Report 92-510, 1992.

Rorie, S. "The Rediscovery of Hemp." *Organic & Natural News*, Aug 1999, 17–19.

Roulac, J.W., and Hemptech. *Hemp Horizons: The Comeback of the World's Most Promising Plant*. White River Junction, VT: Chelsea Green Publishing Company, 1997.

Soyatech, Inc. *Soya & Oilseed Bluebook*. ME: Bar Harbor, 1999.

Thompson, E.C, M.C. Berger, and S. Allen. "Economic Impact of Industrial Hemp in Kentucky." Cent. Bus. Econ. Res., University of Kentucky, 1998.

——. *Industrial Hemp in the United States: Status and Market Potential*. ERS Rep. No. AGES001E, Washington DC, 2000.

van der Warf, H.M.G. "Hemp Facts and Hemp Fiction." *J. Int. Hemp Assoc.* 1(December 1994):58.

Vantreese, V.L. "*Industrial Hemp: Global Markets and Prices*." Dept. Ag. Econ., University of Kentucky, 1997.

——. *Industrial Hemp: Global Operations, Local Implications*. Dept. Agr. Econ., University of Kentucky, 1998.

Vavilov, N.I. *Origin and Geography of Cultivated Plants*, English edition. Cambridge: Cambridge University, 1992.

von Sternberg, B. "In Canada, Hemp Hasn't Lived Up to the Hype." *Minneapolis Star Tribune*. Minneapolis, MN, October, 1999.

Wang, Q., and G. Shi. "Industrial Hemp: China's Experience and Global Implications." *Rev. Agr. Econ.* 21(Spring/Summer 1999):344–57.

West, D.P. *Second Annual Report to the Hawaii State Legislature*. Hawaii Industrial Hemp Research Project. January 2001.

Wright, A.H. *Wisconsin's Hemp Industry*. University of Wisconsin, Madison, Agr. Exp. St. Bull. No. 293, 1918.