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The Lansing Tri-County Bio-Manufacturing Feasibility Study

Evaluating Regional Capacity and Performance in the Emerging Automotive Bio-Manufacturing Sector of the Global Bioeconomy

Fall 2008

Michigan State University
Center for Community and Economic Development

UNIVERSITY OUTREACH & ENGAGEMENT

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Acknowledgements

The Michigan State University Center for Community & Economic Development (MSU CCED) in the Office of University Outreach and Engagement has over 30 years of experience in addressing the economic problems of communities across Michigan. Through applied research and outreach activities, CCED mobilizes the university's resources and expertise to strengthen Michigan communities. CCED practices translational research, through which relevant cutting-edge scholarship and best practices are made accessible to Michigan communities. The CCED mission is to advance MSU's land-grant mission by creating, disseminating, and applying knowledge to improve the quality of life in distressed Michigan communities. We implement, evaluate, and disseminate innovative approaches through responsive engagement, strategic partnerships, and collaborative learning. Our work takes place at the engagement interface—the messy, unpredictable place where theory and practice meet in real-time about real-life problems. This project report and the pre- and post activities that surround this feasibility study reflects this informed process of community change and were made possible by the collaboration of many organizations and people.

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1. Project Overview

The shift from a traditional manufacturing economy to a knowledge-based bioeconomy creates formidable new challenges. Individuals, organizations, and communities find themselves struggling to envision new livelihoods in an increasingly competitive global economy, enhance neighborhood vitality despite highly transient populations, and improve quality of community life in an atmosphere of diminishing public resources. These challenges are common to communities nationwide, but Michigan communities have suffered disproportionately.

Chronically high rates of unemployment, closures of automobile manufacturing plants, decreases in levels of homeownership (and increases in delinquencies and foreclosures), declines in personal wealth (and increased rates of personal bankruptcies), and steady out-migration of Michigan's youth have eroded the state's traditional economic leadership and pose steep challenges to the future viability of Michigan's communities.

At the same time, spiraling energy and health care costs and shrinking allocations of state revenue-sharing have imposed unanticipated demands on local governments and resulted in continuous rounds of budget cuts in services to neighborhoods, townships, and cities. State government leaders find themselves hamstrung by fiscal policies, such as the Headlee Amendment and Proposal A, which have synergistically combined to limit the financial options available to Michigan's metropolitan areas (where more than 80% of Michigan's population resides). Even financially stable communities realize that these structural barriers will have significant and detrimental effects on the quality of life in their communities in the not-so-distant future.

At no other time in our state's history has the imperative been greater for local public and private sector institutions and leaders to come together in new and innovative collaborative partnerships to serve, support, and strengthen Michigan's communities.

The Lansing Tri-County Bio-Manufacturing Feasibility Study is part of a two-year initiative to help the Lansing Tri-County Region respond to these fundamental changes.

1.1 A Bio-Based Economy: An Innovative and Prosperous Future for the Lansing Tri-County Region

A bio-based economy is increasingly pointing the way to future prosperity and environmentally-sustainable production and consumption. Communities and companies across the globe are aggressively pursuing the economic advantages and environmental benefits from developing manufacturing processes and products more heavily based on renewable and biodegradable agricultural and natural resource materials. This emerging bioeconomy uses many of the same agricultural and manufacturing inputs used in the traditional economy—crops and natural resources, physical infrastructure, land, labor—but with an added emphasis on the role of technology and knowledge as key economic drivers.

Bio-manufacturing links the agricultural raw materials with other more traditional inputs to create new environmentally-friendly alternatives to traditional manufacturing products. Bio-manufacturing uses plant-based materials in products such as automotive components, textiles, furniture, building materials, solvents, cleaners, and others. "Bio-products" are defined as "a commercial or industrial product (other than food or feed) that is composed, in whole or in significant part, of biological products or renewable domestic agricultural materials (including plant, animal, and marine materials) or forestry materials" by the U.S. Department of Energy. [1]

The percentage of bio-products as a share of overall biomass in the U.S. is expected to grow from 5 percent in 2005 to 25 percent by 2030. A 2000 European Union Directive mandates that all cars be 85 percent recyclable by component weight by 2015.[2] To meet this policy requirement as well as satisfy growing consumer demand for environmentally-friendly products, some manufacturers are incorporating bio-based components made from such plant-based materials as soy, corn, sisal and flax. Bio-based components help auto manufacturers meet this goal.

In 2007, 6.5 billion gallons of ethanol and 450 million gallons of biodiesel were produced, compared to 4.9 billion gallons of ethanol produced in 2006.[3] For the first four months of 2008, 3.3 billion gallons of ethanol were produced and based on that level, annual production could reach 10 billion gallons.[4]

The 2007 Renewable Fuels Association annual report cited an expert's economic appraisal of 2006 ethanol production as a $41.1 billion economic sector, supporting creation of 160,231 jobs in all economic sectors including 20,000 manufacturing jobs, saving American consumers $6.7 billion, and contributing $2.7 billion in new federal tax revenues and $2.3 billion in new state and local government revenues.[5]

The growth of the U.S. biofuel industry, corn-based ethanol and a small biodiesel segment at this point, is driven in large part by U.S. mandates. The 2005 Energy Policy Act established a federal Renewable Fuel Standard (RFS) requiring the use of 7.5 billion gallons as transportation biofuels by 2012 (or approximately 3 percent of projected gasoline demand) and 36 billion gallons of renewable fuels by 2022. The current capacity of the corn-based ethanol industry at 8.5 billion gallons has already exceeded the 2012 federal RFS of 7.5 billion gallons. And another 5.1 billion gallons are on the way from facilities currently under construction.

The 2007 Energy Independence and Security Act (EISA) incorporated the renewable fuel standard of 36 billion gallons in the motor fuel supply by 2022. This Act also specified that at least 16 billion gallons are to be produced from "advanced biofuel feedstocks," largely cellulose-based ethanol, by 2022. Corn-based ethanol is capped at 15 billion gallons. An interim target of 3 billion gallons of cellulosic fuels is also set for 2015.[6]

To achieve these ambitious goals, development and construction of cellulose-based ethanol biorefineries is imperative.

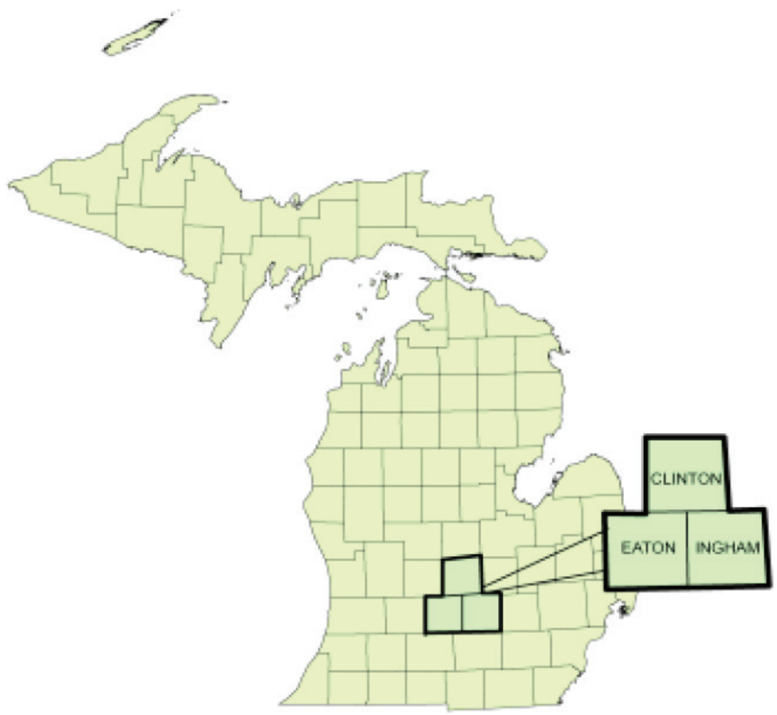
The potential global market for biofuels including cellulosic ethanol is expected to expand to $10 billion by 2012, according to a Shell Oil estimate.[7]

1.2 Purpose of the Feasibility Study

This study assesses ***the potential to create and sustain a bio-based manufacturing capacity in the Lansing Tri-County Region.*** To determine this potential, a rigorous analysis of the needed bio-manufacturing inputs, industrial infrastructure, intellectual capacity and regional leadership was conducted. While this analysis applies to the general bio-manufacturing sector with short-term implications for manufacturing such consumer goods as home products, computers, textiles, clothing, and furniture, our focus is the automotive bio-manufacturing sector. The orientation of this study is based on a recognition of the unique economic strength and potential the Tri-County Region has in the global automotive manufacturing market.

Figure 1-1

The Lansing Tri-County Region



Source: MSU Center for Community & Economic Development.

Based on this analysis, a decision-making matrix was constructed to help inform regional stakeholders about regional opportunities and challenges in developing an automotive bio-manufacturing cluster in mid-Michigan. The findings of this feasibility study provide ***an evidential base from which communities may make informed decisions about investing in an alternative community and economic development future based on the bioeconomy.*** The predictive reliability of a feasibility study is limited in part by the appropriateness of its research methods, the accuracy of the data analyzed, and the willingness of stakeholders to take informed risks, change behavior and blaze a path into a mostly uncertain future. While every reasonable effort was made to construct a realistic assessment, predicting the future has only one certainty and that is the future is ever changing and largely unknown.

1.3 Feasibility Study Methodology

This study assesses the feasibility of developing an automotive bio-manufacturing industry cluster in the Lansing Tri-County Region by applying, in large part, a methodology employed by the Michigan State University Office of Bio-Based Technologies in cooperation with the MSU Product Center for Agricultural and Natural Resources in a 2006 feasibility study entitled *Linking Knowledge and Resources to Support Michigan's Bioeconomy*, prepared by the Centrec Consulting Group, LLC.[8]

In using a tested methodology, the research team sought to improve the reliability of this feasibility study while incorporating some of the more traditional elements of business feasibility studies employed by planners and economic developers. The research team relied on the on-going advice and guidance of a Project Technical Advisory Committee (see appendix A for list of members). The project team routinely sought the consultation and advice of scholars, industry leaders and community leaders as data and information were gathered, sorted and interpreted.

This study consists of seven sections. Following this introduction (Section 1), the study examines the following five areas and concludes with an executive summary and recommendations (Section 7):

- A Tri-County Demographic and Employment Profile
- Agriculture/Natural Resources/Environment Profile
- Industrial and Infrastructure Capacity

- Intellectual Capabilities
- Leadership Commitment

Five key performance factors were analyzed to determine the viability of bio-manufacturing in the Tri-County Region, including:

1) Market growth and potential
2) Agriculture/natural resources/environment
3) Industrial and infrastructure capacity
4) Intellectual capabilities
5) Leadership commitment

Each performance factor was benchmarked to the extent possible to assess the Tri-County Region's relative strengths and weaknesses for that factor. Seventeen indicators providing measurements of these five performance factors were identified. Understanding the scope and impact of these performance factors in the bioeconomy is essential to determining the feasibility of developing an automotive bio-manufacturing industry cluster in the region.

1.4 The Emergence of the Bioeconomy: Old Wine in "New" Bottles

The advent of modern biotechnology and related sectors resulted in large part from the 1953 discovery of the double-helix structure of DNA by Francis Crick and James Watson. Their discovery paved the way to mapping the human genome during the 1990s. Scientific innovations associated with the new biotechnology were quick to find commercial applications like diagnostic tools for genetic diseases and genetically-modified organisms.[9] Innovation, collaborative research, and bold entrepreneurship to commercialize knowledge-based applications have become major drivers in the global New Economy.

The emerging bioeconomy consists of economic activities using renewable biological resources (forest, agricultural, aquatic resources, microorganisms) and processes to produce biofuels and energy, gene-modified foods and organisms, bioplastics, biochemicals, biopharmaceuticals, and nutraceuticals in addition to traditional food, feed, and fiber. Biomass provides much of the feedstock for a bio-based economy; a significant amount of biomass is provided by the agricultural sector as well as from forest and other natural resources.[10] The purpose of the bioeconomy is to produce and consume products in ways that are consistent with sustaining natural ecosystems and "without compromising the ability of future generations to meet their own needs."[11]

The global market for bio-products in 2003 was valued at approximately $70 billion, 85% of which was for biochemicals and bioplastics. Potential bioeconomy markets may reach $500 billion in the global economy by 2015.[10]

Production of chemicals and materials from bio-based products will increase substantially from approximately 12.5 billion pounds or 5% of the current production of target U.S. chemical commodities in 2001, to 12% in 2010, 18% in 2020, and 25% in 2030.[1]

Bio-manufacturing has emerged as a new sector in the emerging bioeconomy based on applications of renewable bio-based materials as a substitute for non-renewable petroleum-based resources in the production of materials. The development of alternative renewable fuels represents a key component of the bio-manufacturing sector. The production of corn-based ethanol has expanded across the Midwest as ethanol has become an increasingly important alternative to petroleum-based fuel. Bio-manufacturing uses many of the same agricultural and manufacturing inputs as the traditional economy – natural resources and crops, physical infrastructure, land and labor, etc., but with a new emphasis on the role of knowledge and innovation as key drivers in sustainable growth based on renewable resources.

Sales revenues from corn-based ethanol production in 2007 were $4.3 billion, compared to $1.4 billion in 2004, a 211% increase. Operating costs were $3.5 billion thus providing an operating income of $895.4 million in 2007, according to a U.S. International Trade Commission July 2008 report.[12]

1.4.1 Life Sciences and Bio-Pharmaceuticals

Biotechnology has become a major global business with innovative commercial applications of medical discoveries related to genetic testing and diseases and the mushrooming growth of bio-based pharmaceuticals.

U.S. businesses have benefitted from the positive economic impacts of the ongoing biotechnology revolution. Bioeconomy companies grew to 1,453 U.S. companies by 2001 employing 141,000 people with revenues over $25 billion.[13]

1.4.2 Industrial Bio-Products

Industrial bio-products are defined as "industrial products manufactured wholly or in part from agricultural feedstocks (plant-based materials)," as defined by the U.S. Department of Energy.[14] Forest-based feedstocks may also be used in the manufacture of bio-products.

Consumers are increasingly demanding eco-friendly products with narrow carbon footprints in response to increasing concerns about global climate change and environmental sustainability. The rising costs of petroleum and other nonrenewable resources are shifting demand to renewable bio-based inputs. In response to this demand and prodded by public policy mandates, companies are substituting renewable, compostable/biodegradable agricultural and other bio-based feedstocks for petroleum-based inputs in producing consumer goods as diverse as office furniture, textiles, homebuilding materials, cups, bottles, and even automotive components.

Companies like Cargill (a major multinational supplier of agricultural and food products), for example, have begun production of bio-based intermediates from corn incorporated in new biodegradable consumer products like coffee cups, textiles, and packaging. [15]

Bioplastics are successfully being used in packaging and fibers, and beginning to penetrate automotive, computers, and consumer electronics markets. Global bioplastic demand is expected to reach over $1 billion by 2010.[16] One bioplastic resin manufacturer, Cereplast, Inc. recently reported the growth of the sales in its bio-based resins that are now used in Jack-in-the-Box and Chipotle compostable food service products, compostable horticulture market containers and packs, and other applications. Sales grew to $1.9 million for the first six months of 2008, a 104% increase over the same period in 2007. Cereplast plans to open a second manufacturing facility in Seymour, Indiana in 2008.[17]

1.4.3 Bio-Products in the Automotive Industry

While the recent rise of automotive bio-manufacturing has focused on producing alternative biofuels such as ethanol and biodiesel, many global automotive companies and suppliers have also developed more environmentally friendly automotive components using renewable biomaterials.

The use of biofuels and bio-based components in automobiles is not new. Henry Ford invented the Model T a hundred years ago to run on both gasoline and ethanol. Ford also invested millions of dollars as early as the 1930s to research the production of soy-based auto components. But cheap petroleum and crop shortages during World War II precluded development of eco-friendly auto components at that time

Current interest in bio-based parts has been sparked in part by consumer demand for more environmentally-friendly cars and a lighter carbon footprint in addition to new government incentives supporting ethanol and other biofuels. Perhaps the largest impact has been from European Union Directive 53 of 2000 requiring that each auto component be 85 percent recyclable by weight by 2015.

Innovative car makers have responded by using bio-based materials

Figure 1-2

Benefits and Challenges of Bio-Based Auto Components

Benefits

Up to 40 percent lighter than petroleum counterpart to increase fuel efficiency

Helps reduce landfill use

Non-food market for agricultural crops

Challenges

Inconsistent feedstock crops and product quality

Issues with mold, product life and premature degradation

Source: Institute for Local Self-Reliance.

to produce new automotive components such as soy-based seat cushions, corn-based tires and door claddings made from sisal and flax. These efforts are helping to green what was once regarded as a strictly petroleum-based industry.

Technological advances have helped to make many bio-based automotive components up to 40 percent lighter than their petroleum-based alternatives, reduce landfill waste, and provide new non-food markets for agricultural crops. While challenges persist with crop and product consistency, odor problems and mold issues, and product life and degradability, automakers have started to use plant-based 'feedstocks' as primary inputs for various car components. Bio-based components like seat cushions, body panels and floor mats help auto companies meet European recycling standards and world-wide demand for greener products.

Some examples of automotive manufacturers incorporating bio-manufactured products include the following:

- **Daimler AG** has been the bio-manufacturing leader in the automotive industry incorporating agricultural feedstocks like flax, hemp and sisal for door claddings, seatback linings, and the space behind rear seats in sedans. Daimler also uses coconut fiber and abaca to make under-floor body panels, seatback cushions and head restraints and currently incorporates 27 different bio-based components (42.7 kg) in its Mercedes-Benz S-Class models sold in Europe.
- **Ford Motor Company** launched its concept car at the 2003 North American International Auto Show, dubbed Model U, powered by a hydrogen fuel-cell engine, that included soy-based seating foam and body panels, corn-based tires and canvas roofs.
- Japanese automaker **Toyota** launched its i-foot and i-unit concept cars, which incorporate kenaf grass in its body structures and continues to research other applications at its production facility in Osaka, Japan for kenaf grass and other plant-based feedstocks.[18]
- By 2004, **BMW** was using 10,000 kg of raw plant-based materials in different models. For example, the 7 Series model boasts cotton soundproofing, wood fiber-based seatback cushions, wool-based upholstery and flax and sisal in the interior door panels.
- **General Motors** is incorporating flax and kenaf mixtures in door inserts and bumpers in its Saturn L300 and European-market Opel Vectra, while the GMC Envoy, Chevrolet Trailblazer and Cadillac DeVille contain wood fiber seatbacks.

As automakers increasingly incorporate bio-products into their models, new variations and additional parts are developed and manufactured from plant-based materials.

Ford Motor Co. and Lear Corp. teamed up to produce soy-based seat foam in the 2008 Ford Mustang, F-150, Navigator, and Expedition and will expand the use of bio-based seat foam to the 2009 Escape and Mariner. These seats contain 40 percent soy-based materials and are produced at the Ford-Mazda Flat Rock, MI production facility.[19] Ford also collaborated with Urethane Soy Systems Company (USSC), the first company to use soybean oil in polyurethane applications; Renosal Corporation, a manufacturer of molded polyurethane seating and interior trim products; and the United Soybean Board New Uses Committee, a group of 64 farmers and agriculture industry leaders; and Bayer Corporation in developing the soy-based seats. The collaboration started in 2004.

Examples of other bio-based automotive part initiatives include:

- **Foam seats.** Agricultural giant Cargill and Dow Chemical, along with suppliers USSC and Michigan-based Woodbridge Group, have developed bio-based foam for use in automotive seats.
- **Tires.** Goodyear Tire and Rubber Co. produces a tire called BioTred which substitutes corn-based filler for a portion of the rubber to increase tire performance and fuel efficiency.
- **Floor Mats and Canvas Roofs.** Interface Fabric, a worldwide leader in fiber production and recycling with facilities in Grand Rapids, uses Cargill-developed technology to produce corn-based floor mats and canvas roofs that are easily recyclable at the end of the product's life.

1.4.4 Bio-Products in the Furniture and Home Construction Industries

Two major markets responding to "green" consumer demands include furniture and home construction products. Manufacturing bio-products for these markets could successfully take advantage of evident and extensive market demand. The existence of companies like Steelcase, Herman Miller, and Haworth in the Grand Rapids and Holland area provide highly-accessible end-markets for bio-based products manufactured in the Tri-County Region. Moreover, these companies have previously demonstrated leadership in environmental sustainability initiatives. Their corporate commitment to reducing their CO2 footprints and using sustainable and renewable bio-based materials is well-established.

Bio-based composites could be particularly attractive to these potential end-market customers. The MSU Composite Materials and Structures Center has provided world-class R & D leadership in this area for over 20 years with substantial success in commercial applications of R & D innovations.

The range of home construction products includes various types of bio-plastic panels, adhesives, carpeting, window treatments, and others. With the cutting-edge R & D and well-developed manufacturing capacity in the Tri-County Region, there could be lucrative opportunities for the region to develop and advance these end markets for bio-products manufactured here. Green housing and construction is an area that has advanced significantly over the past 10-12 years. Leadership in Energy and Environmental Design (LEED) standards developed by the U.S. Green Building Council have become increasingly important to the overall home construction industry.

1.5 The Potential of Automotive Bio-Manufacturing and Bio-Product Markets

As oil prices steadily increased in 2007 and exploded in the first six months of 2008, the bioplastics that first emerged in the 1980s but then faded, have taken on new life. Corn and soy feedstocks as alternatives to petroleum-based plastics can be expected to be increasingly used in automotive components and other products. Recent growth of consumer bio-products is underlined by the broad range of companies engaged in the bio-manufacture of some type across industry sectors and geographic locations around the world.

While bio-based products remain more expensive than their petrochemical counterparts in many cases, growing consumer demand for green products and rapidly-rising petroleum prices are stimulating companies to research and develop bio-products. Bio-products historically have faced challenges in terms of their consistency in quality (plant raw materials may show variation from one growing season to the next) and durability (a tendency to bio-degrade prematurely). Bio-based component manufacturing has continued to improve and overcome previous short comings.

International markets for bio-based products continue to expand. For over a decade, bio-products have been used by German automotive companies to reduce weight and improve fuel efficiency while offering an environmentally-friendly alternative to petroleum-based plastic components. From 1996 to 2003, the annual amount of natural fibers used by German auto companies in components increased from 4,000 to 18,000 tons. European and North American markets for bio-products reached 685,000 tons or $775 (USD) million by 2002.[20]

Figure 1-3

Selected International Manufacturers of Bio-Based Consumer Products

Company	Bio-Products	Website
BASF (Ludwigshafen, Germany)	Compostable starch-based shopping bags, mulching films	http://www.basf.com/
Birkel (Waiblingen, Germany)	Cellulose-based plastic packaging for pasta products	http://www.birkel.de/
Sony (Japan)	Walkman housing based on biopolymer platform in Japanese market	http://www.sony.com/
Novamont (Novara, Italy)	Plant pots, twine, gardening equipment and packaging, cotton swabs, corn foam	http://www.novamont.com/
Innovia Films (United Kingdom)	Biodegradable sticky tape made from cellulose	http://www.innoviafilms.com/
Versace (Milan, Italy)	Corn-based winter coat	http://www.versace.com/
Huhtamaki (Espoo, Finland)	Cups and trays made from bioplastics	http://www.huhtamaki.com/

Source: European Bioplastics.

Many U.S. companies have incorporated eco-friendly consumer products into their marketing schemes. Wal-Mart and McDonald's now urge suppliers to use bio-degradable and environmentally-friendly packaging; Starbucks and Green Mountain Coffee have embraced corn-based coffee cups. Batelle, an international non-profit energy research organization based in Columbus, Ohio, reports that bio-based products could lead to a $150 billion dollar market in the U.S. if bio-products replace just 10 percent of petroleum-based products.[21] Firms across a range of industry sectors are using bio-materials to produce textiles and clothing, fast-food cups and service containers, packing, home furnishings, cleaners and solvents, and even composite plastic materials. Selected domestic firms and bio-products reflecting the broad range of firms and industry sectors engaged in bio-manufacturing are described in Figure 1-4.

Figure 1-4

Selected U.S. Manufacturers of Bio-Products

Company	Bio-Products	Website
Agriboard Industries (Electra, TX)	Environmentally engineered panelized building systems utilizing rice and wheat straw	http://www.agriboard.com/
Biodegradable Food Service, LLC (Berd, OR)	Food service packaging	http://www.bdfs.net/
BICgroupUSA, Inc. (Palm Harbor, FL)	Sales partner for BioBag branded tags and films	http://www.biogroupusa.com/
Cargill (Minneapolis, MN)	Industrial lubricants, PLA plastics for packaging, and PLA fibers for clothing, carpet face and furnishings	http://www.cargil.com/
DuPont (Wilmington, DE)	Sorona polymer for fabrics and bio-based content	http://www.dupont.com/
Dynamold Solvents, Inc. (Fort Worth, TX)	Bio-based solvents for industrial cleaning	http://www.dynamold.com/
Earth Shell Corporation (Santa Barbara, CA)	Food service wares and packaging	http://www.earthshell.com/
GEMTEK (Phoenix, AZ)	Janitorial and industrial cleaners and lubricants	http://www.gemtek.com/
Metabolix (Cambridge, MA)	Natural PHA polymers from corn sugar into a versatile range of biodegradable and compostable plastics	http://www.metabolix.com/
Mohawk (Calhoun, GA)	Carpet with bio-based backing	http://www.mohawkcarpet.com/
Renewable Lubricants, Inc. (Hartville, OH)	Bio-based lubricants	http://www.renewablelube.com/
Urethane Soy Systems Corp. (Volga, SD)	Spray foam insulation, truck bed liners and flexible foam	http://www.soyoyl.com/home/
West Central Soy (Ralston, IA)	Industrial cleaners and lubricants	http://www.west-central.com/
GREEN LINE Environmental (Washington, DC)	Distributor of bio-based hand sanitizers, cleaners, food service wares, and wastewater treatment	http://www.glepro.com/

Source: Tri-County Regional Planning Commission.

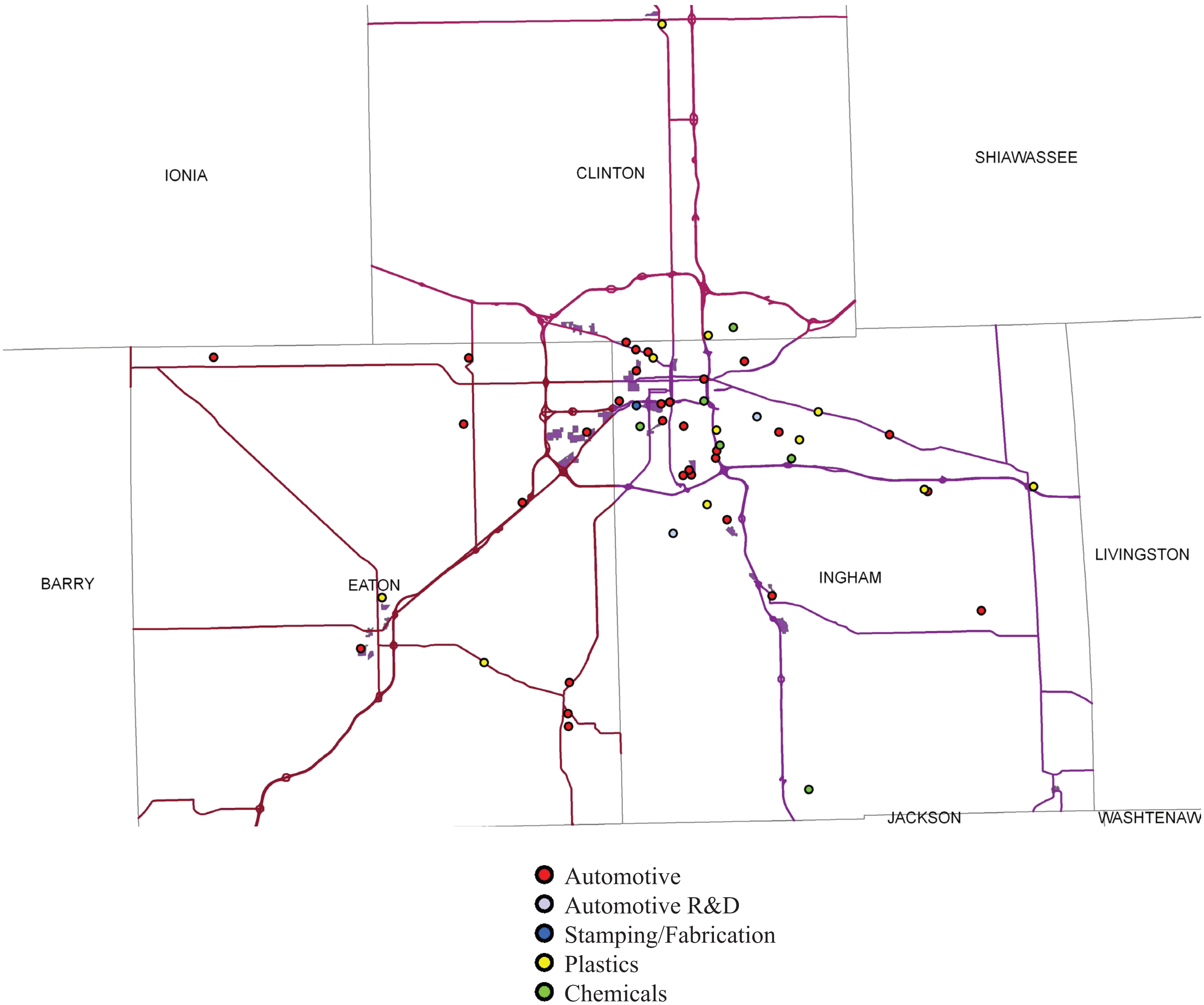
Some bioplastics are made directly from starch including those used in drug capsules, an application that's been around since the 1950s. The two other principal bioplastics include polylactic acid (PLA) made from polymerized lactic acid produced by fermenting starch from sweet corn and other plants; the other is poly-3-hydroxybutyrate (PHB) with properties similar to polypropylene.[22]

Substantial and even dramatic growth in bio-product markets is expected, especially in a high-priced petroleum and natural gas environment. For example, the global chemical industry is projected to grow 3-6 percent per year through 2025, with bio-based chemicals' share of that market rising from 2 percent currently to 22 percent or more by 2025.[23]

Given the Tri-County Region's deep roots in both manufacturing and agricultural production, farmers and existing businesses are well-positioned to secure a share of the growing bio-products market, particularly in the automotive industry. An analysis of Tri-County automotive and related industries indicates that the Tri-County Region has significant capacity to compete successfully in various bio-product markets.

Figure 1-5

Automotive Manufacturing, Automotive R&D, Plastics, and Stamping/Fabrication Facilities in the Tri-County Region



Source: MSU Center for Community & Economic Development.

The map above shows the locations of automotive manufacturing, automotive research and development, plastics, and stampings/fabrication facilities in the Tri-County Region. Most are clustered in the northwest portion of Ingham County. This cluster is interlaced by interstate highways providing these facilities easy access to transportation routes to southeastern Michigan, Ontario, northern Michigan, Chicago, Indianapolis, and major points beyond.

Other facilities are scattered across the other two counties. Clinton County has facilities near the northern border of the county that are connected to Lansing by a major road. Eaton County has more of these facilities than Clinton, but they are dispersed throughout the county.

The region appears to have a large and well-connected network of manufacturing firms and expertise. To document the extent of this network, the MSU Center for Community and Economic Development (CCED) collected data for five key industry sectors: Automotive, Automotive R&D, Chemicals, Plastics, and Stamping & Fabrication using the Michigan

Economic Development Corporation's online Business Directory. Employment and sales data were collected for each company using the 2007 edition of the online Harris Infosource database for market research information. This data was aggregated to obtain industry sector and aggregate totals to assess the market potential in substituting bio-based products for petroleum-based products in the region. Each company was geocoded by address using ArcGIS software to determine the spatial distribution of these facilities and transportation connectivity. Some existing facilities may not appear on the map due to geocoding techniques and software limitations.

The Tri-County Region clearly has a significant concentration of automotive manufacturing, automotive research and development, plastics, and stamping/fabrication facilities. This concentration contributes to the region's leadership in automotive and related manufacturing design, research, and production. A large potential bio-based product market clearly exists. To tap this market, manufacturing and research/development managers need to make decisions to use bio-based materials in the manufacture of their products. The annual sales in this sector are estimated at well over $600 million (see Figure 1-6). Thus, incorporating even a modest percentage of bio-based materials in automotive components could act as a critical catalyst to the manufacturing of automotive bio-products in the region.

Figure 1-6

Selected Tri-County Automotive and Related Companies with Bio-Manufacturing Potential

Industry Sector	No. of Companies	Employees	Annual Sales
Automotive	21	7,845	$437,144,407
Automotive R&D	1	10	$1,750,000
Chemicals	4	22	$18,000,000
Plastics	6	322	$109,250,000
Stamping/Fabrication	4	183	$98,000,000
Total	**32**	**8,328**	**$664,144,407**

Source: MEDC, MSU Center for Community & Economic Development, Reference USA.

1.6 Section Summary

Emerging bio-based product markets, technology advances to improve quality and performance, and greater consumer interest in reducing our reliance on nonrenewable oil based products are fundamentally altering traditional consumer and industry markets. The markets for quality bio-based materials in a variety of consumer and manufacturing applications show highly significant potential and future promise. Lucrative bio-based markets may be reasonably expected to develop in the future.

2. Tri-County Regional Demographic and Employment Profile

2.1 Introduction

This chapter briefly describes the Lansing Tri-County Region's most "valuable resource," its human talent. This profile provides a quick snapshot of the quality of life and the skills of the workforce in the region. Data was aggregated from a number of sources, including a City of Lansing Community Profile, prepared by Michigan State University Urban and Regional Planning students in the spring of 2007.[24]

Readers are encouraged to review other descriptive materials characterizing the quality of life in the region by visiting http://www.powerofwe.org/report.pdf. Prepared by the Power of We, a regional consortium of civic organizations, public agencies and service providers committed to making mid-Michigan the state's most "livable community," this report assesses the community's performance and progress in several specific areas.

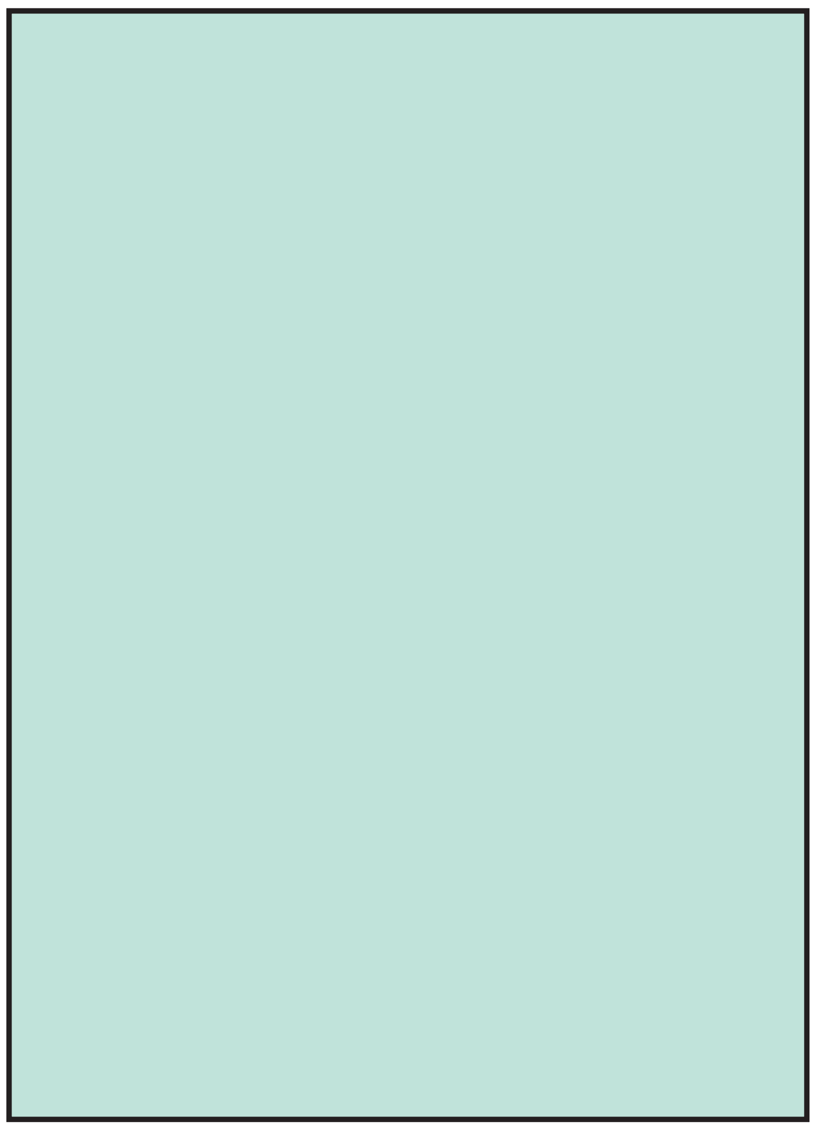
In addition to a capable workforce and a rich quality of life, major employers and higher education institutions like Michigan State University and Lansing Community College are noted by the Power of We Consortium.

Cooley Law School, located in downtown Lansing, has become the nation's largest law school, offering a top-notch legal education in the seat of Michigan government to students from across the country and the world.

Other institutions of higher education, including Western Michigan and Central Michigan Universities, have local branches or satellite campuses in mid-Michigan. As a result, area residents have a wide range of world-class higher education options. This educational infrastructure supports the region's intellectual capacity to compete successfully in emerging, knowledge-based bioeconomic sectors.

Figure 2-1

Capital Area Community

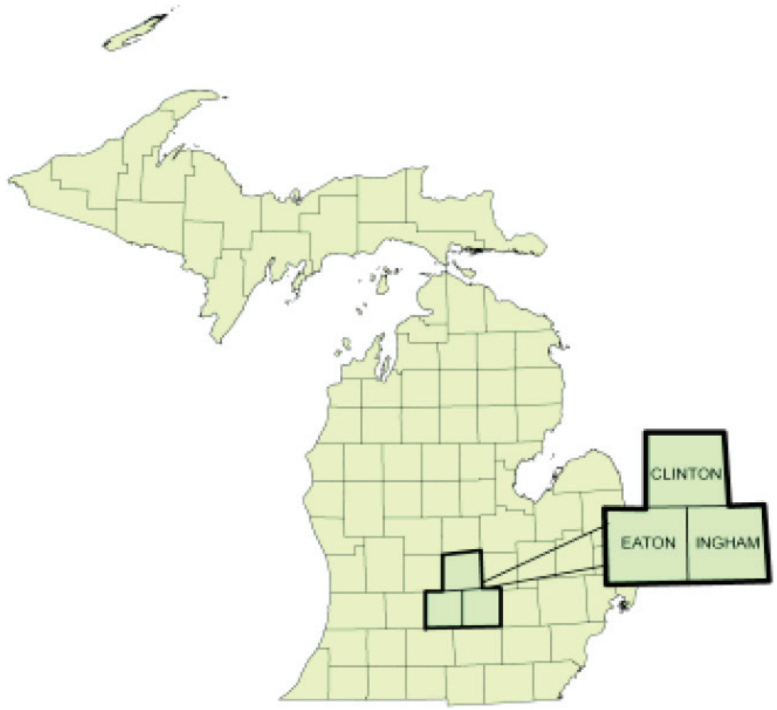


Source: Power of We. *Indicators of Community Well-Being.* Retrieved November 29, 2007, from http://www.powerofwe.org/indicators.htm

2.2 Regional History and Local Government

Figure 2-2

The Lansing Tri-County Region



Source: MSU Center for Community & Economic Development.

Mid-Michigan was settled by Europeans in the 1820's and native peoples had lived in the region for many hundreds of years prior to that. In 1847, the state legislature chose this central location for the new state capital and named Lansing Township (now the City of Lansing) as its home. The area was sparsely populated and heavily forested with extensive wetlands. In 1855, the state Legislature established the Michigan Agricultural College located in what would become East Lansing. Seven years later, passage of the Morrill Act established the nation's land grant system "to provide colleges for the benefit of agriculture and the Mechanic arts" as well as the liberal arts based, in part, on the model of Michigan Agriculture College.

Following its designation as state capital, Lansing and the area underwent industrial development that came with railroads and then the automotive industry in 1897 which, though transformed, continues today. The state agricultural college evolved and became Michigan State University in 1955, now one of the largest public higher education and research institutions in the world.

The region includes a mix of rural, urban and suburban development and encompasses 78 units of government, including 27 cities and villages, 48 townships, and the three counties. The City of Lansing with a population of approximately 118,000 in 2006 is the region's cultural and economic center.

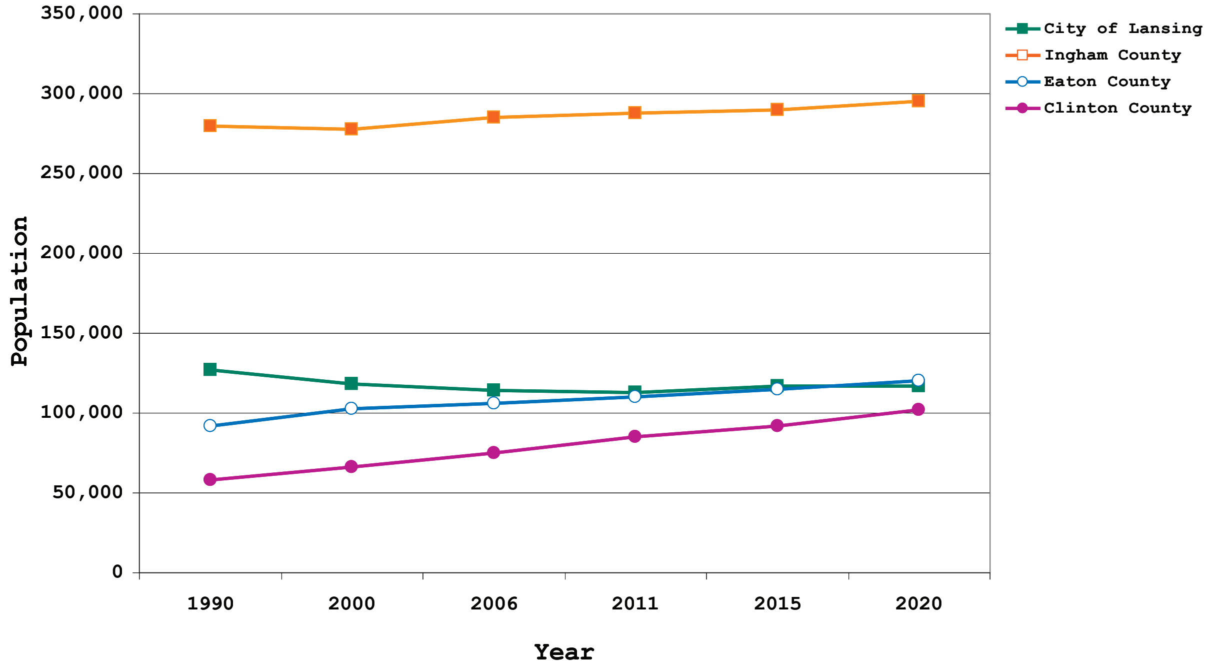
2.3 Regional Population and Selected Demographic Data

Like many areas in the Midwest, the Tri-County Region has experienced sluggish population growth in recent decades. However, unlike many other communities, the Tri-County Region is expected to experience modest population gains through the year 2020. While Ingham County will remain the region's most populous county, Clinton County is projected to experience the largest increase in population growth. The City of Lansing, currently experiencing a population decline, is expected to level off by 2020.

Figure 2-3

Lansing and Tri-County Population

1990-2020



Source: Lansing Community Profile and Pattern Book Practicum Team. [ESRI]. Unpublished raw data.

The region has experienced a slower population growth rate than the state, although the difference is expected to narrow in the next few years.

Figure 2-4

Comparison of Growth Rates in Region

1990, 2000, 2006, and 2011

	Year				Compound Annual Growth Rate (CAGR)		
Location	**1990**	**2000**	**2006**	**2011**	**1990 - 2000**	**2000-2006**	**2006 - 2011**
City of Lansing	127,321	119,128	118,296	118,888	-0.70%	-0.10%	0.10%
Ingham County	281,912	279,320	285,310	288,669	-0.10%	0.40%	0.20%
Eaton County	92,879	103,655	109,471	114,239	1.10%	0.90%	0.90%
Clinton County	57,883	64,753	75,072	84,006	1.10%	2.50%	2.30%
State of Michigan	9,295,297	9,938,444	10,317,569	10,605,939	0.70%	0.60%	0.60%

Source: Lansing Community Profile and Pattern Book Practicum Team. [ESRI]. Unpublished raw data.

2.3.1 Education

As might be expected with the presence of multiple higher education institutions, the region has a generally well-educated population over the age of 25. In Lansing, 13% of the adult population has bachelor's degrees compared to 13.7% for the state and 16.9% for the Tri-County Region. The region also has an above average number of post-graduates over 25 years old at 11.5% compared to the state average of approximately 8%. Over half of the Lansing population has some college education (some college years, bachelor's degree, master's degree, or doctoral degree), and approximately 60% for the region, higher than the state average of 52%, according to the U.S. Census Bureau.[25]

This educational level is an important attribute of success in the global economy.

2.3.2 Age

The median age for the Tri-County Region was 36.4 years in 2006. Projections of 33.2 and 32.6 years for Lansing and Ingham County in 2011 are over five years younger than the state median of 38.3 years. Clinton and Eaton counties are slightly above the state median at 40.5 and 39 years, respectively.

Figure 2-5

Comparison of Median Ages in Region

1990, 2000, 2006, 2011, 2015, and 2020

	Census		ESRI		Calculated using CAGR	
Location	**1990**	**2000**	**2006**	**2011**	**2015**	**2020**
City of Lansing	30.0	31.4	32.4	33.2	33.9	34.7
Ingham County	28.4	30.4	31.7	32.6	33.3	34.3
Eaton County	32.9	36.4	38.3	39.0	39.6	40.3
Clinton County	32.3	36.6	39.1	40.5	41.7	43.1
State of Michigan	32.6	35.5	37.2	38.3	39.2	40.4

Source: United States Census Bureau and ESRI, Inc.

2.3.3 Race and Ethnicity

The Tri-County Region is becoming increasingly diverse. About 60% of the city of Lansing's population was white/ Caucasian with 20% Black/African-American and 9.1% Hispanic in 2006 (see Figure 2-6). Diversity declines outside the city of Lansing. The white populations of Ingham County and the state constitute 75.1% and 77.6% while Eaton and Clinton Counties' white populations are 87.4% and 93%, respectively. The region is projected to become more diverse by 2011 as shown in Figure 2-7.

Figure 2-6

Comparison of Ethnicities in Region

2006

Race	City of Lansing	Ingham County	Eaton County	Clinton County	Michigan
White/ Caucasian	59.40%	75.10%	87.40%	93.90%	77.60%
Black/ African American	19.90%	10.30%	5.10%	0.60%	13.80%
American Indian/ Aleut	0.70%	0.50%	0.40%	0.40%	0.60%
Asian	2.60%	3.50%	1.10%	0.50%	1.70%
Other Race	4.10%	2.30%	1.10%	0.80%	1.30%
Two or More Races	4.20%	2.80%	1.60%	1.10%	1.90%
Hispanic	9.10%	5.50%	3.10%	2.50%	3.20%

Source: United States Census Bureau and ESRI, Inc.

Figure 2-7

Comparison of Ethnicities in Region

2011

Race	City of Lansing	Ingham County	Eaton County	Clinton County	Michigan
White/ Caucasian	52.20%	69.00%	84.00%	91.90%	78.20%
Black/ African American	21.40%	11.30%	5.80%	0.70%	13.40%
American Indian/ Aleut	0.70%	0.50%	0.40%	0.40%	0.60%
Asian	4.30%	5.90%	2.00%	0.90%	1.70%
Other Race	5.20%	2.90%	1.50%	1.10%	1.20%
Two or More Races	4.80%	3.30%	2.00%	1.40%	1.80%
Hispanic	11.30%	7.10%	4.20%	3.50%	3.10%

Source: United States Census Bureau and ESRI, Inc.

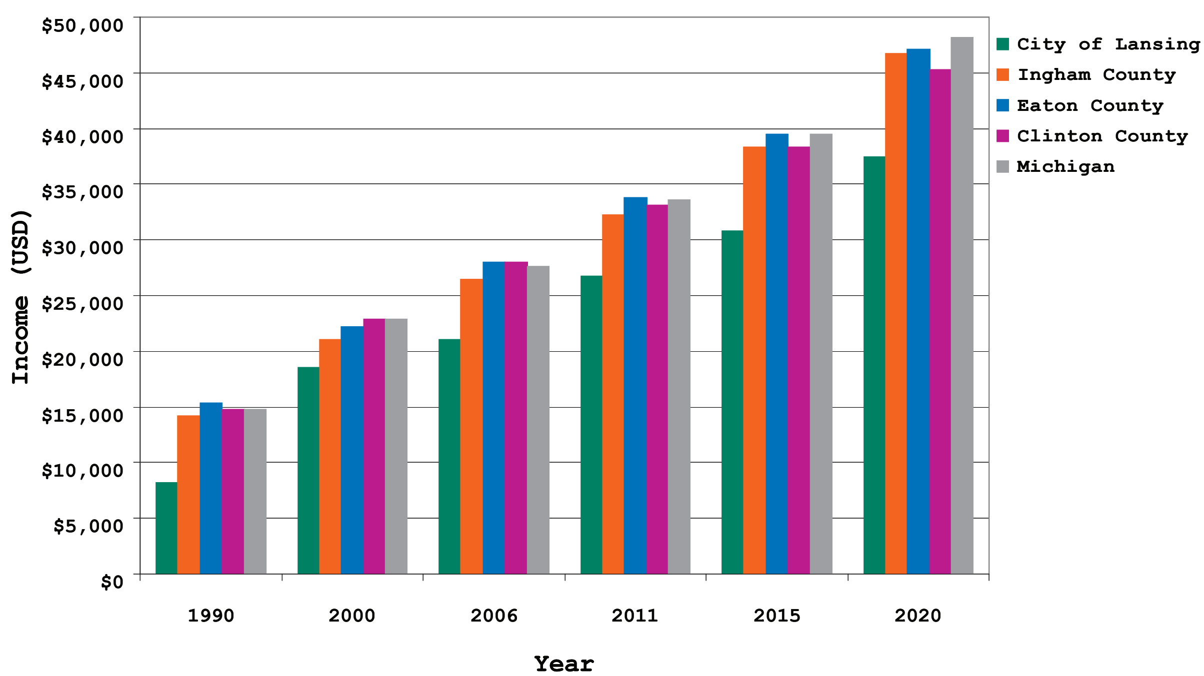
2.3.4 Income

The region's per capita and household incomes are comparable to the state averages, and allow many residents to afford an attractive quality of life. Information was obtained from a Michigan State University 2007 student practicum report, the U.S. Census Bureau, the city of Lansing and ESRI, Inc. focusing primarily on 1990 and 2000. Forecasts for 2006 and 2011 were obtained from ESRI Data Business Analyst, using a Compound Annual Growth Rate (CAGR) formula. These projections provide a near-future glimpse of socio-economic trends for the city of Lansing and Ingham, Eaton and Clinton counties as well as state demographic variables.

Figure 2-8

Comparison of Per Capita Incomes in Region

1990, 2000, 2006, 2011, 2015, and 2020



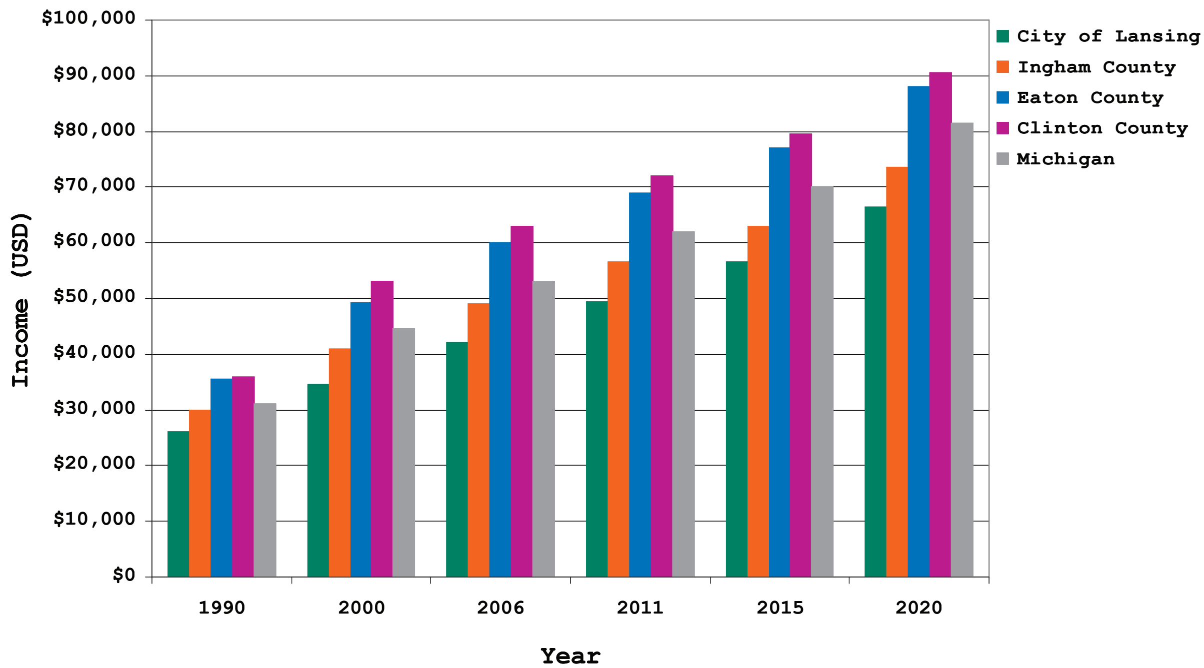
Source: United States Census Bureau, City of Lansing, and ESRI, Inc.

Figure 2-9 compares median household income for the Tri-County Region. In 2000, the city of Lansing median household income was $34,833, lower than that of Ingham County at $40,807, Eaton County at $49,589, Clinton County at $53,066 and the state at $44,683. By 2020, Lansing's median household income is projected to increase to $66,502 compared to $81,368 for the state.[26]

Figure 2-9

Comparison of Median Household Incomes in Region

1990, 2000, 2006, 2011, 2015, and 2020



Source: United States Census Bureau, City of Lansing, and ESRI, Inc.

2.4 Major Employers in the Regional Economy

The Tri-County Region has a relatively diversified employment base. State government is the region's single largest employer, employing more than 14,000 people. Michigan State University employs approximately 4,800 faculty and academic staff and an additional 6,100 support staff. Lansing Community College employs approximately 3,000 faculty and support staff. The Lansing Tri-County Region clearly has the intellectual infrastructure and capacity to be a major player in the development of the state's knowledge-based bioeconomy.

Figure 2-10

Major Regional Employers

2006

Employer	Sector	# of Employees
State of Michigan	Government	14,355
Michigan State University	Higher Education	10,500
General Motors	Automobiles	6,300
Sparrow Health System	Health Care	6,000
Lansing Community College	Higher Education	3,180
Ingham Regional Medical Center	Health Care	2,500
Lansing School District	Higher Education	2,106
Meijer	Warehousing, Groceries	2,000
Auto Owners Insurance	Insurance	1,500
Peckham, Inc.	Rehab & Manufacturing	1,400

Source: Lansing Regional Chamber of Commerce.

Automotive manufacturing employs approximately 6,300 workers at two General Motors facilities (2006). Recent GM investments in new manufacturing plants, including the 2006 opening of the cutting-edge Lansing Delta Township Car Assembly plant, suggest a continuing automotive manufacturing presence for years to come. The Delta facility is the most environmentally-friendly manufacturing facility in the world and the first automotive plant to earn a Leadership in Energy and Environmental Design (LEED) “gold” certification. In addition to green building standards and additional acreage set aside for wildlife habitat, this facility houses 700 robots and robotic welding applicators to enhance worker productivity. The Grand River Assembly facility located in downtown Lansing also uses state-of-the-art assembly methods in the manufacture of three Cadillac models.[27]

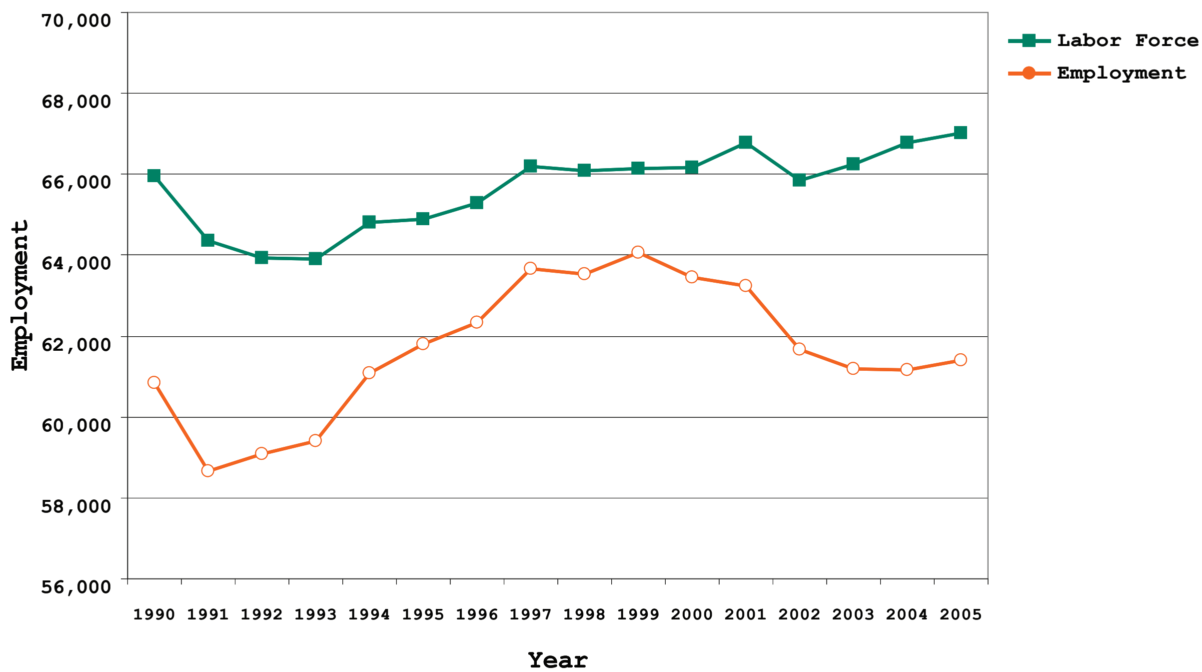
2.4.1 Regional Labor Force and Employment

The Tri-County Region’s labor force increased 1.6% from 1990 to 2005 (Figure 2-11), and the city of Lansing’s increased 1%. However, the city’s unemployment rate increased by from 7.7% to 8.4% for the same period. Lansing’s unemployment rate was higher than the rates of the surrounding counties (Figure 2-12). The state unemployment rate was higher than the city’s until 2000 when Lansing’s unemployment rate surpassed the state rate.

Figure 2-11

City of Lansing Labor Force and Employment Trends

1990 to 2005



Source: United States Bureau of Labor Statistics.

Figure 2-12

Comparison of Unemployment Rates in Region

1990 to 2005

Year	City of Lansing (%)	Ingham County (%)	Clinton County (%)	Eaton County (%)	Tri-County Average (%)	State of Michigan (%)
1990	7.7	6.2	6.4	5.9	6.2	7.7
1991	8.8	7.0	7.6	7.1	7.2	9.3
1992	7.6	6.0	5.8	5.6	5.8	9.2
1993	7.0	5.6	5.6	5.4	5.5	7.4
1994	5.8	4.6	4.1	3.8	4.2	6.2
1995	4.8	3.8	3.4	3.3	3.5	5.3
1996	4.5	3.6	3.3	3.1	3.3	4.9
1997	3.8	3.0	2.6	2.5	2.7	4.3
1998	3.9	3.0	2.9	2.8	2.9	4.0
1999	3.1	2.5	2.0	2.1	2.2	3.8
2000	4.1	3.0	2.6	2.8	2.8	3.7
2001	5.3	3.9	3.3	3.6	3.6	5.2
2002	6.3	4.7	3.9	4.1	4.2	6.2
2003	7.7	5.6	4.6	4.8	5.0	7.1
2004	8.4	6.2	5.1	5.3	5.5	7.0
2005	8.4	6.2	5.0	5.3	5.5	6.8

Source: United States Bureau of Economic Analysis.

Data in the Metropolitan Statistical Area (MSA) shows a decrease in the unemployment rate as reported by the Lansing Regional Chamber of Commerce. As the unemployment rate is for October 2007, it includes seasonal variations resulting from summer reductions in student and support staff employed by the public colleges and universities.

Figure 2-13

Regional Labor Force and Unemployment Rates

October 2007

	Clinton County	Eaton County	Ingham County	Lansing MSA
Total Labor Force	37,772	59,030	153,257	250,059
Employment	35,778	56,206	144,451	236,435
Unemployment	1,944	2,824	8,806	13,574
Unemployment Rate	5.2%	4.8%	5.7%	5.2%

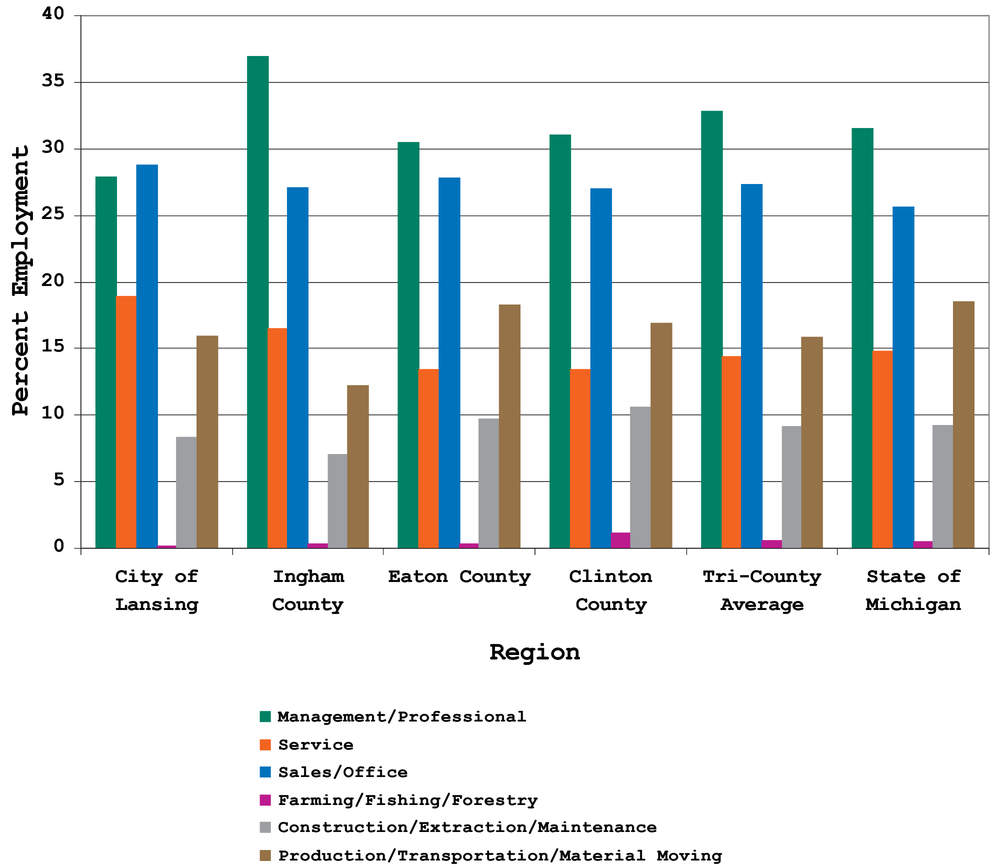
Source: Michigan Department of Labor & Economic Growth, Office of Labor Market Information. Retrieved October, 2007, from http://www.milmi.org/

2.4.2 Regional Employment by Occupation

The largest occupation sectors in the region are management/professional and sales/office, according to the 2000 Census. The construction and production sectors are also significant employers and comparable to the state average (see Figure 2-14 below).

Figure 2-14

Regional Comparison of Employment by Occupation



Source: Lansing Regional Chamber of Commerce.

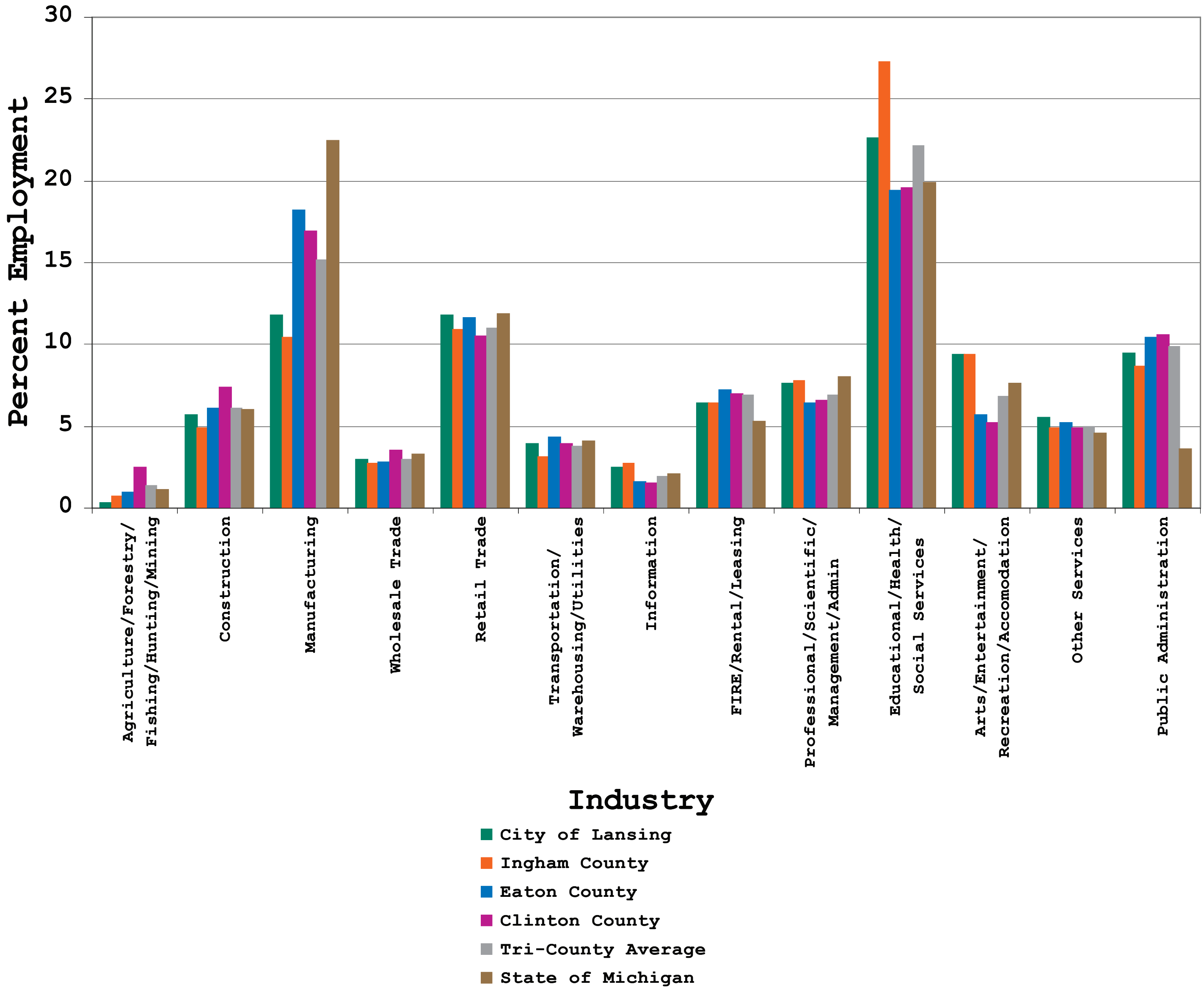
2.4.3 Regional Employment by Industry

Industries with significant categories of employment were also examined. Analysis suggests a potential critical mass or a competitive "cluster" with the highest employment in the educational, health and social services sectors. The manufacturing sector is the second largest. A bio-manufacturing sector relying on an educated, skilled workforce engaged in modern manufacturing processes would find a supportive labor environment in these employment clusters.

Figure 2-15

Regional Comparison of Employment by Industry

2000



Source: United States Census Bureau.

Natural resources and construction are two sectors that have experienced slight employment increases from 2005 to 2006. Information and manufacturing sectors have experienced the highest percentage decreases in employment for the same period, suggesting the availability of a skilled manufacturing workforce to support development of a bio-based economic sector. Figure 2-16 shows employment by sector for 2005 and 2006 as reported by the Lansing Regional Chamber of Commerce.

Figure 2-16

Lansing Region Comparison of Employment by Sector

2005 and 2006

Employment Sector	April 2005	April 2006	% Change
Total Non-farm Jobs	231,000	230,400	-0.26%
Nat Resources & Construction	8,400	8,700	3.45%
Manufacturing	22,700	21,600	-5.09%
Trade, Transport & Utilities	36,300	36,500	0.55%
Wholesale Trade	5,600	5,800	3.45%
Retail Trade	24,500	24,500	0.00%
Information	3,200	3,000	-6.67%
Financial Activities	15,300	15,500	1.29%
Professional & Business Service	20,800	20,400	-1.96%
Educational & Health Service	27,100	27,400	1.09%
Leisure & Hospitality	19,500	19,700	1.02%
Other Services	11,100	10,900	-1.83%
Government	66,600	66,700	0.15%

Source: Lansing Regional Chamber of Commerce.

The computer & mathematical sector is expected to experience the greatest employment increase, based on Lansing Regional Chamber of Commerce employment projections for 2012 (Figure 2-17). Employment in the farming and production sectors is expected to decline slightly.

The 2012 occupational forecast shows an increase of just over 24,000 jobs (see Figure 2-17). The greatest job growth is predicted for business and financial operations, education/training/library, food preparation and serving, and sales. Fishing and forestry employment is expected to decline, suggesting the availability of those workers for the bio-manufacturing sector.

Figure 2-17

Occupational Employment Forecast
Lansing-East Lansing MSA
2002 and 2012

	Employment		Change		Annual Average Openings		
Occupation Group	**2002**	**2012**	**#**	**%**	**Total**	**Growth**	**Replacement**
Total, All Occupations	245,045	269,240	24,195	9.9	8,232	2,419	5,813
Management	11,455	13,005	1,550	13.5	361	155	206
Business & Financial Operations	11,615	13,705	2,090	**18.0**	410	209	201
Computer & Mathematical	5,030	6,425	1,395	**27.7**	209	139	69
Architecture & Engineering	3,515	3,960	445	12.6	123	44	78
Life, Physical & Social Science	3,180	3,480	300	9.4	104	30	74
Community & Social Services	6,355	6,610	255	4	141	25	116
Legal	2,285	2,380	95	4.2	37	10	28
Education/Training/Library	22,400	26,365	3,965	**17.7**	870	397	473
Arts/Design/Entertain/Sports/Media	3,885	4,525	640	16.6	135	64	70
Healthcare Practitioners/Technical	11,275	13,010	1,735	15.4	388	173	214
Healthcare Support	5,285	6,395	1,110	**21.1**	199	111	87
Protective Service	4,185	4,520	335	8	166	33	132
Food Preparation & Serving Related	18,910	21,125	2,215	11.7	971	222	750
Building/Grounds Cleaning/Maintenance	7,520	8,770	1,250	16.7	275	125	149
Personal Care & Service	5,195	6,250	1,055	**20.3**	232	105	127
Sales and Related	23,980	26,605	2,625	10.9	1,058	262	796
Office & Administrative Support	44,620	44,610	-10	0	993	0	993
Farming, Fishing, & Forestry	950	935	-15	**-1.3**	25	0	25
Construction & Extraction	10,150	11,440	1,290	12.7	320	129	191
Installation, Maintenance, & Repair	8,075	8,895	820	10.2	265	82	183
Production	19,775	19,200	-575	**-2.9**	480	0	480
Transportation & Material Moving	15,410	17,030	1,620	10.5	532	162	369

Source: Michigan Department of Labor & Economic Growth, Office of Labor Market Information. (2005).

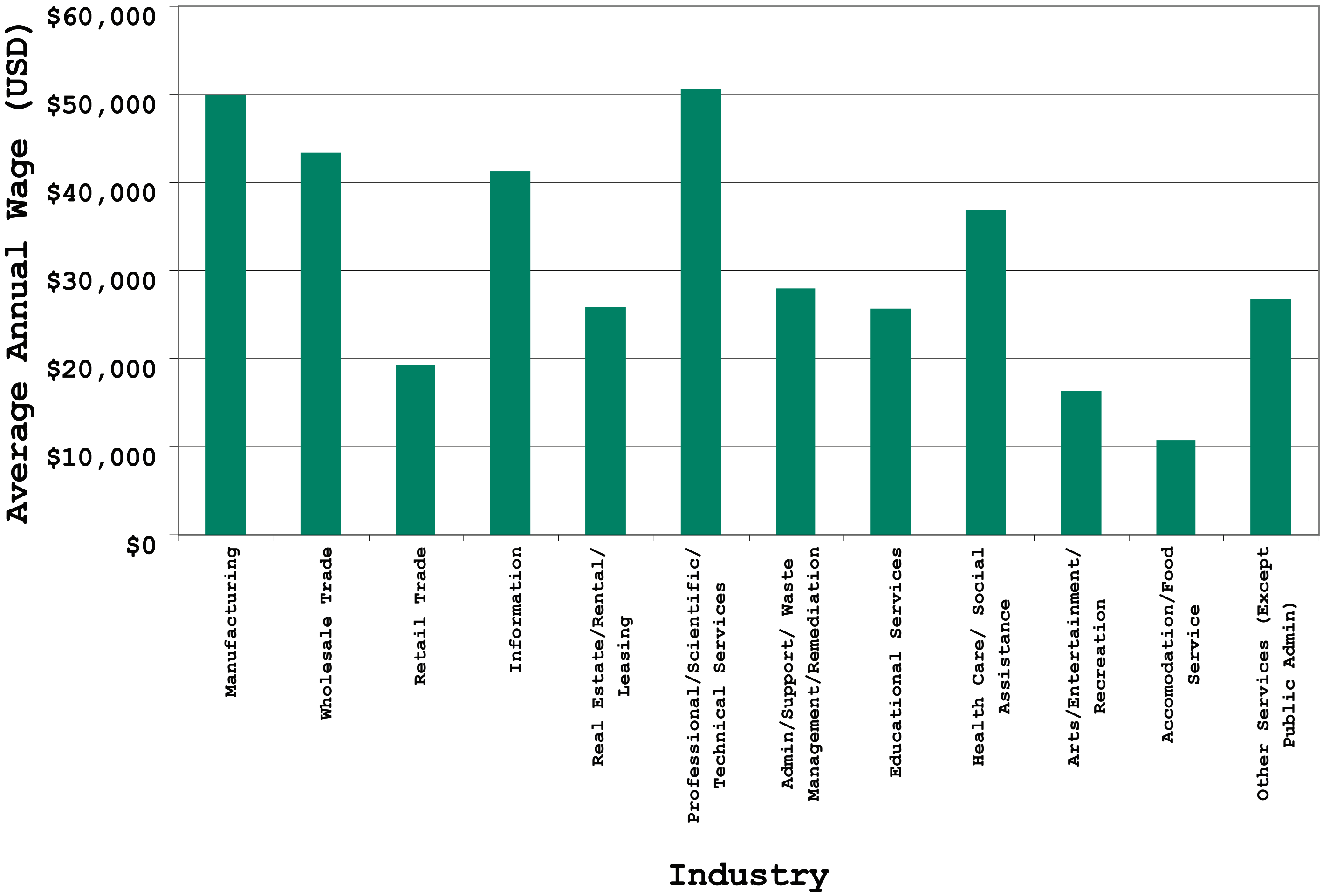
2.4.4 Wages and Establishments

The Tri-County Region has a relatively high average annual wage across selected key industries. Professional, scientific & technical services, and manufacturing sectors have the highest average annual wages for 2005 at $50,000.

Figure 2-18

Average Tri-County Region Annual Wages

2005

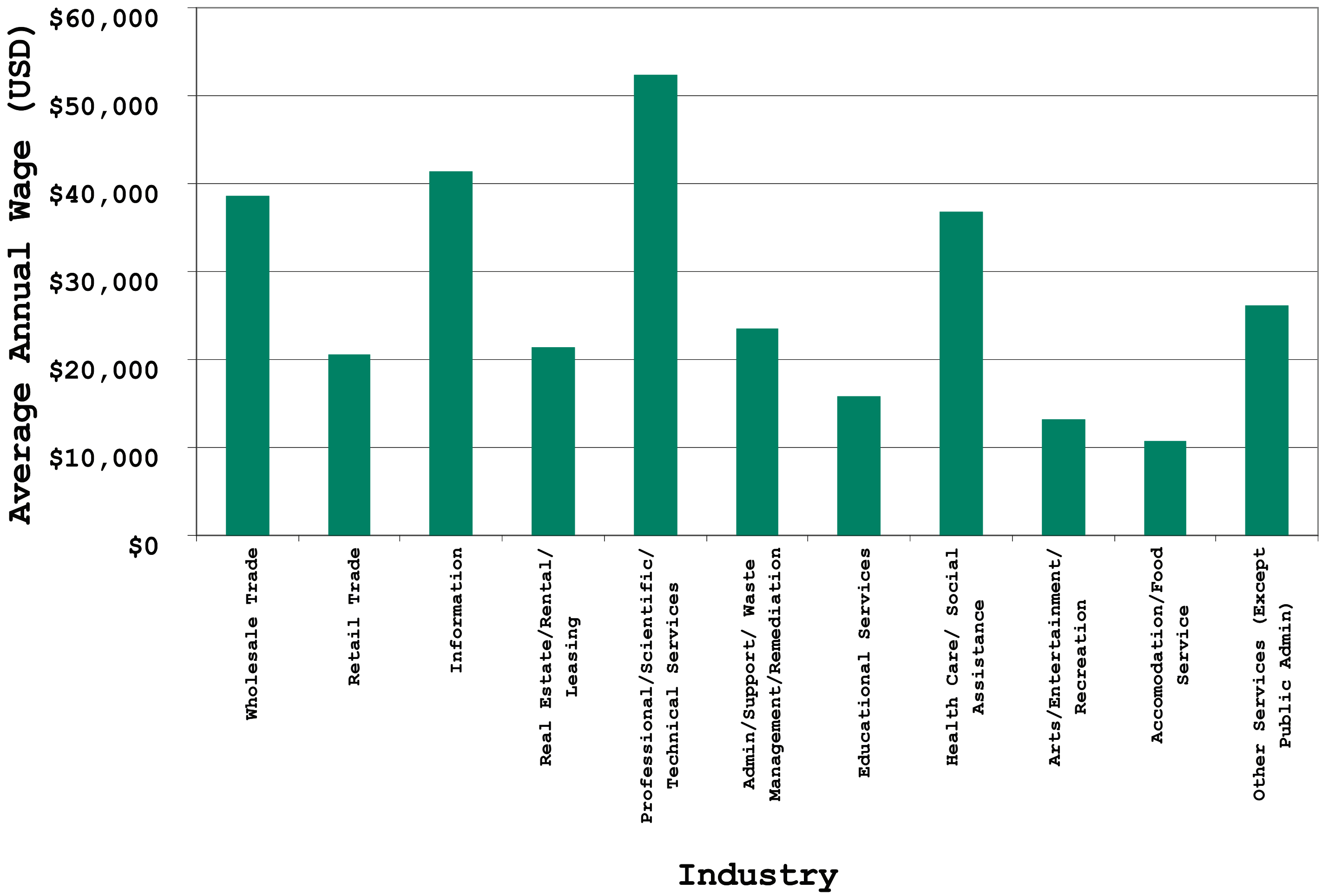


Source: United States Census Bureau. (2005). *Metropolitan Business Patterns*.

Wages in retail trade, arts, entertainment, & recreation and accommodation & food services are all under $20,000 in the region with the lowest wages in accommodation and food services (Figure 2-18 above).

Figure 2-19

Average City of Lansing Annual Wages
2002



Source: United States Census Bureau. (2002). *2002 Economic Census.*

2.4.5 High-Skill, High-Wage, High-Growth Jobs in the Region

An important factor in assessing economic conditions is the quality of jobs. Regions with a high 'concentration' of high-skill, high-wage, and high-growth occupations are better positioned to compete in the new global knowledge economy.

Recent declines in manufacturing further emphasize the need for growth occupations to to sustain regional economic prosperity. To measure concentration of high skill, high wage, high growth (H3) jobs, Bureau of Labor Statistics (BLS) data for "High Wage-High Growth Occupations" was obtained and then filtered to those requiring an associates degree or higher.

For 2005, 12.7 percent of the Lansing region's workforce were employed in H3 occupations lagging behind the state at 13% and the U.S at 14.4% (as shown in Figure 2-20). Falling behind the state and nation in its percentage of high skill, high wage, and high growth jobs, the region runs the risk of missing out on future participation and prosperity in the knowledge economy.

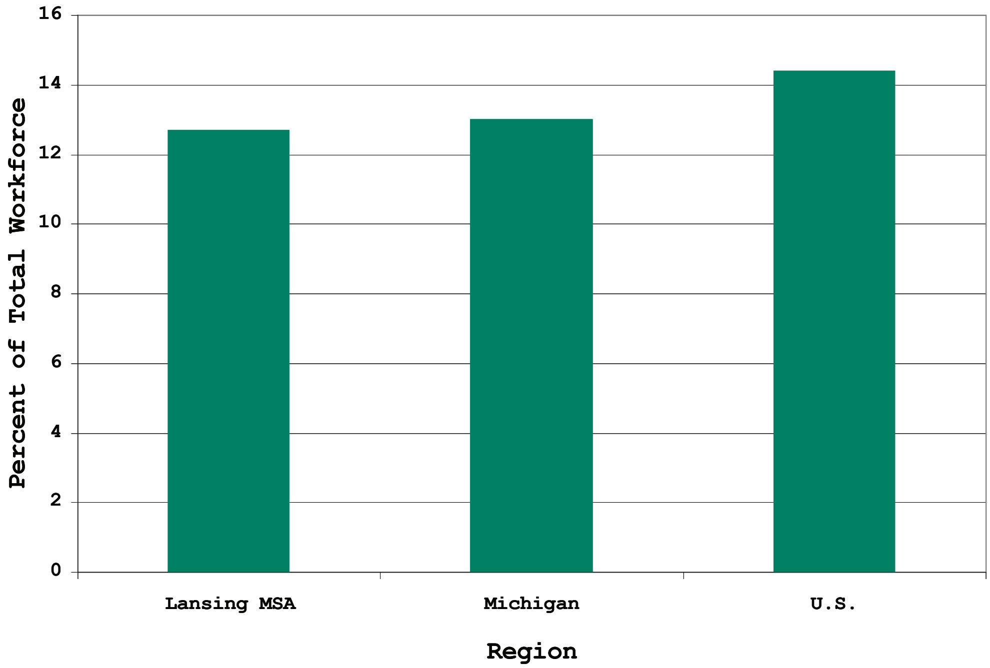
It is also important to assess the change of H3 jobs in the region over time. Lansing has experienced a decline in H3 jobs from the 1999 level of 13.4% to a low of 12% in 2003. H3 jobs increased to 12.7% in 2005, but were still below the 1999 percentage. This suggests that Lansing faces challenges in developing and attracting H3 jobs with a potential impact on other economic sectors. Higher levels of H3 workers tend to generate spin-off jobs in the retail and other service sectors.

Figure 2-20

High Skill, High Wage, High Growth Jobs

Lansing MSA, Michigan, and U.S.

2005



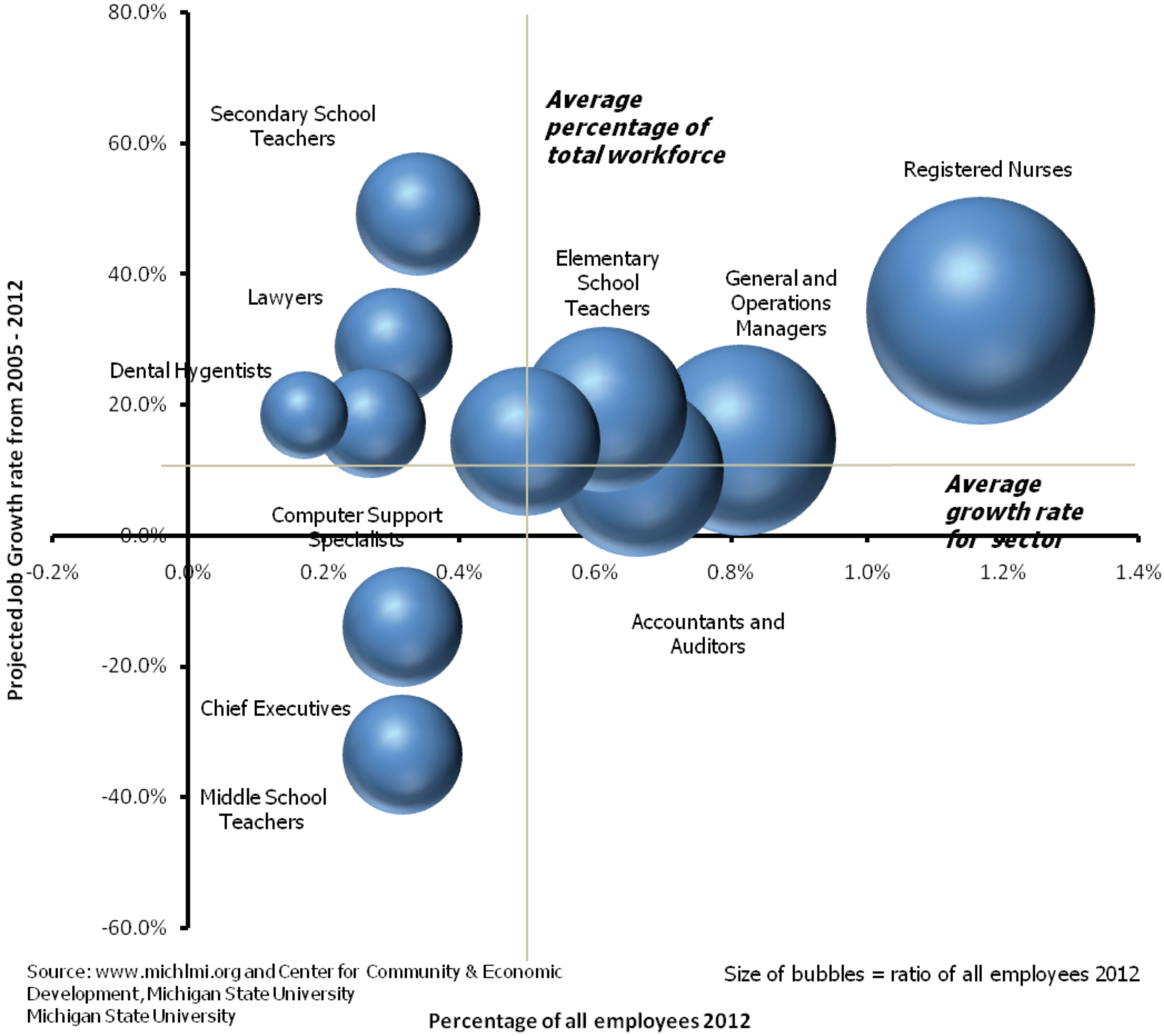
Source: Michigan State University, Urban and Regional Planning Program. (2007, April). *Planning Practicum Project*.

This analysis gives reason for pause in terms of the future economic prospects of the region because many of these H3 occupations are in traditional sectors such as education, law and accounting. The only 'high-tech' H3 job sector expected to experience average growth and retain its share of total workforce is that of computer support specialists. In addition, high-tech occupational sector computer support specialists are expected to see average growth and remain a small share of total employment. This suggests that while certain high-tech sectors are strong in the Lansing region, greater effort is needed to develop and attract high-tech, knowledge economy jobs and workers to strengthen this critical occupational sector in Lansing and the region.

On the up side, the IT industry is particularly strong in the region. Between 1998 and 2004, this sector grew by 20 percent and now accounts for over 300 companies employing 9,500 in the Lansing region. Further growth in many IT-related occupations is projected to continue through 2012, with a potential of nearly 25,000 new high-tech IT jobs. This high-skilled, high-wage job growth potential will further the region's effort at economic diversification and effective positioning in the global knowledge economy.[28]

Figure 2-21 below shows the top ten high-skill, high-wage, high-growth occupations in the Lansing area and the projected rates of increase or decline as well as percentage of total workforce; the larger the bubble, the larger the share of the total workforce. Of the current top H3 jobs, registered nurses will see a 1.2% increase in share of total regional workforce as well as a 34% occupational growth rate. Secondary school teachers will experience the largest percentage of growth, but will lose its percentage share of total workforce as other newly-emerging occupational sectors expand their share of the region's workforce.

Figure 2-21
Selected H3 Job Sector Growth
Lansing MSA
2005 to 2012



2.5 Section Summary

The Tri-County regional demographic and employment profile suggests a moderately well off community that is in transition. While enjoying a relatively diverse economic base, employment is shifting away from manufacturing and moving into knowledge-based sectors. Skilled workers, then, would be available for employment in emerging knowledge-based sectors of the bioeconomy needing a skilled work force.

3. Tri-County Region Agriculture/Natural Resources/Environment Profile

3.1 Introduction

The bio-manufacturing sector of the bioeconomy relies on the availability of bio-based materials to provide consistent supplies of feedstocks for production processes. Quantity, quality, diversity and availability of these bio-materials affect the scope and extent of the potential development of a bio-manufacturing cluster in the region. This section examines the types and volumes of agriculture and natural resource products currently harvested or growing in the Tri-County Region.

Most bio-manufacturing experience at this point is associated with corn-based ethanol production. The production of commercial ethanol fuel currently relies on corn feedstocks and biodiesel production relies on soybean feedstocks. The use of food crops for manufacturing feedstocks impacts consumer food costs as aggregate demand for these food crops increases. Corn stover (stalks, corn cobs, leaves) and switch grass represent potential alternative sources of agricultural nonfood feedstocks. This use of nonfood feedstocks could augment the value of existing crops by using what was previously regarded as agricultural waste byproducts in economically productive ways.

Alternative bio-based inputs like agricultural waste or cellulosic materials from various wood waste sources could provide inputs for ethanol or other bio-manufacturing production. Current state and federal agricultural information systems do not provide direct assessments of the quantities of these non-food materials. For the immediate purposes of this study, estimates of overall food and non-food feedstock production are based on 2007 crop categories and values as compiled by the Michigan office of the National Agriculture Statistics Service (NASS).

Cellulosic resources such as switch grass and woody materials show great promise as non-food feedstock. Municipal solid waste represents another potential source of cellulosic biofeedstocks. Cellulose can be extracted from switch grass and woody materials (e.g., forest harvest residues, paper and saw mill waste, urban wood waste) and processed by biorefineries.

Other feedstocks for higher value-added bio-products like PLA, a bioplastic polymer, include sugar beet residues and soy.[29]

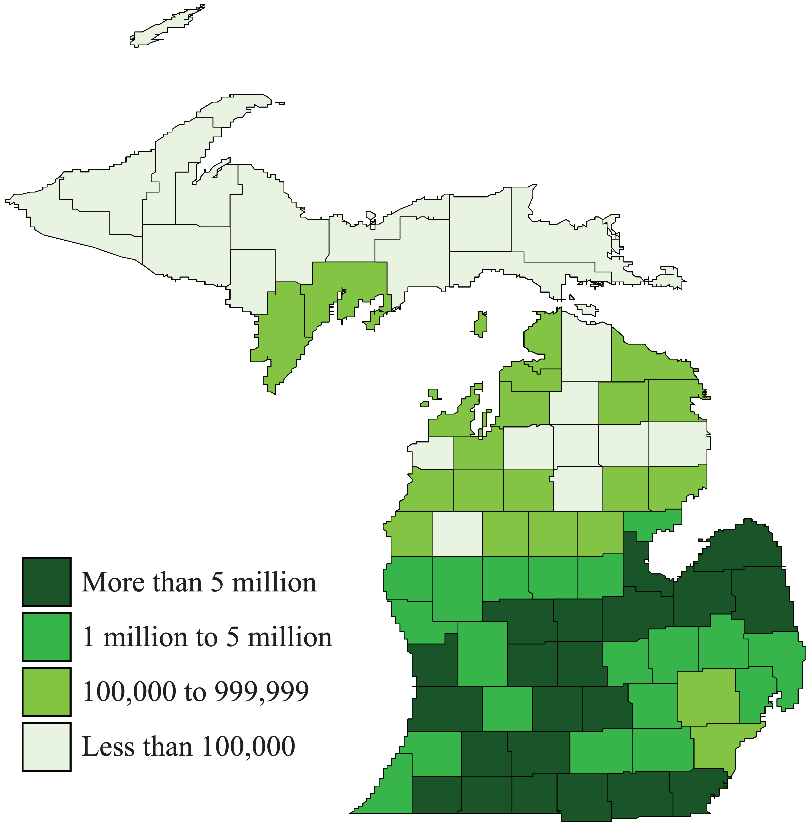
The quality of agricultural products is another important consideration in the bio-manufacturing sector. A principal characteristic of bio-based materials is its variability. Anyone who has gardened knows the quality of produce varies from season to season, depending on weather patterns and other factors. Mid-Michigan's temperate weather with generally reliable and fairly predictable levels of sun and rainfall compares favorably to other parts of the U.S. The moderate climate tends to minimize crop variation and would result in less variability in the quality of potential bio-manufacturing inputs. However, the length of the growing season is relatively shorter compared to states like neighboring Indiana, Ohio, and more distant states like North Carolina, South Carolina, and Georgia.

Bio-manufacturing process technologies using cellulosic (non-food) bio-materials as production feedstocks are in various stages of development (see Section 4.2 for discussion of bio-manufacturing technologies under development).

3.2 Regional Corn Production and Potential Corn Stover Supply

Corn is currently the major bio-manufacturing feedstock in the United States. Field corn accounts for more than 90 percent of biomass feedstocks in the country.[30]

Figure 3-1
Corn Yield
(in Bushels)
2007



Source: United States Department of Agriculture National Agricultural Statistics Service. (2007). Retrieved August 1, 2008, from http://www.nass.usda.gov/Statistics_by_State/Michigan/Publications/County_Estimates/index.asp

Ingham, Clinton, and Eaton Counties are major corn producers compared to other Michigan counties. In 2007, Clinton County corn yield was 8.9 million bushels with Eaton and Ingham yields of over 8.3 million and 6.6 million bushels of corn, respectively. Each county is well above the state's county corn yield average of 2.9 million bushels.[31]

Corn stover, the residue left after the corn is harvested, provides an opportunity to use biomaterials that are currently underutilized. Corn stover consists of 50% stalks, 22% leaves, 15% cob, and 13% husk. Moreover, using stover does not require using additional land, an important benefit in finding the right balance in the use of renewable natural resources to produce non-petroleum-based energy or bio-products. Harvesting stover may also encourage no-till cultivation. This would result in reducing the amount of CO2 generated from the decomposition of stover residue on the soil and further reduce soil erosion (by not tilling).[32]

Corn tonnage is calculated based on the assumption that there are 56 lbs per bushel of corn.[33] County yield estimates are based on current National Agriculture Statistics Service (NASS) data. It is further assumed that one ton of harvested corn produces one ton of corn stover, and that a 50% stover recovery rate allows sufficient residue to remain and prevent soil erosion and excessive loss of nutrients.[34]

The region has considerable potential as a supplier of corn stover that is in close proximity to potential industrial facility sites. Transportation costs would be constrained and less CO2 contributions from long-distance hauling would result.

Figure 3-2

Tri-County Region Corn Harvest Yield and Potential Corn Stover Supply

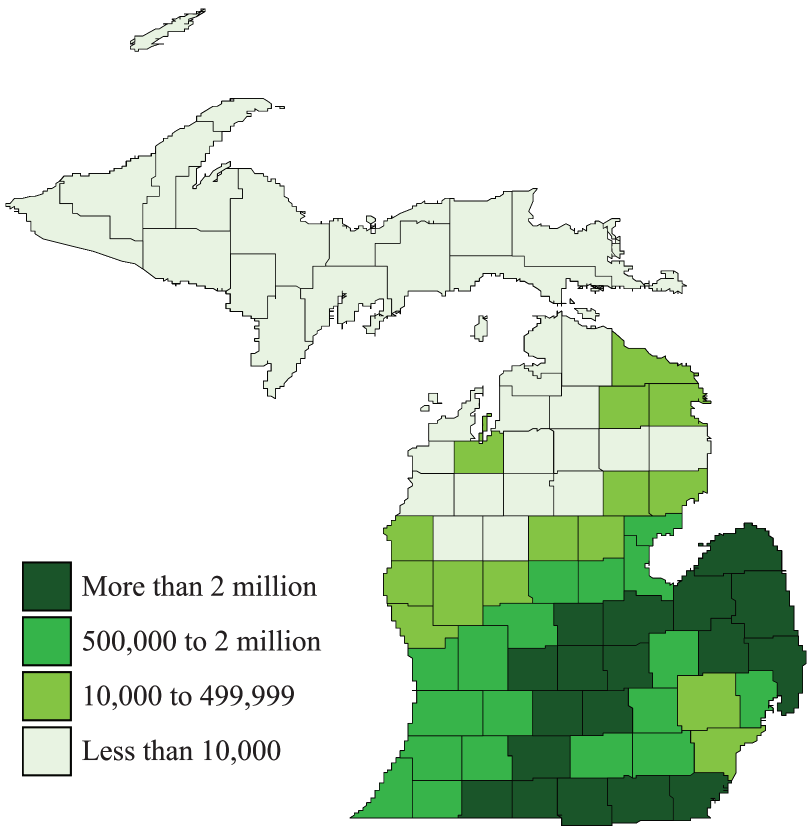
	Corn			Stover	
County	**Acres Harvested**	**in Bushels**	**in Tons**	**in Tons**	**50% recovery**
Clinton	72,000	8,990,000	251,720	251,720	125,360
Eaton	67,400	8,290,000	232,120	232,120	116,070
Ingham	54,900	6,560,000	183,680	183,680	91,480
Regional Total	**194,300**	**23,840,000**	**667,520**	**667,520**	**332,260**

Source: National Agriculture Statistics Service and Institute of Self-Reliance.

3.3 Regional Soybean Production

Figure 3-3

Soybean Yield
(in Bushels)
2007



Source: United States Department of Agriculture National Agricultural Statistics Service. (2007). Retrieved August 1, 2008, from http://www.nass.usda.gov/Statistics_by_State/Michigan/Publications/County_Estimates/index.asp

Figure 3-4

Soybean Production

2007

County	Bushels
Clinton	2,510,000
Eaton	2,420,000
Ingham	2,050,000
Regional Total	**6,980,000**

United States Department of Agriculture National Agricultural Statistics Service. (2007). Retrieved August 1, 2008, from http://www.nass.usda.gov/Statistics_by_State/Michigan/Publications/County_Estimates/index.asp

Ingham, Eaton, and Clinton counties are major soybean producers. This crop has become an important feedstock supply in the production of biodiesel fuel as well as other automotive applications, including bio-based seat cushions and vehicle tires. The region produced nearly 7 million bushels of soybeans in 2007.

3.4 Other Biomass Feedstock Supply Streams

Michigan has 19.3 million acres of forest, about half of the land in the state. Private landowners hold 12 million acres, the state 3.9 million, and federal lands account for 3 million acres. Michigan has the largest public state forest system in the country. The Michigan Department of Natural Resources Forest Management Division sells timber from state-owned lands with the five principal species including aspen, jack pine, upland hardwoods, oak, and red pine. Current MDNR calculations suggest that the northern Lower Peninsula has a surplus of 2.8 million cords, or 3.6 million tons.[35]

Forest cover in the immediate Tri-County Region is relatively negligible, about 10-15% of the land in the region (see Appendix K). However, fast-growing trees like poplars could be planted on marginal land to harvest as a biomass crop for feedstock supplies to different types of bio-manufacturing facilities. Moreover, aggressive outreach could be conducted with more forested counties north of the Tri-County Region to set up wood waste collection networks to obtain wood waste from forest harvest operations. Responsible residue management could provide biomass feedstock and contribute to forest health and proactive fire protection. Over 865,000 tons of mill waste is generated in the northern Lower Peninsula and 34.1 million ft^3 of harvest residue. Approximately 239,000 tons of mill waste and 7.5 million ft^3 of residue are also generated in the southern Lower Peninsula.[36] Most mill waste, however, is utilized in fiber production or boiler fuel, but using some quantity of harvest residue for biofeedstock is feasible.

Switchgrass and miscanthus are two energy crops that could also be grown to supply feedstocks for bio-manufacturing to produce power, liquid fuel, or bio-products. Switchgrass has received increasing consideration as a feedstock crop in the U.S. and miscanthus has been successfully grown in northern Europe.

Additional research is needed to better document the quantities of potential woody biomass feedstock supplies available for various types of bio-manufacturing in the region.

3.5 Water Resources

Availability of water is critical to the quality and quantity of bio-based material. Mid-Michigan experiences fairly reliable patterns of precipitation but global climate change affecting local weather patterns introduces new levels of uncertainty. Corn-based ethanol requires between 2,500 and 29,000 gallons of water per million per Btu of energy produced, primarily for crop irrigation; cellulosic crops require significantly less water.[37]

However, there are no studies clearly identifying water needs for cellulosic materials. In part, it is difficult to quantify how much water is needed for some cellulosic sources as they are waste by-products and water is not needed specifically to produce these byproduct sources, e.g., wood waste or corn stover. To date, there are no studies quantifying the amount of water needed for energy-dedicated crops like switch grass.

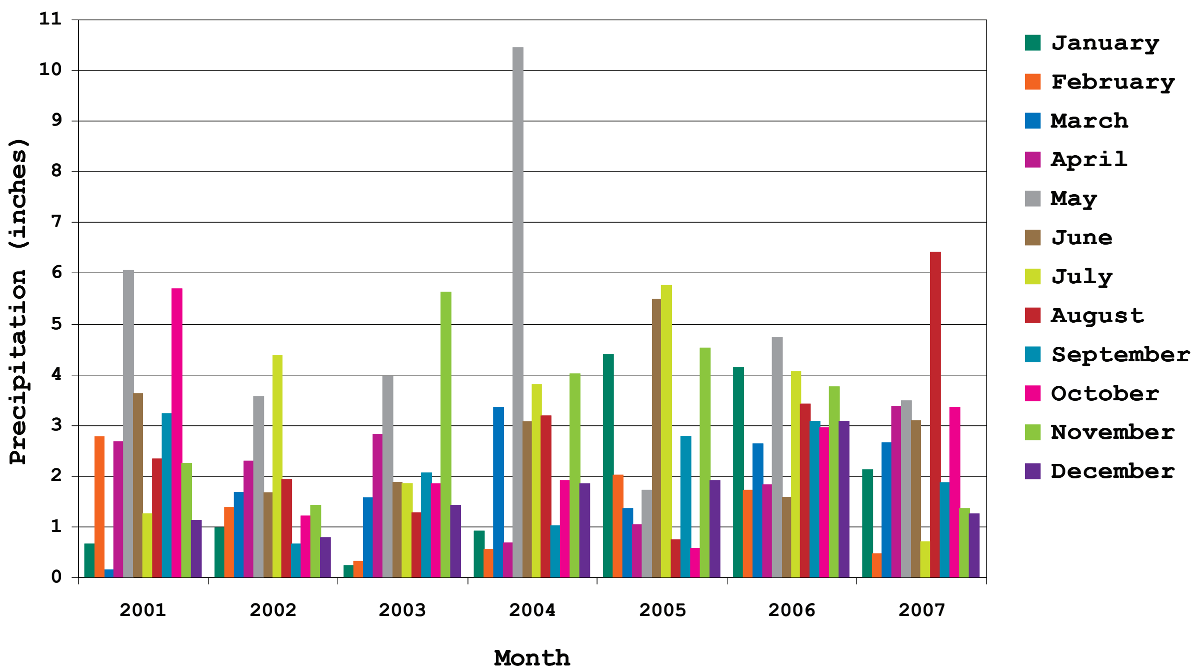
Water is essential to producing ethanol in grinding, liquefaction, and fermentation processes. The amount of water used in these processes has declined significantly as a result of technological improvements. Michigan has extensive water supplies from surface and ground water sources but some highly localized areas face serious supply constraints. The mid-Michigan region has generous supplies of groundwater and surface water. In a 2002 U.S.D.A. study of 21 ethanol plants (the Shapouri study), it was found that water use averaged 4.7 gallons per gallon of ethanol produced. Old ethanol plants had used more than 15 gallons of water per gallon of ethanol.[38] Minnesota ethanol plants report a range of 3.5-6.0 gallons of water consumed per gallon of ethanol produced. Average water use has declined from 5.8:1 in 1998 to 4.2:1 in 2005, according to the Minneapolis-based Institute for Agriculture and Trade Policy.[39]

Michigan region has generous supplies of groundwater and surface water. In a 2002 U.S.D.A. study of 21 ethanol plants (the Shapouri study), it was found that water use averaged 4.7 gallons per gallon of ethanol produced. Old ethanol plants had used more than 15 gallons of water per gallon of ethanol.

Figure 3-5

Monthly Lansing-Area Precipitation

2001-2007



Source: National Oceanic and Atmospheric Administration, National Weather Service.

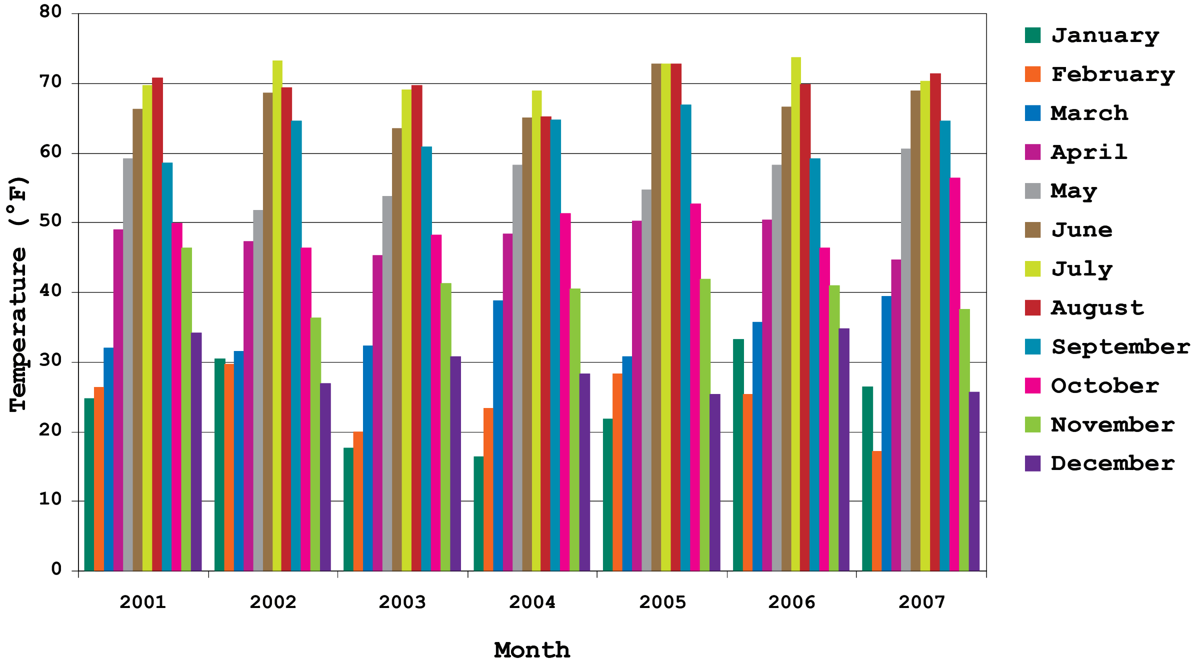
3.6 Regional Climate

Climate conditions in Michigan are more stable during the summer months compared to relatively more erratic patterns during winter months. This trend supports generally stable crop production although the length of the growing season is limited. Highly variable weather patterns could affect feedstock production for bio-products in terms of both quality and volume.

Figure 3-6

Monthly Lansing-Area Temperatures

2001-2007



Source: National Oceanic and Atmospheric Administration, National Weather Service.

3.7 Section Summary

Current agricultural production capacity in mid-Michigan represents a promising source of renewable bio-based materials for industrial feedstocks. Wisely managed and prudently harvested, the region has sufficient capacity to provide a supply stream of non-food bio-based feedstock for current and emerging bio-manufacturing applications. Additional feedstock supplies from a broader area than the Tri County Region may also be needed.

To augment current yields of crops used for bio-manufacturing feedstocks, the introduction of new crops like switch grass and new harvesting and distribution systems may be required. This may increase producers' start-up costs for bio-manufacturing material production. Marginal agriculture lands currently in the U.S. Natural Resources Conservation Service Conservation Reserve Program (CRP) would be a source of additional feedstock supplies. The region's moderate climate, albeit with a limited growing season, could sustain additional crops.

4. Regional Industrial and Infrastructure Capacity

4.1 Introduction

The number of biorefineries producing biofuels and bio-based products has steadily expanded over the past ten years. These agri-industrial facilities offer new non-food markets for local agricultural crops, the potential reuse of abandoned or underutilized industrial sites, and new rural and urban economic and employment opportunities.

The federal Department of Energy (DOE) National Renewable Energy Laboratory (NREL) defines a biorefinery as "a facility that integrates biomass conversion processes and equipment to produce fuels, power and chemicals from biomass."[1] The variation in biorefinery platforms is currently extensive and these platforms are constantly evolving. Corn or cellulosic materials from grasses and/or woody material are used to provide feedstocks in producing bio-based intermediates that are converted to ethanol, chemical intermediates, or bio-based plastics or fibers. Soybeans are used as feedstocks for biodiesel production and other bio-products.

The scale of commercial production and specified catchment areas are discussed in this section, and the infrastructure needs of a plant including transportation networks, utilities, and labor are also reviewed.

Readers should note that most of the information that is currently available and included here describes first and second generation bio-refineries producing ethanol for motor fuel (see next section). It is the considered opinion of the study team that in evaluating bio-manufacturing opportunities available to the Tri-County Region, it is more appropriate to consider the potential of market development in new advanced bio-based products manufactured by third generation biorefineries. These facilities may be co-located with the production of ethanol. Third-generation biorefineries will be able to take advantage of the rapidly-changing technologies benefiting from the experiences of first and second-generation bio-refineries. As a result, the costs of production and facility requirements will likewise evolve and change.

4.2 Overview of U.S. Biorefineries

As of April 2008, there were 147 biorefineries operating in the United States producing renewable ethanol and biodiesel transportation fuels as well as bio-based plastics and fibers. In addition, 55 plants were under construction and six plants were being expanded. Michigan at this writing has five operating corn-based ethanol biorefineries, one under construction, and one in the permitting process. Another four have been proposed.[37]

Biorefineries are predominantly located in rural areas to provide proximity to available and stable feedstock supplies. However, a recent analysis shows that regions with a well-developed industrial base and infrastructure as well as a strong agricultural base may benefit from siting biorefineries in urbanized areas. Such siting could minimize transportation costs and maximize logistical efficiency.[40]

New technologies are being aggressively researched and developed using nonfood feedstocks, such as corn stover, switch grass, wheat straw, wood waste, and others that preclude competition with commercial animal feed and consumer food markets.

The federal Department of Energy is currently funding five cellulosic ethanol pilot projects that were announced in July, 2007. Funding for each ranges from $33-89 million. These pilot projects are using several different types of biofeedstocks including:

- Corn stover, wheat straw, milo stubble, switch grass in a 11.4 MGY Abengoa Bioenergy facility in Colwich, Kansas that will produce 11.4 million gallons/yr. of ethanol and energy to power the operation and sell excess to co-located dry-grind ethanol production plant.
- Assorted green waste and wood waste from land fills in a 19 million MGY BlueFire Ethanol Inc. facility in southern California that will produce 19 million gallons/yr. ethanol.
- Corn fiber, cobs, and stalks in a 31 MGY Brion companies facility in Emmetsburg, Iowa that will produce 125 million gallons/yr. ethanol, approximately 25% from cellulosics and chemicals and animal feed from lignocellulosics.
- Wheat straw, barley straw, corn stover, switch grass, and rice straw in a 18 MGY Iogen Biorefinery Partners

LLC facility in Shelley, Idaho that will produce 18 million gallons/yr. ethanol.

- Wood residues and wood-based energy crops in a 40 MGY Range Fuels facility in Soperton, Georgia that will produce 20 million gallons/yr. in first unit; ~100 million gallons/year of ethanol and about 20 million gallons/yr. of methanol from a commercial unit.

Empirical data and field-based information for different biorefinery technologies, processes, and cost economics associated with different feedstocks will be generated from these projects. At this point, cellulosic biorefineries are in the pre-commercial stages of development so observations related to third-generation biorefineries are based on pilot-scale experiences and experimental results for the most part. However, there are three U.S. facilities producing bioplastics on a commercial scale, including:

NatureWorks, LLC
Blair, Nebraska

- This facility produces 140,000 tons per year of polylactic acid (PLA) from natural plant sugars alongside a wet mill facility. NatureWorks PLA resins are trademarked as is its Ingeo fiber. PLA is already widely used in biodegradable medical implant and packaging applications.[41,42] This polymer is cost competitive with petroleum-based polymers such as PET (polyethylene terephthalate). NatureWorks is a fully-owned subsidiary of Cargill. This facility and process was co-developed by Cargill and Dow Chemical but Dow pulled out in 2005.

DuPont-Tate and Lyle BioProducts LLC
Loudon, Tennessee

- This $100 million facility, co-developed by DuPont and Tate and Lyle (UK-based), has operated since 2006 but only went to commercial scale in 2007. Located alongside a 60 MGY ethanol plant in Loudon, TN, the facility produces the biopolymer 1,3 propanediol from corn sugar feedstock in a proprietary fermentation process using engineered organisms. The trademarked Bio-PDO is used in cosmetics, deicing fluids, antifreeze, heat transfer fluids, and solvents. DuPont converts the Bio-PDO to its Sorona polymer at its Kinston, NC plant; the latter polymer is used in automotive, electrical, and electronics parts. DuPont also expects to use Bio-PDO in its Hytrel material used in automotive extruded hose and tubing applications.[43]

Metabolix and Archer Daniels Midland (ADM)
Clinton, Iowa

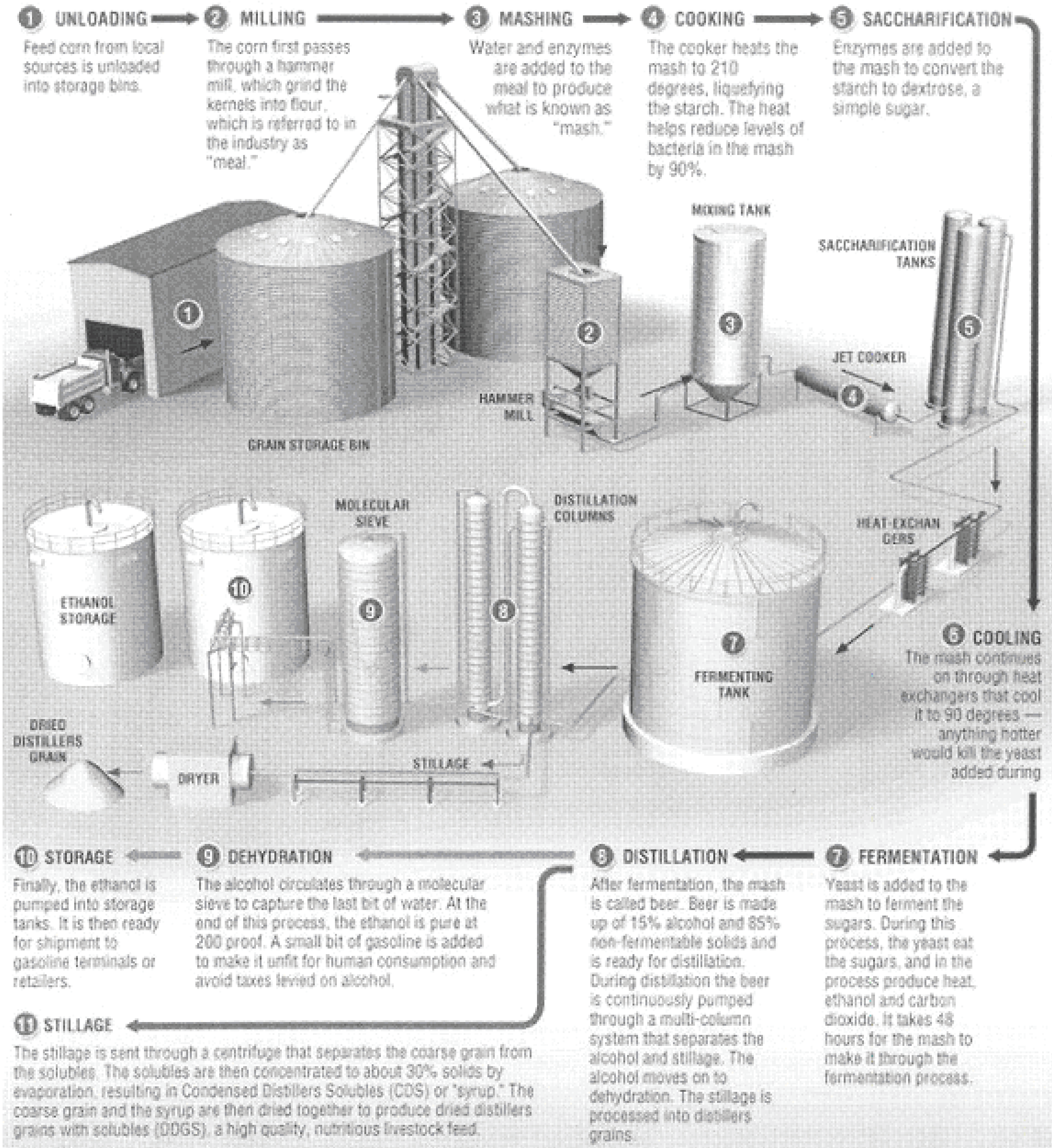
- This facility, adjacent to an existing ADM wet mill, produces 110 million pounds of bio-based polyhydroxybutryric acid (PHA) using a natural fermentation process converting sugars to plastics. The process is licensed by MIT to Metabolix. Cambridge-based Metabolix is investigating switchgrass and sugarcane as feedstocks.

Boston-based Mascoma Corporation announced plans in June 2008 to develop a commercial-scale cellulosic ethanol biorefinery in the eastern Upper Peninsula. Michigan could have the first commercial cellulose-based facility in the country up and running. MSU and Michigan Technological Institute are strategic partners in this initiative as is the Michigan Economic Development Corporation and a local feedstock supply and siting consultant.

Emerging biorefining technologies will make manufacturing processees more efficient. These processes will have the capacity to produce a flexible range of bio-products using various types of agricultural inputs for both chemical intermediates and end-products. Thus, there will be flexibility in both the types of products that can be manufactured as well as multiple feedstocks. Three types of biorefineries are discussed below.

Figure 4-1

Biorefinery Production Process



Source: Institute for Agriculture and Trade Policy.

4.3 Types of Biorefinery Processes

Various types of production processes, infrastructure, and scale are associated with biorefineries producing biofuels (ethanol or biodiesel) or bio-based intermediates like PLA (polylactic acid). New technologies and innovations are continuously being developed to improve production and decrease the size of carbon footprints, allowing facilities to increase output and use less petroleum-based energy and water. Achieving commercial scales of production at economically feasible costs remain a critical goal. DOE research and development expenditures on advancing production of liquid biofuels reached $152,536,000 in 2007. However, in 2006 R & D expenditures were about half that amount at $74,195,000.[12]

The **first generation** of biorefineries in the U.S. is based on a "dry mill" process. The whole kernel of corn is the production feedstock, which is first crushed – or milled – into flour. During the cooking process, the starch from corn is heated at 210 degrees Fahrenheit, liquefying the starch and removing bacteria. The starch is then removed from the milled flour both physically and through a variety of different microorganisms and enzymes and water during the saccharification stage. This simple sugar, dextrose, is then cooled and fermented with yeast for up to 48 hours. The end product is ethanol or bio-based intermediate slurry used to produce bio-products. Dry-mill refineries predominate and have realized significant improvements in energy-saving technologies such as the re-use of liquefaction and scarification energy for removing water from ethanol in the distillation column. This has led to a 70% decline in thermal and electrical energy used to produce a gallon of ethanol. Plants now produce more than 2.8 gallons of ethanol from a bushel of corn (as of the 2002 Shapour study), compared to 2.5 gallons in 1980.[38]

Second generation biorefineries – known as "wet mills" – separate corn kernels into separate components: germ, fiber, protein, and starch, prior to fermentation. This process, used by leading PLA producer NatureWorks, turns the dextrose sugar through fermentation into lactic acid, which is then dried, crystallized and formed into polylactic acid pellets. These pellets can be used to make a variety of bio-based plastic products.

A **third generation** of biorefineries is currently being researched and developed by companies, communities and researchers with DOE funding support in many cases. These facilities offer the potential for highly-flexible processing technologies to accommodate product change-over. The ability to switch product streams enables a producer to meet changing market demands. These third generation biorefineries will use highly integrated processes that make efficient use of agricultural feedstocks for both manufacturing production and energy production to meet the plant's utility needs and reduce its carbon footprint. Finally, these biorefineries will be able to take advantage of emerging cellulosic technology that utilizes non-food agricultural waste such as corn stover, switch grass, forest materials, and wood waste.

Mascoma's consolidated bioprocessing technology, for example, is designed to use a single-step cellulose-to-ethanol method using wood chips and other biomass materials as feedstocks. Using site integration and innovative supply chain strategies as a development platform, Mascoma will collaborate with MSU and Michigan Technology University (MTU) to develop and refine scientific processes based on cutting edge research and innovation to utilize these biofeedstocks in high-volume cellulosic ethanol production.

MSU will provide expertise on pretreatment technology for cellulosic ethanol production and assistance with renewable energy crops that can be utilized by the biorefinery. MTU will contribute its knowledge of sustainable forestry management practices and its automotive engineering laboratories for analysis of the biofuels produced at the facility. Mascoma is also developing a pilot project in Rome, New York scheduled to go online by year's end. Mascoma attracted equity investments from General Motors and Marathon Oil Corporation in the company's $61 million third round of funding.

The industrial infrastructure to support a third generation facility is investigated in the following pages. This appraisal consists of a series of contingent estimates of inputs as technology, financial, and policy developments affecting these estimates evolve and change rapidly. Indeed, significant changes occur virtually every week. The amount of acreage necessary to supply a 100 MGY facility, the types and volumes of agricultural nonfood feedstocks, transportation infrastructure, utilities, water and labor to implement production processes are reviewed in the following pages.

4.4 Biorefinery (100-MGY equivalent) Requirements

A 100-million gallon per year (MGY) equivalent biorefinery is used as the appropriate scale of a hypothetical facility sited in the Tri-County Region. This scale provides a realistic scenario in which production requirements, market demand, and economies-of-scale may be evaluated.

4.4.1 Site Size Requirements

An intermediate 100 MGY biorefinery, strictly speaking, requires only 10-15 acres on land zoned light-industrial. However, to meet the needs for adequate sound and odor buffering and potential facility expansion, a site of a minimum 40 acres is preferable.

4.4.2 Capital and Operating Costs

The capital costs of developing and constructing a biorefinery of this size will require $200-250 million in addition to annual operating costs of up to $95.7 million or more for procuring agricultural feedstocks, electricity, power, enzymes, yeast, chemicals, water, labor force, maintenance, and administration. Operating costs for a 100 MGY facility would be $95,740,000 based on Shapouri's 2002 U.S.D.A. survey data. He calculated an average variable cost of $0.9574 per gallon of ethanol for cash expense items, including feedstock costs and byproduct credit offsets.

Figure 4-2

General Biorefinery Requirements

Proximity to feedstock/nonfeedstock
Biomass handling capacity
Highway and rail access to trainsport bio-inputs and refinery outputs
Proximity to energy sources/utilities
Forty acres of land (or more) for an intermediate biorefinery
Access to source of water for production processes
Acess to skilled labor force

Sources: The Clean Fuels Development Coalition. (2006). *A Guide for Evaluating the Requirements of Ethanol Plants*. United States Department of Agriculture.

Holtzapple, M. (2007, September 5). *Advanced Biomass Refinery: Third-Generation Technology*. Presented at the Department of Chemical Engineering, Texas A&M University, College Station, TX.

4.4.3 Estimates of Corn Stover Feedstock Requirements

Ethanol and other types of bio-manufacturing require the transport of significant volumes of feedstocks to a central refinery or interim storage facility (also called queuing). A 100 MGY equivalent ethanol biorefinery, for example, would require an annual supply of approximately 1 million tons of stover feedstock based on extracting 91 gallons of ethanol from one dry ton of stover. This extraction rate is at the high end of current DOE estimates.

To supply the facility with 1 million tons of this feedstock, 160 truck loads of 18 tons per day would be required. The bale size is assumed for biomass feedstock; specific stover bale sizes may vary. Current DOE-funded projects and other research will provide empirical field data that will impact these assumptions and calculations. DOE is also investigating alternative collection/harvesting techniques that do not require baling.

Figure 4-3

Estimates of Corn Stover Feedstock Requirements and Supply Logistics

(100 MGY Biorefinery)

Category	Quantity	Assumptions/Calculations
Stover Supply Requirement	~1,000,000 TPY[a]	Tons Per Yr.
		Based on 91 Gal. from 1 Dry Ton (for Stover)
		100,000,000/91=1,098,901
1 Truck Load	~18 Tons[b]	39 Bales per Truck Load
		1 Bale=900 lbs.
		39x900=35,100 lbs
		35,100/2,000=17.55 Tons
Truck Loads Per Year	55,556	1,000,000 TPY/18 Tons
Truck Loads Per Day	159	55,566/350=159 @ 350 day year
Truck Loads Per Hour	7	24-hour day (159/24=6.63)
Truck Loads Per Hour	9	18-hour day (159/24=8.85)

Sources: a. Klein, I. (2007, October 2). Presented at the 7th Annual Conference on Renewable Energy from Organics Recycling, Indianapolis, IN.

b. Mukunda, A. (2007). *A simulation based study of Transportation Logistics in Corn Stover to Ethanol Conversion*. Unpublished master's thesis, Purdue University, West Lafayette, IN.

4.4.4 Costs of Stover Feedstock

Costs for collecting, handling, and transporting corn stover to an ethanol biorefinery have been evaluated for plants requiring 500 - 4,000 dry tons/day (i.e., 175,000 - 1.4 million dry tons per year).

Use of conventional baling and transportation equipment was assumed. Stover producers were compensated at $10/dry ton to cover nutrient value plus profit with delivered costs ranging from $43.10 to $51.60/dry ton. Adjustments to reflect 2006 fuel and fertilizer costs would raise stover costs to $51.72 - $61.92.[44]

The high end of stover feedstock costs for a 100 MGY facility, then, would be approximately $60,000,000, based on this study. Feedstock costs could rise based on supply incentives.[45]

4.4.5 Energy Utilities and Water Requirements

One of the key benefits of an integrated intermediate biorefinery is the reduced amount of energy and water needed for its operation. The following requirements will vary depending on the exact type of technology used, but represent current benchmarks for an intermediate bio-refinery.

Figure 4-4

Utilities and Water Use

Utility	Usage
Electricity	<1 kWh/gal ethanol
Water	4.7 gal/gal ethanol
Steam	30,000 BTU/gal

Source: Shapouri, H., & Gallagher, P. (2005, July). *2002 Ethanol Cost-of-Production Survey*. United States Department of Agriculture.

4.4.6 Costs of Energy/Water Utilities

Co-locating a refinery where "waste heat/steam" is available to support the production processes may be feasible at specific sites in mid-Michigan.

The data in Figure 4-5 provides an annual cost estimate for 100 million gallon per year ethanol equivalent third generation biorefinery.

Figure 4-5

Estimated Annual Utility Costs

Utility	Cost
Electricity	$955,809
Steam	$4,578,851
Natural Gas	$2,324,945
Cooling Water	$1,023,622

Source: Holtzapple, M. (2007, September 5). *Advanced Biomass Refinery: Third-Generation Technology*. Presented at the Department of Chemical Engineering, Texas A&M University, College Station, TX.

4.5 Cellulosic Feedstock Supply Catchment Areas

Our study reviews cellulosic sources of feedstocks and supply requirements. Other feedstock sources will be investigated in the future, pending additional funding for that purpose. The first stage in the feedstock supply system requires the ability to grow and collect large amounts of cellulosic feedstocks for pre-processing and distilling. An intermediate stage consists of storage, pre-processing, and transportation to the biorefinery. The final stage is the handling and queuing (interim storage) of feedstocks at the biorefinery.

Corn stover, the residue left in the field after harvesting to fertilize and rejuvenate soil, can be used as cellulosic feedstock in the production of bio-based fuels and products. Recent studies indicate that up to 50% of stover can be removed without degrading soil quality and provide a sufficient feedstock stream to meet biorefinery supply requirements. Collecting corn stover would entail modest changes in harvesting methods by requiring a two-pass system to harvest corn for grain and residue, respectively.

A 100-MGY production facility would require approximately 1 million tons of feedstock. Changes resulting from technological innovation or available agricultural feedstock supplies could affect the scale of the facility and/or its production volume.

Our study provides a simple analysis of two corn stover supply catchment areas within a 70-mile radius and 45-mile radius, respectively, for a biorefinery in the Lansing area. Our analysis relies for the most part on a methodology developed by Centrec Consulting and the MSU Agriculture Product Center.

4.5.1 Proximity to Feedstocks

In our first supply catchment analysis, corn stover feedstock is collected from an area within a 70-mile radius of the Lansing Tri-County Region and encompasses 16 counties:13 are entirely within the prescribed radius and three are at least 75% within the radius. Two counties (Wayne and Oakland) are excluded because their yields are negligible.

Two collection scenarios were assumed: 1) 50% of available corn stover is collected from 100% of planted corn acreage, and 2) 50% of available corn stover is collected from 50% planted corn acreage.

(See Figure 4-7 and Figure 4-9 for corresponding maps)

Figure 4-6

Corn Yield Catchment Area

70-Mile Radius

(In Bushels)

2007

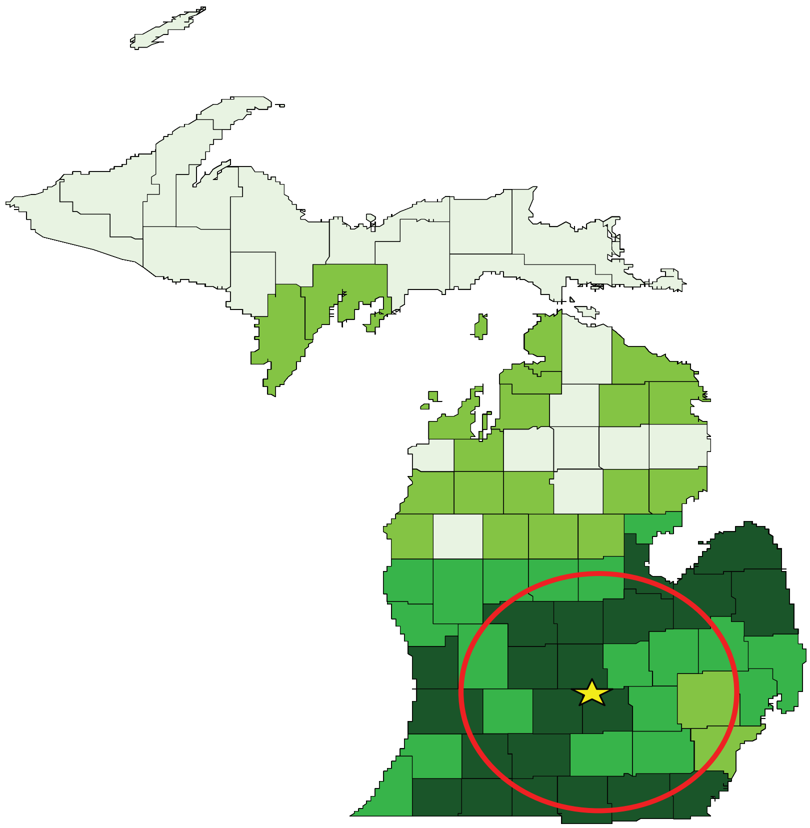
County	Yield
Saginaw	15,200,000
Gratiot	12,100,000
Montcalm	6,600,000
Ionia	9,700,000
Clinton	9,000,000
Shiawassee	7,750,000
Genesee	3,900,000
Livingston	2,300,000
Ingham	6,600,000
Eaton	8,300,000
Calhoun	9,400,000
Jackson	6,000,000
Washtenaw	5,800,000
Hillsdale	8,300,000
Lenawee	15,600,000
Kent	4,200,000
Total Catchment Area	**130,750,000**

At 56 lbs per bushel, the yield is 3,661,000 tons and at a 50% collection rate of available corn stover, 1.83 million tons of corn stover would be collected. This supply stream, then, would be more than adequate to meet facility feedstock requirements. At a 50% collection rate of 50% of available corn stover, 900,850 tons would be collected. As the facility in our scenario requires 1 million tons, there is a supply shortfall of approximately 99,000 tons. This gap could be filled by securing wood waste from forest harvest residues or some other biomass supply source within a cost-effective distance from the facility.

Figure 4-7

Corn Stover Catchment Area

70-Mile Radius



Source: MSU Center for Community & Economic Development.

Figure 4-8

Corn Yield Catchment Area

45-Mile Radius

(In Bushels)

2007

County	Yield
Saginaw	15,200,000
Gratiot	12,100,000
Ionia	9,700,000
Clinton	9,000,000
Shiawassee	7,750,000
Livingston	2,300,000
Ingham	6,600,000
Eaton	8,300,000
Calhoun	9,400,000
Jackson	6,000,000
Total Catchment Area	**86,350,000**

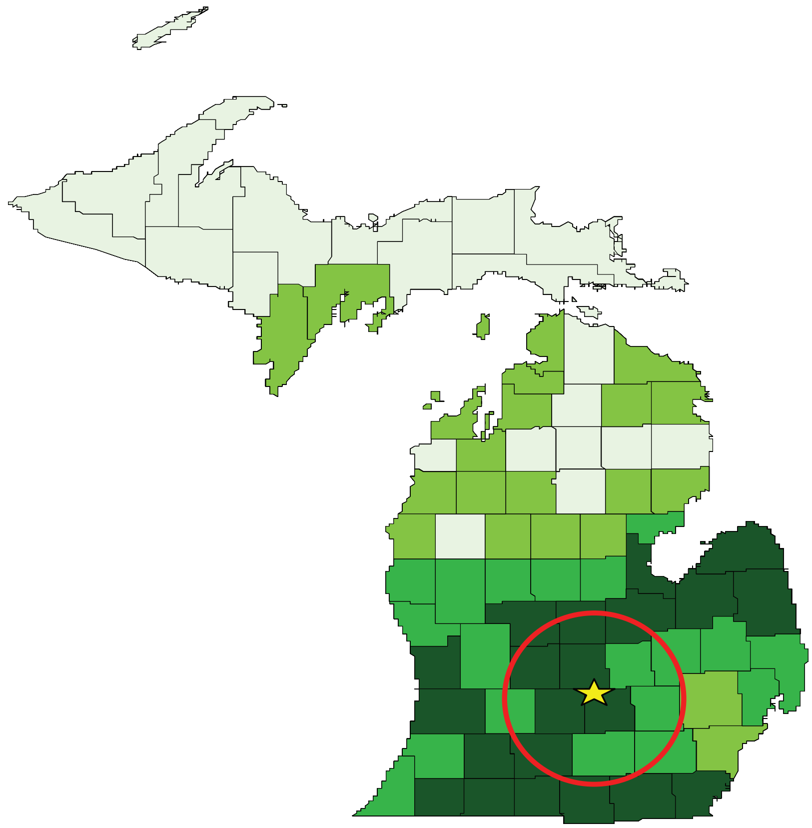
In our second supply catchment analysis, 600,000 tons of corn stover would be supplied by collecting 50% of the total yield in ten counties. However, there would be a shortfall of 400,000 tons.

It must be recognized that these supply catchment analyses were conducted at a very coarse level of detail. No attempt was made to ascertain the yields of the areas in those counties partially within a respective catchment area and exclude the yields of the areas in those counties outside the catchment area. Clearly, more detailed analysis and due diligence must be performed to determine the technical and economic feasibility of using corn stover as bio-manufacturing feedstocks by measuring actual yields that can be captured within a supply catchment area.

Figure 4-9

Corn Stover Catchment Area

45-Mile Radius



Source: MSU Center for Community & Economic Development.

Nevertheless, this simple analysis indicates that corn stover could be used as a reliable feedstock supply in the bio-manufacture of renewable, bio-degradable bio-products that can replace petroleum-based products.

4.6 Tri-County Region Transportation Infrastructure

The Tri-County Region is well-positioned to access biofeedstocks from agricultural supply sources both within and outside the region. The regional transportation infrastructure provides an effective network through which feedstocks can be delivered to the biorefinery at all times of day and in all types of weather. By the same token, bio-products manufactured at the facility can be shipped by road or rail in all directions, including major interstate highway routes to reach end-markets in Chicago, Southeastern Michigan, Ontario, Indiana, Ohio, and points beyond.

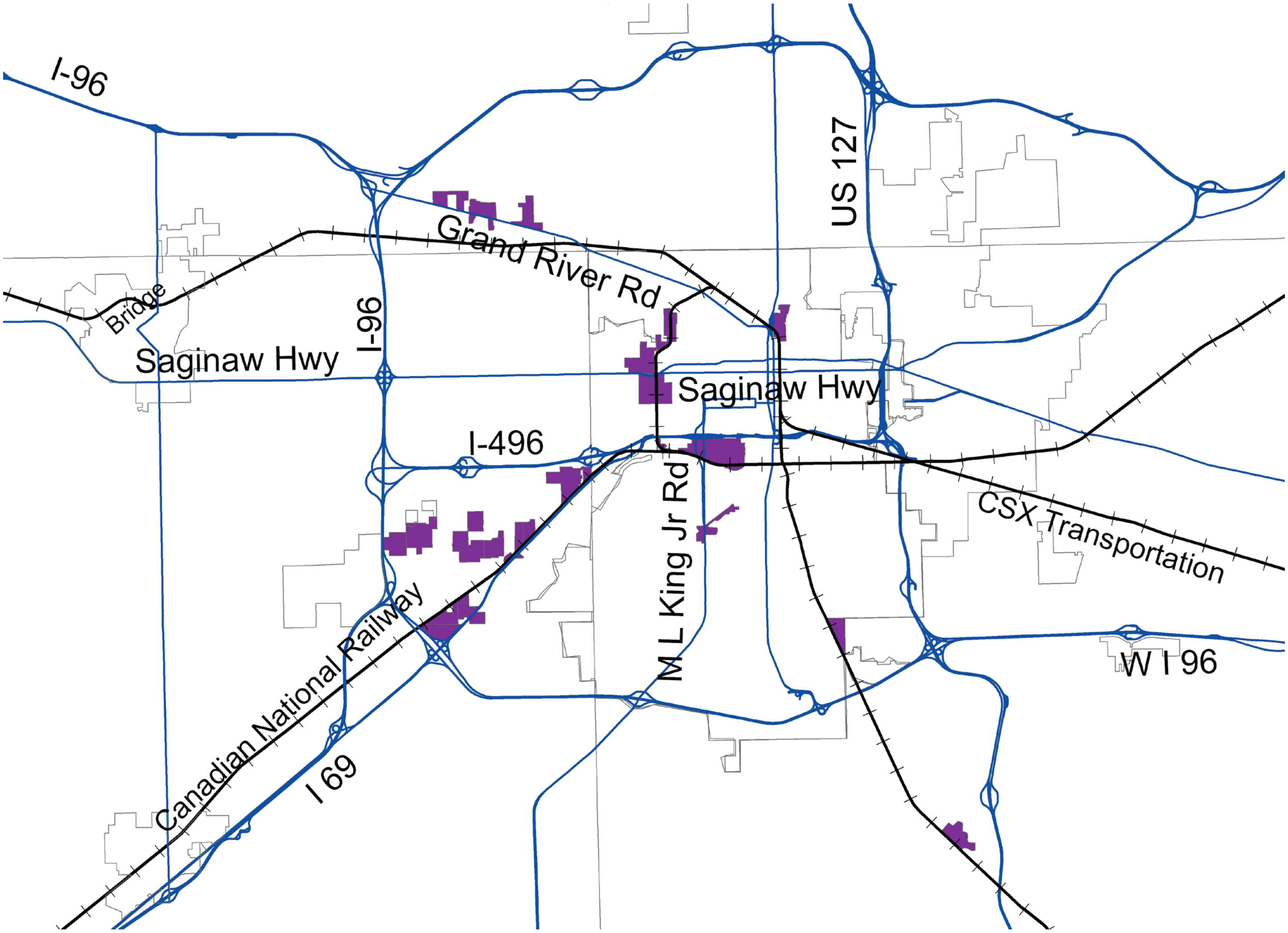
4.6.1 Logistical Sufficiency of the Tri-County Transportation Infrastructure

A biorefinery must also have access to an adequate transportation network to efficiently distribute its bio-products to its end-market customers. Figure 4-10 and Figure 4-11 show the transportation infrastructure in the region that can provide strong logistical support to biorefinery operations.

The maps below show the connectivity of road and rail transportation with industrial sites in the Tri-County Region.

Figure 4-10

Industrial and Transportation Infrastructure for Lansing and Vicinity



Source: MSU Center for Community & Economic Development and Tri-County Regional Planning Commission.

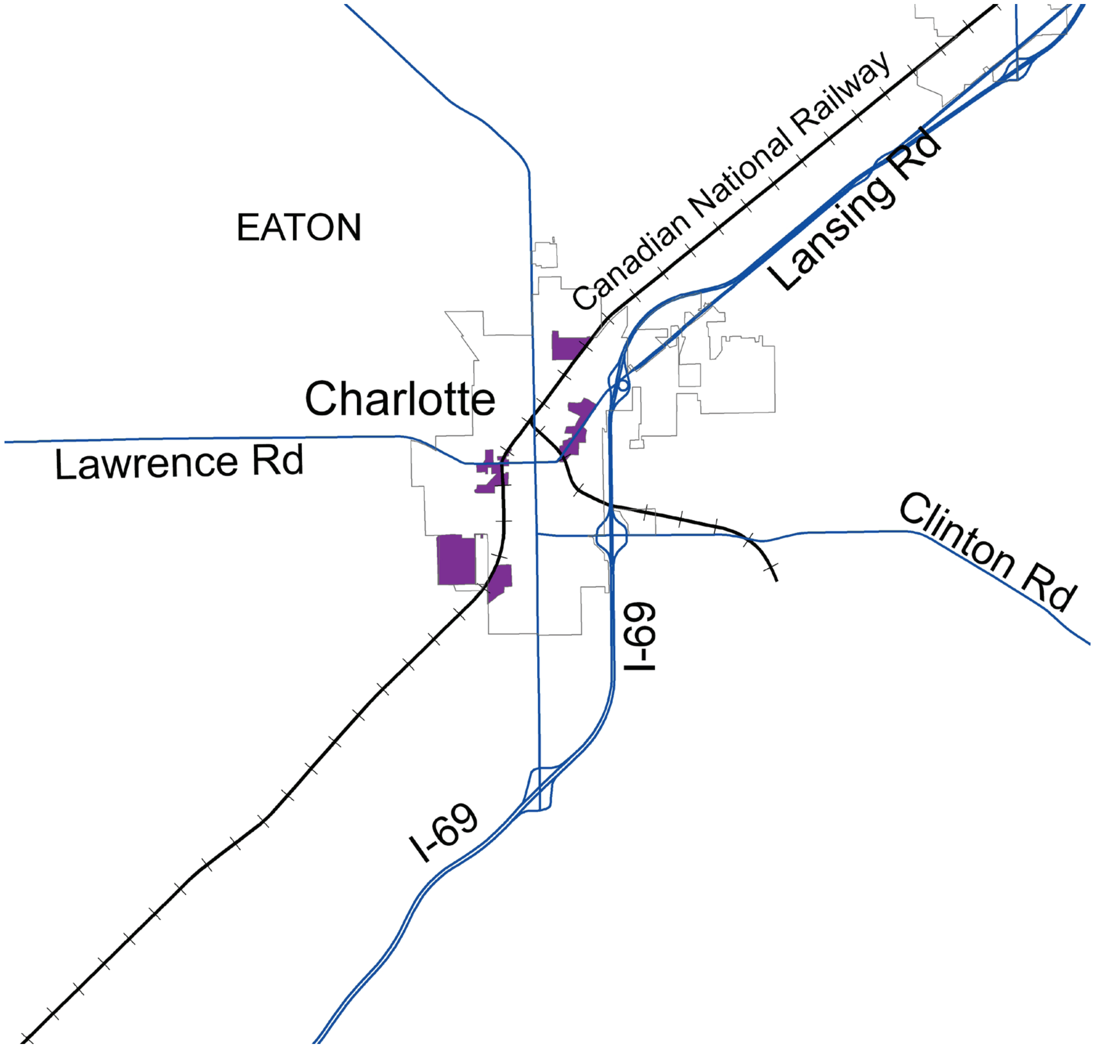
The Lansing and vicinity map above shows existing industrial parcels of 40 acres or larger in close proximity to major roads, railways or interstates. The industrial parcels are represented in the purple blocks, interstates in blue, major city streets in gray and railways in black. A 100- MGY bio-refinery is estimated to need 40 acres or more for its manufacturing production and material storage.

There are about 10 industrial parcels either vacant or in use in the Lansing region. Some of these sites may have expansion potential if needed.

Several industrial parcels are located on either major highways, such as I-496, I-96 or I-69 or the Canadian National Railway. Accessibility to these major arterials allows easy transportation access to and from the bio-refinery.

Figure 4-11

Industrial and Transportation Infrastructure for Charlotte and Vicinity



Source: MSU Center for Community & Economic Development and Tri-County Regional Planning Commission.

The map above shows five 40-acre industrial parcels located in Charlotte and vicinity, or about half of the number in the Lansing area.

The industrial sites are primarily located near the Canadian National Railway. This railway also has the capacity to connect to some of the parcels in Lansing. Few of the parcels are near smaller arterial roads such as Lawrence Road and Clinton Road. None are directly off of the closest interstate (I-69).

Commercial roads with the capacity to transport feedstock supplies to industrial sites are those roads with over 5,000 commercial annual average daily trips (CAADT) within each county. These roads have the capacity to accommodate the increase in truck traffic supplying a biorefinery. Most of the larger industrial parcels are located near I-96, I-69 and I-496.

4.7 Labor and Employment

A refinery by itself is not a large employer. It employs, on average, approximately 30 full-time employees (see Figure 4-12). However, as both an end user of agricultural products and producer of feedstocks for other industry sectors, a biorefinery supports employment in the agricultural production and bio-manufacturing sectors. In the Tri-County Area the agricultural sector employed 2,427 in 2000 and 2,645 in 2006, according to the U.S. Census.

The Tri-County Region has long been a leader in automobile and consumer product manufacturing. Severe reverses in the domestic auto industry have left many workers in the region without jobs (see section 2). Bio-manufacturing offers the Lansing area a new opportunity to tap a new well of manufacturing production. Regional economic revitalization will depend on the ability to develop eco-friendly products in the post petroleum economy.

Figure 4-12

Estimated Costs of Labor

Labor	Cost
Plant Manager (1)	$150,000
Supervisors (4)	$320,000
Sales (1)	$80,000
Clerical (3)	$120,000
Workers (20)	$900,000
Total Labor	**$1,570,000**

Source: Holtzapple, M. (2007, September 5). *Advanced Biomass Refinery: Third-Generation Technology*. Presented at the Department of Chemical Engineering, Texas A&M University, College Station, TX.

The data in Figure 4-13 indicate hourly automotive worker wages of $13.23 per hour. However, the wages of most Lansing area automotive workers are covered by the UAW contract which provides a current hourly wage of $28.43.[46]

Figure 4-13

State and National Hourly Wages

Labor	Hourly (U.S.)	Hourly (MI)	Yearly (U.S.)	Yearly (MI)
Automotive Workers	$11.63	$13.23	$24,200	$27,500
Chemical Technicians	$23.60	$23.15	$49,100	$48,200

Source: Occupational Information Network.

Our regional workforce, including auto workers, has many of the skills and knowledge needed for bio-manufacturing. Some skill categories have more overlap than others, such as the work styles, abilities and the activities. The requirements within those areas could be learned on the job or be a general trait a person has such as cooperation, self control and attention to detail which are listed under the work styles. Some examples of work abilities would be control precision, problem sensitivity and oral expression. An example of work activities would be the ability to identify objects, actions, and events performing general physical activities.

There are more gaps under the categories where prior information is required. The chemical technicians' requirements are more focused on prior knowledge, while the automotive team assemblers' requirements could be learned on site. Chemical technicians need a background in chemicals, law and government, mathematics, computers and electronics and other things requiring a formal education. Automotive team assemblers share knowledge in production and processing, and skills such as operation monitoring, active listening and quality control analysis; however skills such as troubleshooting and speaking were not identified.

4.8 Section Summary

Based on traditional manufacturing capacity, the Tri-County Region has sufficient material collection and processing capacity, industrial infrastructure, and a skilled industrial labor force capable of producing ethanol and other bio-products from cellulosic feedstocks.

The Tri-County Region may be exceptionally well-positioned to compete in the emerging bio-manufacturing sector with the development of a cellulose-based biorefinery. The feasibility of a 100 MGY ethanol biorefinery is based in large part on access to reliable and consistent supplies of cellulosic feedstocks (corn stover, energy crops, wood waste, and others) from rural parts of the region as well as available industrial parcels where a biorefinery may be sited.

The regional transportation network provides a fully-developed road network and rail system with sufficient carrying capacity to accommodate the moderate increases in traffic resulting from feedstock delivery and outgoing shipping.

The region has, in addition, effective capacity to retrain manufacturing and other skilled workers displaced by the severe structural changes in U.S. automotive markets.

5. Regional Intellectual Infrastructure

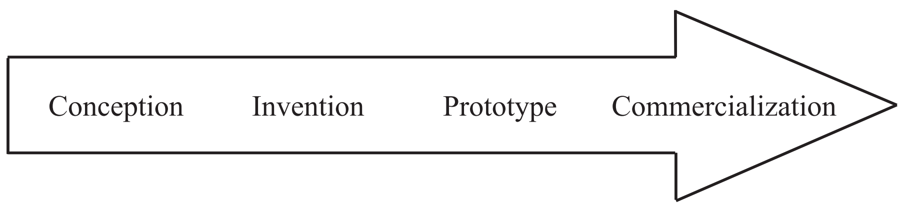
5.1 Introduction

Identifying the intellectual capabilities of the region is fundamental to determining the feasibility of developing a bio-manufacturing industry in the Tri-County Region. The capacity to develop and sustain a bio-manufacturing economy depends in large part on the intellectual abilities to invent products and develop innovative new methods of production, markets, and supply chains. Early adapter communities will face significant "start-up challenges" but they will be better positioned as bio-manufacturing economic centers with great expansion potential in the near and long-term future.

This section provides a comparative assessment of the Tri-County Region's intellectual capabilities associated with the emerging bioeconomy. The region has of course the distinct advantage of being home to a major research institution in Michigan State University. MSU has a nationally-recognized expertise in the emerging bioeconomy. MSU has committed significant faculty and related resources to grow Michigan's bioeconomy and bio-manufacturing sector. The advantage of close proximity to this institutional intellectual capacity can not be over emphasized.

Figure 5-1

The Innovation-Commercialization Continuum



The bio-manufacturing sector, like other emerging technology-driven sectors, relies on research institutions to create relevant knowledge, invent new products, and make scientific discoveries that lead to innovation in the conceptual stages. The capacity to test and evaluate new methods of production and products in the prototype stage (See Figure 5-1) is equally fundamental to the commercialization process.

University-private sector collaboration can facilitate licensing and provide critical inputs to the developing patents. Innovation is so completely critical to success in the bioeconomy but much of the necessary R&D needed for innovations is beyond the capacity of small and medium enterprises and even major corporations. The private sector simply lacks the capacity to conduct sufficient research needed for the rapidly flowing stream of innovations driving the bioeconomy. Moreover, the processes of discovery as well as the dissemination of ideas and techniques are by their very nature collaborative processes. Finally, the university needs the engagement of the private sector to take research-based ideas and inventions to their commercial applications and creation of markets. University-private sector collaboration is critical to successfully compete in the technology-driven global knowledge economy.

5.2 Performance Indicators of Regional Intellectual Capabilities

The MSU Center for Community and Economic Development conducted assessments of the capacity of Michigan counties and metro centers to compete in the global knowledge economy in 2006 and 2007, respectively. An overall ranking for each county and metro center was calculated by applying the Knowledge Economy Index and producing a set of simple unweighted averages for 17 specific indicators to determine each ranking.

The 17 indicators evaluate performance in five key areas of the knowledge economy and include the following:

Knowledge Jobs

- Information Technology Jobs
- Managerial and Professional Jobs
- Workforce Education

Digital Economy

- Internet Use
- Cable Modem Access
- Digital Government

Innovation

- High-Tech Jobs
- Venture Capital
- Patents
- Engineers
- Bioscience Jobs

Globalization

- Firms with Foreign Parents
- Exporting Firms

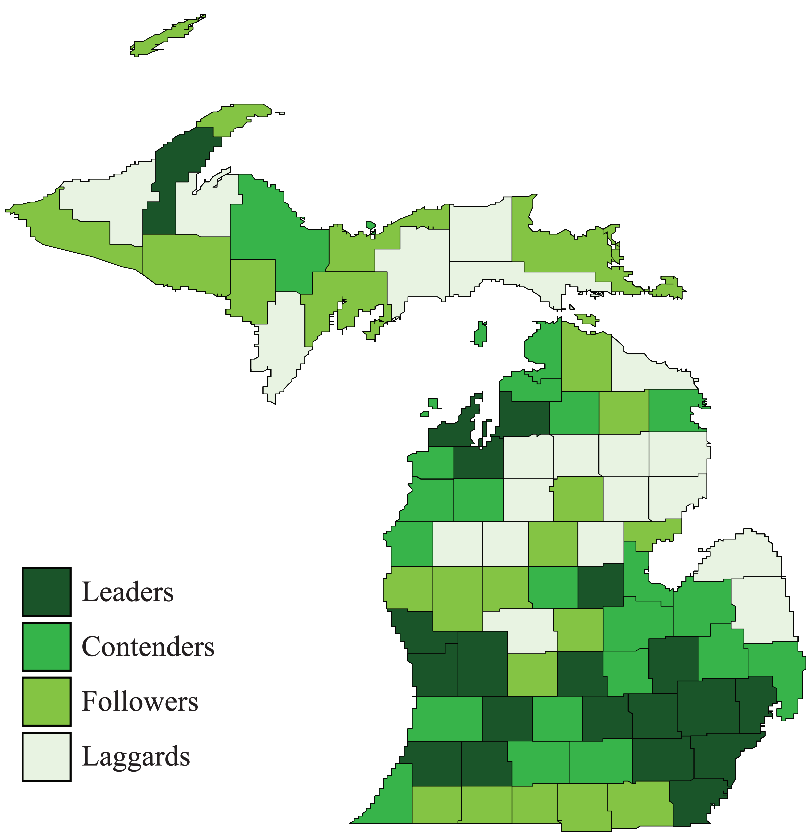
Dynamism/Creative Community Capacity

- Change in Manufacturing
- Sole Proprietorship
- Service Sector Jobs
- Assessments of community's creative capacity

Figure 5-2

Michigan Knowledge Economy Index

County Rankings



Source: Michigan Knowledge Economy Index. (2007, July). *Overall Rankings* (2nd ed.).

Ingham and Clinton Counties are clearly leaders compared to other Michigan counties as shown in Figure 5-2,. Eaton County lags slightly behind as a contender. Readers are encouraged to visit http://ced.msu.edu/techresearchreportspg1.html. for an in-depth analysis of the region's assets and performance in the global knowledge economy.

5.2.1 Patent Applications and Patents Issued

In this section, MSU capabilities are compared to those of other Big Ten Land Grant research universities, based on a 2006 Association of University Technology Manager (AUTM) survey. The survey included the University of Illinois (includes both Urbana-Champaign and Chicago campuses), Purdue University, University of Wisconsin – Madison (U-W Madison), Penn State University, Ohio State University, and the University of Minnesota in addition to Michigan State University.

Experience in the patent application process indicates both inventive capacity and the critical ability to commercialize applications of innovative ideas. Purdue was the leader with 241 patent applications and 32 issued (see figure 5-3). U-W Madison was second with 203 but had the most patents issued with 69. Michigan State University was in the middle range with 148 patent applications and 21 patents issued.

Figure 5-3

Patent Applications and Patents Issued for Big 10 Land Grant Universities

University	Patent Applications	Patents Issued
Purdue	241	32
U-W Madison	203	69
University of Illinois	157	41
Michigan State	148	21
Penn State	106	37
Ohio State	64	27
University of Minnesota	60	28

Source: Association of University Technology Managers.

5.2.2 Licenses

To commercialize discoveries and inventions, it is critical that the licensing process of such discoveries and inventions is both efficient and fairly conducted. With fair and equitable licensing processes, individual innovation is encouraged while protecting public investments in the infrastructure and supplies supporting faculty researchers.

U-W Madison shows the most cumulative active licenses with 907 in 2006 (see figure 5-4). Michigan State was in the second tier with 351 active licenses.

Figure 5-4

Cumulative Active University Licenses
2006

University	Cumulative Active Licenses
U-W Madison	907
University of Minnesota	720
Purdue	356
University of Illinois	354
Michigan State	351
Penn State	156
Ohio State	143

Source: Association of University Technology Managers.

5.2.3 Technology Transfer and University Business Start-Ups

The ability to create new products and develop new production methods must be complemented by the capacity to transfer new technology. This capacity depends on a coherent networking process to take new discoveries and innovations from research labs to new commercial applications or incorporate new methods and techniques of production, marketing, and other related areas.

A key indicator of that capacity is the number of reported university business start-ups. Start ups require a supportive infrastructure and sufficient resources to support researchers in negotiating the process of transferring knowledge generated in a learning institution to the production of goods or services and compete in the market place. Penn State and Purdue had the most businesses start ups, each with 14. Michigan State was in the second tier with four start ups in 2006.

Figure 5-5

University Business Start-Ups

2006

University	Startups
Penn State	14
Purdue	14
University of Illinois	9
U-W Madison	7
Ohio State	5
Michigan State	4
University of Minnesota	3

Source: Association of University Technology Managers.

5.2.4 Dedicated Bio-Manufacturing Research Capacity

In the development of the bio-manufacturing sector, one of the most critical "raw" materials is the number of researchers who can contribute to the development of this sector. Michigan State University has approximately 150 faculty members researching key issues and questions associated with developing the bio-manufacturing sector. These researchers are connected with the MSU Office of Bio-Based Technology that was created in 2006.

Lansing Community College has approximately 9 faculty members engaged in bio-manufacturing.

5.2.5 Targeted Bio-Manufacturing Research Expenditures

A relatively crude method to assess inventive capability is to assess the level of research investments. While this measure may suggest some level of intellectual commitment/ capacity, the aggregate data is unlikely to reflect the level of well-focused intellectual commitments and targeted research expenditures.

The University of Illinois had the highest amount of research expenditures with $817,990,000; U-W Madison followed closely behind with $798,099,000. Michigan State University was last with $333,735,000 (based on 2005 AUTM survey data).

However, MSU recently partnered with the University of Wisconsin-Madison and obtained a major U.S. Department of Energy grant to establish the Great Lakes Bioenergy Research Center. There are seven other DOE centers. MSU will receive $50 million over the next five years for basic science research. UW-Madison will receive $125 million. MSU's world renowned plant scientists will focus on using cellulosic materials to create ethanol fuel. In addition, MSU benefits from its connectivity to agriculture as well as its close proximity to the automotive industry in the Lansing area.

Figure 5-6

Research Expenditures for Big 10 Land Grant Universities

2005

University	Research Expenditures
University of Illinois	$817,990,000
U-W Madison	$798,099,000
Penn State	$637,911,000
University of Minnesota	$548,873,000
Ohio State	$511,500,000
Purdue	$407,837,000
Michigan State	$333,735,000

Source: Association of University Technology Managers.

Another method of assessing research capacity is to identify faculty clusters that focus on generating research and knowledge relevant to the needs of the region and state to compete successfully in the bioeconomy. MSU has 11 institutes and centers with bioeconomy-related research capacity.

The 11 institutes and centers at MSU with bioeconomy-related capacity are briefly described here:

- The **Office of Bio-based Technologies** (OBT) was created in 2006 to integrate innovations in the lab with advances in the market place and foster connections with public and private sector initiatives to support expansion of the state's bioeconomy.
- The **MSU-Department of Energy** (DOE) **Plant Research Lab** (PRL) conducts plant research at the molecular level to create more efficient and economical ways to produce biodiesel, including genetic modification of nonfood plants such as grasses. Up to 10 times more biodiesel feedstock per acre than soybean oil can be produced. Other research has developed technology to allow plants to accumulate extremely high levels of starch which is easier to convert into fermentable sugars (the basic component in ethanol production).
- The **Center for Bio-Based Renewable Energy** focuses on converting biomass into renewable energy.
- The **Biomass Conversion Research Lab** scientists are developing pretreatment, enzymatic, and fermentation technologies to break down cellulose and hemicellulose more economically and efficiently, an absolutely critical component in cellulosic ethanol production. Pretreating cellulose and hemicellulose uses a patented method called ammonia fiber expansion. Using cellulosic resources provides a more sustainable bioenergy system.
- The **Composite Materials and Structures Center** focuses on the production of composite materials and conducts industry outreach programs.
- The **Center for Microbial Ecology** researches the benefits of using microorganisms in the bioeconomy; for example, cleaning up toxic spills by breaking down complex sugars, microorganisms could benefit the bioeconomy.
- The **Energy and Automotive Research Laboratories** provides lab capacity for research and development of automobile engines, with a focus on reducing emissions and using alternative energy resources.
- The **Long Term Ecological Research Project** conducts research on ecosystem management and biodiversity. Researching mainly agriculture and forestry issues, this project addresses questions about the carbon cycle and green house gases when biofuel systems are introduced to the ecosystem.
- The **Center for Nanostructured Biomimetic Interfaces** integrates nanotechnology with protein science to produce devices and processes.
- The **Product Center for Agriculture and Natural Resources** helps entrepreneurs who rely on agriculture and natural resources. The center promotes production of bio-products by providing relevant guidance and information.

- The **Center for Community and Economic Development**, the author of this report, promotes and supports innovative collaborative learning to assist community/economic development and provides multidisciplinary capacity to respond to multiple, interrelated problems of distressed communities. The Center regards the development of the bioeconomy as a key element in revitalizing Michigan communities.

5.3 Section Summary

Technology-led economic development offers vast potential for the generation of individual and community wealth for those who are creative and talented, and have a modern IT infrastructure and the foresight to plan for the new economy. Many of these characteristics are typical of "university towns" like the Lansing-East Lansing area where public and private investments in the generation and application of knowledge have been a long-term priority. Communities with a research and development capacity will likely do well in the technology-led, knowledge-based global economy. However, these communities must demonstrate the intellectual leadership and boldness in the private sector to take risks to advance new bio-products and bio-based technologies.

Current practices suggest that in the early phases of conceptualizing and prototyping an innovation, it is often critical for the "inventor" to be near a university/research institute where the necessary intellectual critical mass (human capital), technological infrastructure, financial capital, and creative environment exist to support the incubation of new ideas/ methods.

The mid-Michigan area has significant intellectual capacity to support the development of the bio-manufacturing sector in the growing bioeconomy.

6. Regional Leadership Capacity

6.1 Introduction

The emergence of a bio-based economy challenges traditional economic development models and offers communities not currently benefiting from other emerging economic sectors the potential for growth. Moreover, the use of agricultural products and cellulosic materials is being developed outside of traditional industrial and high-tech business hubs. This offers regions interested in developing bio-manufacturing the opportunity to reinvent economic development and government strategies that can keep pace with the rapidly evolving paradigms of the emerging bioeconomy.

Development of the bioeconomy depends on regional leadership that values innovation, is not averse to taking risks, and provides peer support for emerging entrepreneurs. Such entrepreneurial support includes providing access to private and public financial capital that will stimulate and support development of bio-manufacturing initiatives.

Communities with significant competitive advantages in natural resources, industrial infrastructure, and intellectual capital may lack the individual and collective will to advance along a new economic frontier. The creation of an innovative economic sector requires visionary leadership at all levels of a community. A shared community vision combined with supportive public policies and creative and persistent entrepreneurs are critical to the development of a new economic sector. This section examines the demonstrated and potential leadership capacity of mid-Michigan to develop and sustain a bio-based manufacturing sector.

The ability to access sufficient capital resources to finance a bio-based manufacturing facility estimated to cost $200-250 million is critical to the development of this new industrial sector. Both short-term and long-term public and private financing need to be secured to provide capital for a bio-manufacturing initiative to develop and refine its bio-manufacturing processes and develop stable markets for its bio-products.

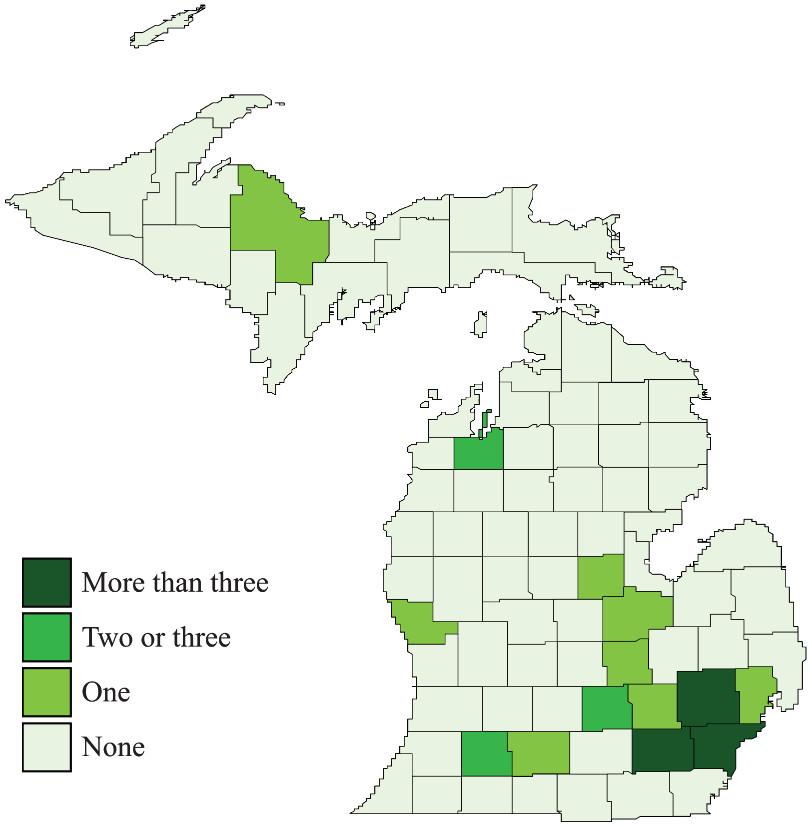
6.2 Venture Capital Firms in the Region

Access to private sector venture capital in the early start up phases is critical. Venture capital firms are less risk averse in their investment decisions than other private investors, but they expect generous rates of return on their early stage, high-risk investments. Venture capitalists also take a keen interest in emerging firms and research indicates they often prefer close proximity to their investments. Thus, one way of assessing the capacity to grow a bio-manufacturing sector is to identify the number of venture capital firms in a region. In the map below, the distribution of venture capital firms in Michigan in 2007 is presented.

Figure 6-1

Number of Michigan Venture Capital Firms

By County



Source: Michigan Business/Organization Directory.

A list of venture capital firms was obtained for this study from the Michigan Business/Organization Directory. Most venture capital firms are concentrated in Southeastern Michigan. Three venture capital firms were identified in Ingham County. None were identified in Eaton County or Clinton County; however, a few were identified in surrounding counties. Nearby venture capital firms may still benefit the Tri-County region by providing financing to develop the region's bio-based economic sector (complete list in appendix E).

Figure 6-2

Venture Capital Firms in the Tri-County and Nearby Regions

Firm	City	County	Type
Capital Area Investments	Lansing	Ingham	Venture
Michigan Homeland Security Consortium	Lansing	Ingham	Venture
Capital Community Angels	East Lansing	Ingham	Angel
Ann Arbor SPARK	Ann Arbor	Washtenaw	Angel

Source: Michigan Business/Organization Directory.

Risks are of course associated with investing in a young, not-yet-mature economic sector. Since venture capital firms are more familiar with investments in more established areas like telecommunications, oil discovery and production, real estate development, agricultural commodities, and traditional manufacturing, investing in the bio-manufacturing sector may take investors to relatively uncharted territory.

Venture capital virtually always plays a critical role in the start-up of new enterprises. However other forms of capital, longer-term debt, and equity investments are also necessary to fully capitalize bio-manufacturing development.

6.3 Community Financing and Biorefinery Cooperatives

Many communities face the realities of inadequate private financing for the construction of biorefineries and other bio-manufacturing cluster development. Biorefinery capital costs are expected in the $200-250 million range with annual operating costs in the $60-100 million range.

An attractive alternative to private financing may exist in cooperatively-owned biorefineries. Communities may want to consider this method of financing as there are the added benefits of providing a measure of local control and a mechanism to generate local wealth (returns on investments to local investors).

Cooperatives offer a sustainable profit stream for local farmers to hedge against market fluctuations. When corn and other commodity prices are high, farmers can benefit from selling their crops for bio-manufacturing feedstocks or food. However, when crop prices slump, farmers with a stake in a local biorefinery cooperative can still benefit from sales revenue from biofuels and other bio-based products. Farmer-owned cooperatives are of course not new. As early as the nineteenth century, cooperatives were formed in the U.S. and by 1930 the number had reached 30,000 locally-owned cooperatives.

Biorefinery co-ops are found across the globe from Australia to California to Mississippi. There are 42 locally owned ethanol plants out of 141 in the United States, or about 30% of the plants with many in the Midwest. Minnesota is the state most supportive of biorefinery co-ops providing state incentives for locally-owned bioeconomy facilities. Minnesota's effort – known as the Minnesota Model – has led to over a dozen smaller and medium-sized plants that generate $3 for every dollar invested.

As bio-manufacturing emerges as a new industry with the potential to reinvigorate both the agricultural and manufacturing sectors, biorefinery cooperatives can offer farmers, manufacturers and residents a direct financial stake in their economic future. Mid-Michigan leaders, farmers, manufacturing workers, local governments, and other residents may want to consider forming a community-owned bio-refinery with monetary investments made by all who participate through ownership and have a direct stake in the region's economic success.

6.4 Public Sector Funding and Resources

In addition to capital available through traditional and innovative private sector investments, entrepreneurs engaged in bio-manufacturing can seek assistance from public programs that help capitalize land acquisition, manufacturing infrastructure, and assist with labor training and development costs. In Figure 6-3 public programs are listed that offer financial assistance to bio-manufacturing facility and/or related infrastructure initiatives in mid-Michigan. Appendix H provides additional detail for these programs.

Figure 6-3

State and Federal Incentives for Bio-based Economic Development

Type	Program	Source
State	Biomass Energy Program Grants	Michigan Dept. of Labor and Economic Growth
State	21st Century Jobs Fund	Michigan 21st Century Investment Fund, LP
State	MEGA High-Tech Jobs Creation Tex Credit	Michigan Economic Development Corporation
Federal	Small Business Innovation Research (SBIR)	Small Business Administration
State	The Economic Development Job Training (EDJT)	Michigan Economic Development Corporation
State	Michigan Economic Growth Authority Tax Credit	
State	Michigan Economic Growth Authority	The Geography of Incentives, Good Jobs First
State	Transportation Economic Development Fund	The Geography of Incentives, Good Jobs First
State	Industrial Facility Property Tax Exemption	The Geography of Incentives, Good Jobs First
State	Renaissance Zones	Michigan Economic Development Corporation
State	Job Creation Tax Credit	Michigan Economic Development Corporation
State	Capital Access Program	Michigan Economic Development Corporation
State	Employee Ownership Program	Dept. of Labor and Economic Growth
State	Industrial Development Revenue Bonds (IDRB)	
State	Singles Business Tax	
State	Michigan SmartZones	Michigan Economic Development Corporation
State	Urban Land Assembly Program	Michigan Legislature
State	Michigan Life Sciences Corridor	
Federal	Economic Adjustment Assistance	http://www.eda.gov/
Federal	Indian Employment Assistance	
Federal	Economic Development Technical Assistance	http://www.eda.gov/
Federal	Grants for Public Works and Economic Development Facilities	http://www.eda.gov/
Federal	Economic Development Support for Planning Organizations	
Federal	Trade Adjustment Assistance	

Source: MSU Land Policy Institute.

6.5 Industry Support Networks and Private Sector Leadership

Communities with a strong business sector are often built, at least in part, upon strong industry support networks. These networks facilitate building coalitions, accessing resources, sharing knowledge, and advocating public and private policies and practices to improve the market performance of that sector. The close proximity of a cluster attracts more people engaged in that economic sector and thereby builds the economy of that region. Clusters also facilitate and promote faster technology advances. Jobs are created and this cluster economic activity can also result in transferring innovative ideas, information, and data which may lead to development of more efficient technology.

Currently there is no bio-manufacturing support network in the region. The formation of such a group could more effectively advance the development of a bio-manufacturing sector.

The Tri-County Region does have effective industry and other support networks that may have interests in the advancement of the region's bio-manufacturing economy. These organizations may complement and indeed support the feasibility of a bio-manufacturing sector in the region by helping to fill the gaps that are relevant to the new sector in areas like education for example. The following list includes existing peer support networks that may be of potential assistance to an emerging regional bio-manufacturing sector.

- The **Capital Area Manufacturing Council** provides a forum for which information and knowledge can be discussed on common issues. The council offers manufacturing skills training employment programs to educate workers in areas in which they lack knowledge.

- The **Michigan Agriculture Business Association** shows natural interest in the bioeconomy by encouraging development of agriculture business. This association is well aware of the importance of educating employees and promoting informational programs to be knowledgeable for the job positions.
- The **Prima Civitas Foundation** (PCF) focuses on job growth to promote economic development in Mid-Michigan. PCF helps support the bioeconomy in Michigan by recruiting workers and providing training opportunities for the new bio-technology jobs that are brought to the Tri-County area. The foundation encourages research for alternative energy as well as developing next generation transportation.
- **Lansing Economic Area Partnership** (LEAP) is a regional economic development collaborative founded in 2007 that focuses on integrating emerging industries, talent and research with business incentives, leadership training, and other programs for a strong economic future through a collaborative regional model.

These regional networks may be positioned to promote development of a new bio-manufacturing sector that complements or even expands their own respective economic sectors. As a bio-manufacturing sector emerges, a specific industrial promotion network for the new sector could spin-off from these existing organizations (see summary and recommendation section).

The region has outstanding private-sector leadership committed to a strong bioeconomy in mid-Michigan. Leaders of these companies, some of which are "spin-offs" resulting from research at Michigan State University, are helping to define the future of the global bioeconomy while fostering an emerging economic sector in the region.

- **Michigan Brewing Company** and **Working Bugs** work together to create products that use bio-chemicals and bio-fuels in their manufacturing.
- **KTM Industries** creates Green Cell biodegradable foam cushions to protect products in shipping. The Green Cell foam is similar to Styrofoam, but biodegradable.
- **EcoSynthetix** uses products to replace petroleum-bases products with nanobiomaterials. This company's vision is to create biomaterials that would wean companies from petroleum-based materials.
- **Woodbridge Group** concentrates on producing materials for automotive manufacturing using urethane technologies.

6.6 Public Sector Leadership and Policy Support

A demonstrated commitment to bioeconomy development by the public sector – state, local and higher educational institutions – provides a key advantage to regions seeking to become leaders in emerging bio-industries. Michigan and the Lansing region have been innovators in both developing new technologies in the bioeconomy and in fostering the public-sector leadership commitment and favorable intellectual/business climate for bioeconomy, and specifically, bio-manufacturing growth.

6.6.1 State and University Leadership and Public Policies

State political leaders have demonstrated a high-profile commitment to positioning Michigan as a world leader in cutting-edge bio-based technologies that deliver alternative renewable fuels, eco-friendly consumer products, and a sustainable environment.

Governor Jennifer Granholm has made the bioeconomy a central component of her economic development strategy. She has led numerous trade missions to Europe to open international bioeconomy markets to Michigan firms and attract international investments to the state. In addition, her call for increased alternative fuel production in Michigan and incentives for other green energy production have helped create new jobs and push Michigan's leadership in alternative biofuels and energy production. The state legislature is currently working on bills to create renewable portfolio standards and reduce Michigan's dependence on foreign oil.

Moreover, Michigan State University's leadership in the bioeconomy goes well beyond that of a typical intellectual and research hub. President Dr. Lou Anna K. Simon has lead her administration in a broad commitment to not only advancing research to benefit scholarship, but in the true land grant tradition, research to improve the quality of life for Michigan's residents and foster economic development across the state and in the Lansing region.

President Simon unveiled her Boldness by Design Initiative in her 2006 State of the University Address. This initiative is designed to harness the university's agricultural and economic development research and outreach resources to make MSU a leader in cutting-edge research in alternative fuels and bio-based products. Leveraging this research can lead to job creation in the state and Tri-County Region.

President Simon stated in her address, "(MSU's Office of Bio-based Technologies) is …a dramatic step toward an economy powered by strategic partnerships among states, research universities and industry… our preeminent scientists are dedicated to addressing problems and opportunities of today, but, more importantly, of the future partnerships among states, research universities and industry."

6.6.2 Community Support for the Development and Growth of a Bioeconomy

In addition to providing financial and other support to development of a bio-manufacturing sector, community planning and economic development organizations can provide a "pre-development readiness" for this emerging sector. This leadership is demonstrated by, for example, the Tri-County Regional Planning Commission, Michigan State University, Lansing Community College and numerous community supporters in developing this feasibility study and companion reports on workforce displacement and retraining programs.

Lansing Mayor Virg Bernero demonstrated his commitment to a stronger and sustainable mid-Michigan in his 2006 State of the City Address by announcing the city's effort to utilize more fuel-efficient and flex-fuel capable vehicles reduce its carbon footprint. The mayor also stated his committment to bio-manufacturing job growth in Lansing and the region.

However, education and information outreach are critically needed. In a 2007 survey of local and regional planners conducted by the MSU CCED with the Michigan Association of Planning, only 14% of respondents indicated that their communities have planning policies or zoning ordinances that support the development and growth of a bioeconomy; 53% do not. About 33% percent of the communities were unaware of whether they even have such plans or ordinances. The Tri-County Region is providing exemplary leadership in assessing the feasibility of bio-manufacturing development for the region.

6.7 Targeted Community Action to Develop the Local/Regional Bioeconomy

Communities have important opportunities to leverage their regional assets, provide incentives, and create catalysts to support the growth of global bioeconomy clusters. Regional leaders can connect regional businesses to emerging U.S. and global markets, and streamline services and due diligence for venture capital and bio-manufacturing firms willing to relocate to clusters developing in the region.

Fostering collaboration among government, business, education and other stakeholders is essential to the growth of the bioeconomy as new paradigms transform the bioeconomy and bio-manufacturing sector. Industry clusters can leverage local assets like industrial specialization and expertise, Great Lakes quality of life, and unique intellectual expertise to attract new firms and investors. Collaborative strategies to fashion a "purposeful response to change" throughout the business cycle from discovery/invention to commercial maturity are also critical to creating bioeconomy clusters.

6.7.1 Ontario Case Study of Regional Clustering: Southwestern Ontario Bioproducts Innovation Network (SOBIN)

In 2005, Southwestern Ontario, Canada formed a bio-products innovation network to leverage its manufacturing and agriculture sectors and link these sectors with cutting-edge research and other regional assets to become a world leader in automotive bio-manufacturing. The Southwestern Ontario Bioproducts Innnovation Network (SOBIN) partners with industry and government to ensure effective reuse of industrial lands, to cultivate synergies between related companies, and help companies maximize resources and minimize waste. This type of regional network may be relevant to mid-Michigan needs and is described below.

Figure 6-4

Southwestern Ontario Bioproducts Innovation Network (SOBIN)

Source: Southwestern Ontario Bioproducts Innovation Network. Retrieved September 2, 2008, from http://www.sobin.ca/

6.8 Section Summary

The Tri-County Region's leadership assets are considerable with the clear potential to support development of a regional bio-based manufacturing sector. Assets include organizational leadership, state and university commitment to bioeconomy development, and an extensive portfolio of public resources to support an emerging bio-manufacturing sector.

Challenges include accessing private capital to finance this sector. However, strong, well informed leadership could create innovative ways to structure deals and capitalize early development of a bio-manufacturing cluster.

Close proximity to agricultural feedstocks, intellectual commitment and capacity, manufacturing and agricultural expertise, and a natural resource base provide a solid platform for locating bio-manufacturing facilities in the Tri County Region.

7. Executive Summary and Project Recommendations

7.1 Overview

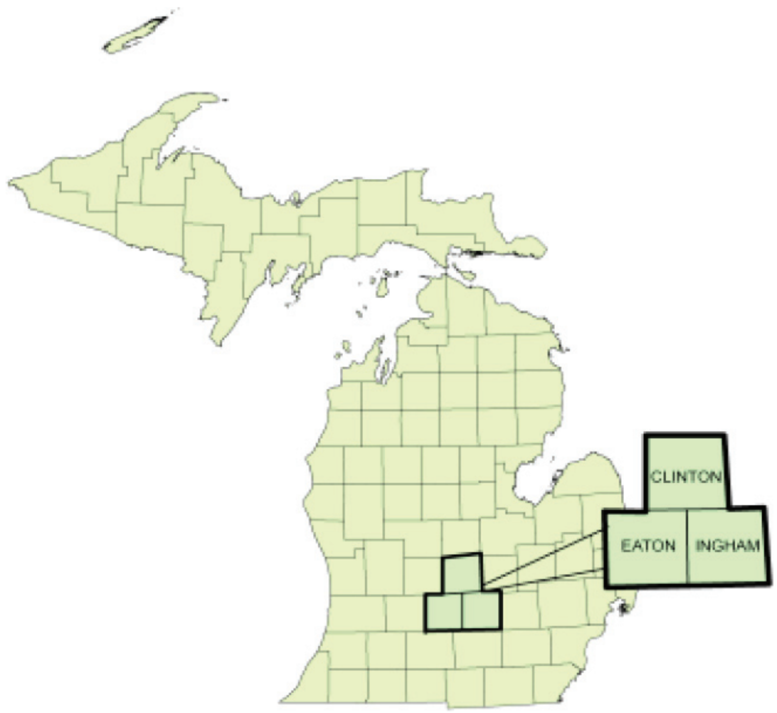
Communities and companies around the world are recognizing the economic and environmental benefits of the bioeconomy-- "going green"--and supporting and developing production processes and products that rely on renewable, bio-degradable natural resource-based and agricultural materials. Indeed it is a new global reality.

Given its historic competitive advantages in both its manufacturing and agricultural sectors, the Lansing Tri-County Region may be uniquely positioned to lead the development of the state's bioeconomy.

The MSU Center for Community & Economic Development Program (MSU CCED) examined the Tri-County Region's current and potential role in the emerging bio-manufacturing sector as part of a project with partial financial support from the U.S. Department of Commerce Economic Development Administration. Bio-based inputs, including agricultural and natural resources, and the labor base, infrastructure capacity, intellectual capabilities, leadership, and access to capital were analyzed. The project team assessed the feasibility of the development of a bio-manufacturing sector in the Tri-County Region based on this information and data.

Figure 7-1

The Lansing Tri-County Region



Source: MSU Center for Community & Economic Development.

This feasibility study provides ***an evidential base from which communities may make informed decisions about investing in an alternative community and economic development future focused on bio-manufacturing***. The predictive reliability of a feasibility study is limited in part by the appropriateness of its research methods and the accuracy of the data analyzed. It is rarely possible to accurately predict the willingness of stakeholders to take informed risks, change behaviors and blaze a new path into an uncertain future. While every reasonable effort was made to insure a realistic assessment of future development, only one certainty exists and that is the future is ever changing and largely unknown.

The research team has sought to improve the reliability of this study by utilizing a previously-developed feasibility model of a new emerging industry sector and incorporating some of the more traditional elements of business feasibility studies employed by planners and economic developers. The research team also relied on the ongoing advice and guidance of its Technical Advisory Committee. Consultation and the advice of scholars, industry managers, and community leaders were routinely sought as data and information were gathered, sorted, and interpreted. The study examined data and information for the region in the following five areas:

- Demographic and Employment Profile
- Agriculture/Natural Resources/Environment Profile
- Industrial and Infrastructure Capacity
- Intellectual Capabilities
- Leadership Commitment

7.2 Key Performance Factors in the Emerging Bio-Manufacturing Sector of the New Global Bioeconomy

Relevant U.S. and international cases were studied, particularly those from the European Union. Bio-manufacturing research, industry definitions, principles and products for automotive, bio-manufacturing were reviewed to identify current industry standards and evaluate market potential. Global firms engaged in automotive bio-manufacturing production were studied to identify their production inputs, products, and supply chains. Key levels of inputs needed for bioproducts including agricultural and other natural resource inputs, labor skills, infrastructure, technology transfer and others, were then benchmarked and the Tri-County Region's performance for each factor was assessed to determine the feasibility of bio-manufacturing in the region (MSU Office of Bio-Based Technologies, 2006).

The region's strengths and weaknesses were determined for five key performance factors in the bio-manufacturing sector of the bioeconomy and 17 indicators based on the evaluation and analysis of information generated from an extensive literature review, over 35 key informant interviews, and periodic reviews by the technical advisory committee. The following matrix summarizes the findings for the region's capacity and performance in the emerging bio-manufacturing sector. A green up arrow indicates a strength; a down red arrow indicates a weakness, and a purple square represents an undetermined position for that particular benchmark. Preliminary findings of the study were filtered through the Technical Advisory Committee before the project findings were finalized. These findings as presented in Figure 1 were used to inform the recommendations to regional leaders and stakeholders interested in bio-based economic development.

Figure 7-2

Evaluating Regional Capacity and Performance in the Emerging Automotive Bio-Manufacturing Sector Summary of Findings

Legend

▲ Regional Strength

▼ Regional Weakness

■ Inconclusive Data

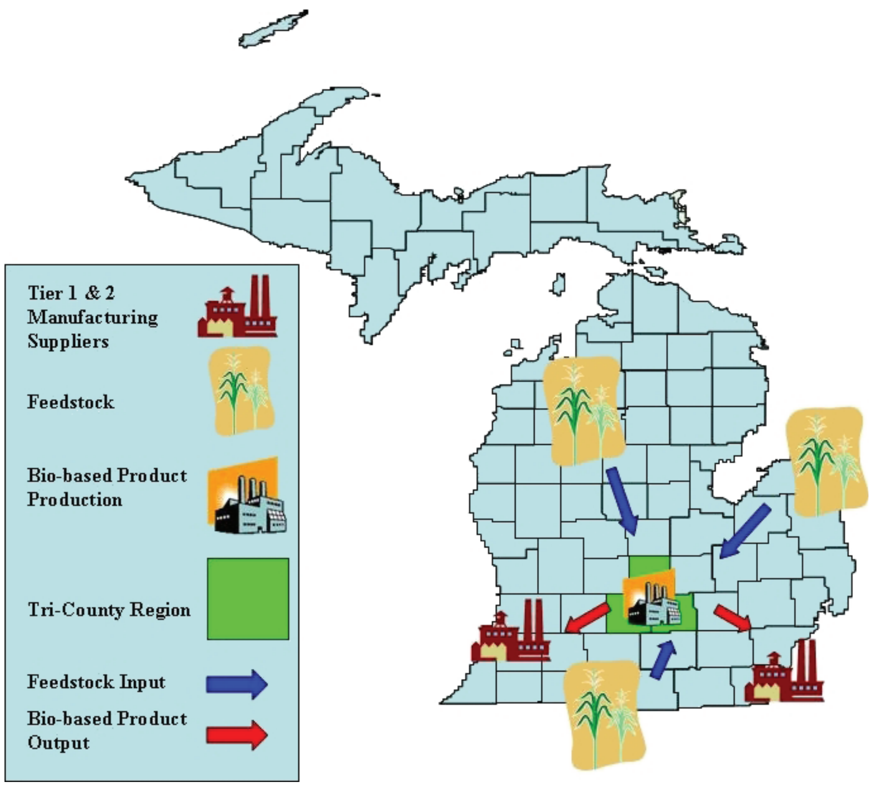
7.3 Assessing the Tri-County Region's Position in the Emerging Bio-Manufacturing Sector

The MSU CCED analysis here indicates that the Tri-County Region ***has the potential to develop a competitive edge in bio-manufacturing given the region's manufacturing strength, accessible agricultural base, skilled labor force and unparalleled higher education research in the bioeconomy***. In addition, the well-developed network of automotive, chemical, plastics and related manufacturing firms and suppliers in the region offers clear market potential for locally-manufactured bio-products. Stronger public and private-sector leadership willing to adopt policies and business models that utilize green products needs to emerge to capture this important new market.

The Lansing Tri-County Region's emerging bio-based economy is structured on the availability of various necessary inputs, existing and emerging markets, and required infrastructure. Readily accessible feedstock supplied by nearby agricultural producers provides the bio-material input without excessive transportation costs. Centralized location, available trained workforce, access to knowledge and innovation, and existing industrial infrastructure and facilities allow the Tri-County Region to provide an effective center to collect and process feedstocks into bio-based products. The region's commanding central location gives it the position to implement of efficient distribution of bio-based products throughout the region, state, and regional automotive manufacturing centers and tier one and two suppliers.

Figure 7-3

The Future of the Lansing Tri-County Region in the Bio-Based Economy



The Tri-County Region shows substantial strength for three of the five performance factors with mixed indicators for two of the factors. The region is strongest with its industrial infrastructure and transportation capacity and relatively strong for food and non-food feedstocks and intellectual capabilities. The region lags in terms of its immediate bio-product market potential and leadership capacity indicators although one strong indicator is Michigan State University's firm commitment to the development of a regional and state bioeconomy. The region's distinct advantage in having a world-class research institution strongly supporting development of a regional bioeconomy could clearly leverage other regional assets and improve performance for those indicators where the region lagged.

The Lansing Tri-County Region's ability to create and sustain a bio-manufacturing economy will depend in large part on the region's inventive intellectual talents in developing new methods of production, products and markets. The bio-manufacturing sector rapidly changes as an emerging component of the fast-paced expansion of the global knowledge economy. Communities that are early adapters will face significant "start-up challenges" but will have the potential to position themselves as bio-manufacturing centers with significant potential to expand in the years ahead.

The Tri-County Region also faces critical challenges including:

- Underdeveloped regional market to support production of automotive and other types of bio-products

- Lack of cellulosic biomass from forest resources for biofuels and bio-products
- Lack of available private sector and public financing in place to support bio-manufacturing production and facilities
- Weak public sector commitment at the local planning and economic development level as well as other public policy that fosters the growth of a regional bio-manufacturing sector
- Absence of a bioeconomy industry network to foster development of a bio-manufacturing sector in the Tri-County Region.

Strategic repositioning of regional resources and capacity can effectively answer these challenges.

There are three areas for which the data are inconclusive: the length of the growing season; the sufficiency of the region's technology transfer capacity; and leadership capacity to position the region to successfully compete in the rapidly-evolving bio-manufacturing sector of the global bioeconomy.

Technology-led economic development offers vast potential for generating wealth for individuals and communities who are creative and talented, and have a modern IT infrastructure and foresight to strategically plan to successfully compete in an innovation-based, post-petroleum global economy. Many of these characteristics are favored by "university towns" like the Tri-County Region where public and private investments in the generation and application of knowledge has been a long-term priority. Communities with research and development capacity will tend to do well in the emerging technology-led global knowledge economy. However, the region must demonstrate the intellectual drive and boldness in the market place to take the risks necessary to advance the region in the early development of the global bioeconomy.

7.4 Recommendations

Based on the analysis of the feasibility study and the summary matrix presented above, the research team recommends the following actions to the leadership of the Lansing Tri-County Region:

- Establish a Lansing Tri-County Region bio-manufacturing industry network that includes private sector leaders from the manufacturing and agricultural crop production sectors with the participation of the region's higher education institutions and regional economic development organizations. The Tri-County Region Bio-manufacturing Network would:
    - Work with companies in the automotive, agricultural, energy and chemical sectors to identify opportunities that advance the development of bio-products and bio-manufacturing in the region.
    - Partner with the research community to identify research needs associated with the development of bio-products and bio-manufacturing processes.
    - Identify and access funding to promote innovation in bio-products and bio-manufacturing.
    - Identify companies interested in making immediate investments in the development and marketing of bio-products,
    - Work with local economic development officials on initiatives to support bio-manufacturing processing improvements, pilot scale production, testing and evaluation, commercial-scale production, and market development of regionally-produced bio-products.
    - Assist small and medium size businesses in evaluating the performance of new regionally-produced bio-products.
- Work to educate public officials and policymakers about the emerging bio-manufacturing sector so that sound planning and economic development decisions are supported consistent with the growth of a bio-manufacturing sector in the region.
- Formulate strategies to raise private-sector capital and leverage the capacity of the new regional bio-manufacturing industry network to administer community financing efforts and establish a regional bio-manufacturing cooperative.

The Tri-County Region's outstanding manufacturing, agriculture and research capacity makes the region a potential major player in the emerging bio-manufacturing sector of the global bioeconomy. A collaborative public-private partnership that can leverage the region's strengths while working to fortify areas of regional weaknesses can help strengthen the agricultural, manufacturing and intellectual connections and ensure that the Lansing Tri-County Region competes successfully in the emerging global bio-manufacturing sector.

The research team expresses its sincere gratitude to our collaborating partners and supporters who assisted the development of this feasibility study, and are already providing visionary leadership to grow a strong regional bioeconomy. As we work creating, disseminating, and applying knowledge to improve quality of life and realize the region's full economic potential, we are very appreciative for the invaluable support of those who shared their expertise and insights. Bold leadership is needed to help our region continue its pursuit of creating a vibrant, healthy economy that balances the environmental, social and economic domains while seizing new opportunities for regional growth in the emerging bioeconomy. Our partners and supporters remain integral parts of our capacity to effectively implement, evaluate, and communicate innovative strategic approaches through responsive engagement and collaborative learning.

As the Lansing Tri-County Region continues to cultivate the seeds of bioeconomy development, we hope that the findings of this feasibility study instigate future dialogue to spur innovative strategic partnerships that are critical to the region's future in the bioeconomy.

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Appendices

Appendix A
Glossary

Biodiesel: A liquid biofuel suitable as a diesel fuel substitute or diesel fuel additive or extender. Biodiesel is typically made from oils (e.g., soybean, rapeseed, or sunflower) or animal fats. Biodiesel can also be made from hydrocarbons derived from agricultural products such as rice hulls.

Biofuels: Liquid fuels and blending components produced from biomass (plant) feedstocks, used primarily for transportation.

Biomass: "Any organic matter that is available on a renewable or recurring basis, including agricultural crops and trees, wood and wood wastes, plants (including aquatic plants), grasses, residues, fibers, and animal wastes, municipal wastes, and other waste materials." (Biomass Research and Development Act of 2000 7 USC 7624 Note.)

Biopolymers: A polymer comprised, at least in part, of building blocks called monomers, produced in a biorefinery from renewable feedstocks such as corn.

Biorefineries: "A biorefinery is a facility that integrates biomass conversion processes and equipment to produce fuels, power, and chemicals. The biorefinery concept is analogous to petroleum refineries, which produce multiple fuels and products from petroleum." (National Renewable Energy Laboratory, Biomass Research.)

Biotechnology: The use of enzymes and metabolic processes of living organisms (often micro-organisms) to produce chemicals that have medical, environmental, or economic value. "Biotechnology is the integrated application of natural and engineering sciences for the technological use of living organisms, cells, parts thereof and molecular analogues for the production of goods and services." Biotechnology thus consists of the use of living organisms or parts thereof, to make or modify products, improve plants and animals, or develop micro-organisms for specific purposes. (European Federation for Biotechnology as cited by Royal Belgian Academy of Applied Science. [2004, January]. *Industrial Biotechnology and Sustainable Chemistry*.)

Enzymes: Biologically-derived, biodegradable proteins that speed up chemical reactions. For example, in a biorefinery producing cellulosic ethanol and other chemicals, a group of enzymes called cellulases needed to break down cellulose into sugars that can be fermented to produce desired products.

Ethanol: A clear, colorless, flammable, oxygenated hydrocarbon (CH3-CH2OH). In addition to its uses as a chemical, ethanol is also a liquid biofuel that can be used as a substitute for, or blended with, gasoline. It is produced by fermenting sugars from carbohydrates found in agricultural crops and cellulosic residues. In the U.S., the biofuel is produced mainly from corn. Cellulosic ethanol is produced from lignocellulosic feedstocks (cellulosic residues), including agricultural residues (e.g., corn stover), forestry residues (e.g., wood chips), energy crops (e.g., switchgrass), and municipal waste. It is also used in the U.S. as a gasoline octane enhancer and oxygenate (blended up to 10 percent concentration, also called E10). Ethanol can also be used in high concentrations (E85, a blend of 85 percent ethanol and 15 percent gasoline) in vehicles designed for its use, which are usually called flex-fuel vehicles.

Fermentation: The use of micro-organisms to break down complex compounds into simpler ones.

Flex-fuel vehicle: A vehicle that can operate on:

1) alternative fuels (such as E85),
2) 100 percent petroleum-based fuels, or
3) Any mixture of an alternative fuel (or fuels) and a petroleum-based fuel.

Flex-fuel vehicles have a single fuel system to handle alternative and petroleum-based fuels.

Greenhouse gases (GHG): Those gases, such as water vapor, carbon dioxide, nitrous oxide, methane, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride, that are transparent to solar (short-wave) radiant energy but opaque to long-wave (infrared) radiation, thus preventing long-wave radiant energy from leaving the Earth's atmosphere. The net effect is to trap absorbed radiation and warm the planet's surface.

Industrial Biotechnology (or white biotechnology): Distinct from medical (red biotech) and agricultural biotechnology (green biotech), industrial biotechnology is "the application of modern biotechnology for the industrial production of chemical substances and bioenergy, using living cells and their enzymes, resulting in inherently clean processes with minimum waste generation and energy use." (Royal Belgian Academy of Applied Science. [2004, January]. *Industrial Biotechnology and Sustainable Chemistry*.)

Patent: A set of exclusive rights granted by the government to an inventor or his assignee for a fixed period of time, usually 20 years, in exchange for the public disclosure of an invention.

Trademark: A word, symbol, device that is used in trade with goods to indicate the source of the goods and to distinguish them from the goods of others.

Source: United States International Trade Commission. (2008, July). *Industrial Biotechnology: Development and Adoption by the U.S. Chemical and Biofuel Industries* (USITC Publication No. 4020). Washington, DC: Author.

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Appendix C
Tri-County Precipitation and Average Daily Temperatures

Tri-County Precipitation
2001 – 2007

Month	2001	2002	2003	2004	2005	2006	2007
January	0.65	0.98	0.24	0.91	4.39	4.14	2.13
February	2.79	1.37	0.32	0.55	2.02	1.72	0.47
March	0.14	1.67	1.57	3.35	1.35	2.64	2.66
April	2.68	2.29	2.82	0.68	1.05	1.82	3.37
May	6.06	3.56	3.97	10.44	1.72	4.74	3.49
June	3.64	1.67	1.88	3.08	5.49	1.60	3.09
July	1.25	4.37	1.84	3.80	5.76	4.05	0.71
August	2.33	1.94	1.27	3.19	0.74	3.41	6.42
September	3.23	0.65	2.06	1.02	2.78	3.07	1.86
October	5.69	1.21	1.84	1.92	0.57	2.95	3.36
November	2.25	1.43	5.62	4.02	4.53	3.75	1.36
December	1.13	0.79	1.43	1.84	1.91	3.07	1.26
Total	**31.84**	**21.93**	**24.86**	**34.80**	**32.31**	**36.96**	**30.18**

Tri-County Temperatures
2001-2007

Month	2001	2002	2003	2004	2005	2006	2007
January	24.7	30.5	17.6	16.4	21.8	33.2	26.4
February	26.5	29.7	19.9	23.3	28.2	25.4	17.2
March	31.9	31.5	32.3	38.8	30.8	35.7	39.4
April	48.9	47.3	45.3	48.3	50.2	50.3	44.6
May	59.2	51.8	53.8	58.2	54.7	58.2	60.5
June	66.3	68.6	63.5	65.0	72.7	66.6	68.9
July	69.7	73.2	69.0	68.9	72.8	73.7	70.3
August	70.8	69.3	69.7	65.1	72.8	69.8	71.4
September	58.6	64.6	60.8	64.7	66.8	59.1	64.5
October	49.9	46.4	48.2	51.3	52.6	46.4	56.4
November	46.3	36.3	41.2	40.4	41.8	40.9	37.6
December	34.2	26.8	30.7	28.2	25.3	34.8	25.7
Total Average	**48.9**	**48.0**	**46.0**	**47.4**	**49.2**	**49.5**	**48.6**

Source: National Oceanic and Atmospheric Administration, National Weather Service.

Appendix D
Tri-County Regional Road Data

Rural Mileage

County	Interstates	Principal Arterials (Non-Freeway)	Principal Arterials	Minor Arterials	Major Collectors	Minor Collectors	Local Roads	Total
Clinton	23.326	17.827	28.430	46.292	246.612	44.729	757.060	1,164.326
Eaton	31.336	1.778	0.000	84.700	246.570	48.557	668.474	1,081.415
Ingham	74.422	19.605	55.055	184.564	731.504	111.197	2,014.269	3,190.616

Urban Mileage

County	Interstates	Principal Arterial Freeways	Principal Arterials (Non-Freeways)	Minor Arterials	Urban Collectors	Local Roads	Total
Clinton	56.107	22.591	19.305	52.862	22.023	156.985	329.873
Eaton	70.213	0.000	24.749	84.631	62.925	252.336	494.854
Ingham	194.209	50.008	122.357	292.137	197.778	1,099.976	1,956.456

Tri-County Total Mileage: 8,217.549

Source: Tri-County Regional Planning Commission

Appendix E
Venture Capital Firms in Michigan

Firm	City	County	Type
Detroit Community Loan Fund	Detroit	Wayne	Venture
Dearborn Capital Corporation	Dearborn	Wayne	Venture
Detroit Investment Fund	Detroit	Wayne	Venture
Nationwide Business Consultants	Flat Rock	Wayne	Venture
Peninsula Capital Partners	Detroit	Wayne	Venture
Ralph Wilson Equity Fund	Grosse Pointe Park	Wayne	Venture
Sterling Capital Funding	Dearborn	Wayne	Venture
Small Business Administration (SBA)	Detroit	Wayne	Venture
Masco	Taylor	Wayne	Private Equity
Oracle Capital Partners	Detroit	Wayne	Private Equity
DTE Energy	Detroit	Wayne	Corporate Venture
Sweet Angel Vending	Detroit	Wayne	Angel
Arbor Partners	Ann Arbor	Washtenaw	Venture
Arboretum Ventures	Ann Arbor	Washtenaw	Venture
Ardesta	Ann Arbor	Washtenaw	Venture
EDF Ventures	Ann Arbor	Washtenaw	Venture
Endurance Ventures	Ann Arbor	Washtenaw	Venture
MacBeedon Partners	Ann Arbor	Washtenaw	Venture
Plymouth Venture Partners	Ann Arbor	Washtenaw	Venture
Wolverine Venture Fund	Ann Arbor	Washtenaw	Venture
Center for Venture Capital and Private Equity	Ann Arbor	Washtenaw	Venture
Enterprise Development Fund	Ann Arbor	Washtenaw	Venture
Essex Woodlands Health	Ann Arbor	Washtenaw	Venture
North Coast Technology Investors	Ann Arbor	Washtenaw	Venture
Syneptics	Ann Arbor	Washtenaw	Venture
The Toxicology Group	Ann Arbor	Washtenaw	Venture
Tullis-Dickerson & Co., Inc	Ann Arbor	Washtenaw	Venture
Waypoint Ventures	Ann Arbor	Washtenaw	Venture
White Pines Venture	Ann Arbor	Washtenaw	Venture
RPM Ventures	Ann Arbor	Washtenaw	Venture
Ann Arbor Angels	Ann Arbor	Washtenaw	Angel
MarketPoint Investers	Ann Arbor	Washtenaw	Angel
Bank of Ann Arbor	Ann Arbor	Washtenaw	Angel
Makati Capital Management	New Haven	Shiawassee	Venture
Bluewater Financial Services	East China	Saint Clair	Angel
Wirt-Rivette Finance	Saginaw	Saginaw	Venture
Grand Angels	Holland	Ottawa	Angel
Seneca Partners	Birmingham	Oakland	Venture
Valenti Capital	Bloomfield Hills	Oakland	Venture
Blue Water Capital	Birmingham	Oakland	Venture
Detroit Technology Ventures	Bloomfield Hills	Oakland	Venture
Economic Energy Solutions	Rochester Hills	Oakland	Venture
Long Point Capital	Royal Oak	Oakland	Venture
MedCap Leasing	Troy	Oakland	Venture

Options Investment Group	Troy	Oakland	Venture
Parr Enterprises	Rochester Hills	Oakland	Venture
Real Estate Investor Solutions	Southfield	Oakland	Venture
Sandad	Birmingham	Oakland	Venture
Sloan Ventures	Birmingham	Oakland	Venture
Strength Capital Partners	Birmingham	Oakland	Venture
Vacation Finance	Birmingham	Oakland	Venture
Wind Point Partners	Southfield	Oakland	Venture
Wingspan Venture Partners	Troy	Oakland	Venture
Beringea	Farmington Hills	Oakland	Private Equity
Delphi Corporation	Troy	Oakland	Corporate Venture
Great Lakes Angels	Bloomfield Hills	Oakland	Angel
Hennessey Capital Solutions	Huntington Woods	Oakland	Angel
David Stradal & Associates	Muskegon	Muskegon	Venture
Dow Chemical	Midland	Midland	Corporate Venture
Telkite Inc	Gwinn	Marquette	Venture
Goodman Factors	Sterling Heights	Macomb	Venture
Entrepreneurial Funding	St. Clair Shores	Macomb	Angel
Accelelrus Technology Group	Green Oak	Livingston	Venture
Bridge Street Capital	Grand Rapids	Kent	Private Equity
NYP Excavating & Construction	Wyoming	Kent	Angel
Apjohn Ventures	Kalamazoo	Kalamazoo	Venture
SWMF Life Science Fund	Kalamazoo	Kalamazoo	Venture
Stryker	Kalamazoo	Kalamazoo	Corporate Venture
First Angels	Kalamazoo	Kalamazoo	Angel
Capital Area Investments	Lansing	Ingham	Venture
Michigan Homeland Security Consortium	Lansing	Ingham	Venture
Capital Community Angels	East Lansing	Ingham	Angel
Digium Cards	Traverse City	Grand Traverse	Venture
The Intelligence Agency	Traverse City	Grand Traverse	Venture
Aurora Angels	Petosky	Emmet	Angel
Hannahville Indian Community	Wilson	Charlevoix	Angel
Maezi's Gifts	Battlecreek	Calhoun	Venture
Raphael Massage Therapy and Bodywork	Three Oaks	Berrien	Angel
Great Lakes Entrepreneur's Quest	Ann Arbor	Washtenaw	Venture
Planned Innovation Institute	Midland	Midland	Angel

Appendix F
Financial Contributors

Meridian Twp EDC
5151 Marsh Road
Okemos, MI 48863

Capital Area United Way
1111 Michigan Ave
East Lansing MI 48823

St Vincent Catholic Charities
2800 W. Willow
Lansing MI 48917

Ingham County EDC
121 E. Maple Street
Mason MI 48854

Delhi Charter Township
2074 Aurelius Road
Holt MI 48842

Charter Township of Lansing
3209 W. Michigan Ave
Lansing MI 48917

MSU Office of the President
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E. Lansing MI 48824-7046

Prima Civitas Foundation
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Lansing MI 48912

Williamstown Twp
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Williamston MI 48895-8180

Michigan State University
Office of Bio-Based Technologies
109 Ag Hall
East Lansing MI 48824

Delta Charter Township
7710 W Saginaw
Lansing MI 48917

Clinton County
100 E. State Street
St Johns MI 48879

Appendix G
Bio-Manufacturing-Related Centers at MSU

MSU-DOE Plant Research Lab
http://www.prl.msu.edu/
East Lansing, MI 48824
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Center for Biobased Renewable Energy
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Steven Pueppke
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Biomass Conversion Research Lab
http://www.everythingbiomass.org/
3270 Engineering Building
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Composite Materials & Structures Center
http://www.egr.msu.edu/cmsc/
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Center for Microbial Technology
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Energy & Automotive Research Laboratories
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(517) 353-9861
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Long-Term Ecological Research Project
http://www.lternet.edu/
3700 East Gull Lake Drive
Hickory Corners, MI 49060
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Phil Robertson
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Center for Nanostructured Biomimetic Interfaces
http://www.biomimetic.org/
2527 Engineering Building
East Lansing, MI 48824
(517) 353-9015

Product Center for Agriculture & Natural Resources
http://www.productcenter.msu.edu/
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http://ced.msu.edu/
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Lansing, MI 48912
(517) 353-9555
Rex LaMore
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Appendix H
State and Federal Incentives for Bio-based Enterprises

Biomass Energy Program Grants

- State
- Incentive Type: State Grant Program
- Target Sector: Nonprofits, schools, local governments, state government
- Description: Provides funding for state bioenergy and biofuels projects on a regular basis
- Source: Michigan Dept. of Labor and Economic Growth

21st Century Jobs Fund

- State
- Incentive Type: State Grant Program
- Target Sector: Universities, non profit research institutions, university research transfer, commercial entities.
- Description: The 21st Century Jobs Fund basic research at universities and non-profit research institutions, applied research, university technology transfer, and the commercialization of products, processes, and services.
- Source: Michigan 21st Century Investment Fund, LP

MEGA High-Tech Jobs Creation Tex Credit

- State
- Incentive Type: Tax Credit
- Description: The objective is to attract new, innovative and cutting-edge companies that specialize in new technologies, such as firms doing advanced computing, biotechnology, electronic device technology, engineering and laboratory testing related to product development, medical device technology, engineering and laboratory testing related to product development, medical device technology, product research and development, advanced vehicle technology or technology which assists in the assessment or prevention of threats or damage to human health or the environment.
- Source: Michigan Economic Development Corporation

Small Business Innovation Research (SBIR)

- Federal
- Incentive Type: Federal Grant
- Target Sector: Michigan companies with matching grants from STTR (Small Business Technology Transfer)
- Description: Grants support the SBIR?STTR Emerging Business Fund Matching Funds Program, for sectors including pharmaceuticals, medical devices, instrumentation, diagnostics and biotechnology, among others
- Source: Small Business Administration

The Economic Development Job Training (EDJT)

- State
- Incentive Type: State Tax Credit
- Description: Not necessarily bio tech
- Source: Michigan Economic Development Corporation

Michigan Economic Growth Authority Tax Credit

- State
- Incentive Type: State Tex Credit
- Target Sector: Instate business, and businesses trying to relocate in Michigan

Michigan Economic Growth Authority

- State
- Incentive Type: State Tax Credits
- Target Sector: Industries in mining, high-tech, research and development, wholesale trade, and office operations
- Description: Tax credits are provided for a maximum of 20 ears
- Source: The Geography of Incentives, Good Jobs First

Transportation Economic Development Fund

- State
- State Grant Program
- Incentive Type: Agriculture, food processing, tourism, forestry, high-tech, research manufacturing, mining and office centers.
- Description: Provide grants to county road commissions, city and village street agencies and/or self administered by Michigan Dept. of Transportation. Grants are for developing transportation infrastructure which will help in creating and/or retaining permanent jobs.
- Source: The Geography of Incentives, Good Jobs First

Industrial Facility Property Tax Exemption

- State
- Incentive Type: Property Tax Reduction
- Target Sector: Industrial or high-tech businesses
- Description: Tax reductions are given as an incentive to create new facilities and/or expand or restore existing ones.
- Source: The Geography of Incentives, Good Jobs First

Renaissance Zones

- State
- Incentive Type: Tax Credit
- Description: To encourage economic activity in designated urban and rural areas of the state by waiving virtually all state and local taxes for up to 15 years. Businesses with a presence in Michigan choosing to relocate Michigan-based jobs to a zone may do so by meeting notification requirements load out in the law
- Source: Michigan Economic Development Corporation

Job Creation Tax Credit

- State
- Incentive Type: Tax Credit
- Description: Each credit may be awarded for up to 20 years. 100 percent of the incremental SBT liability and/or personal income tax attributable to the project.

- Source: Michigan Economic Development Corporation

Capital Access Program

- State
- Incentive Type: Indirect Financing Loan
- Description: The program allows banks to provide access to bank financing for many businesses that might otherwise not qualify. There are no loan size limits. The average loan is approximately $56,000.
- Source: Michigan Economic Development Corporation

Employee Ownership Program

- State
- Incentive Type: Indirect Financing, Business Assistance
- Description: To provide technical assistance to firms, business owners and employees interested in employee ownership and Employee Stock Ownership Plans (ESOPs). To assist business owners with transition strategies involving sale of businesses to Employee Stock Owner
- Source: Dept. of Labor and Economic Growth

Industrial Development Revenue Bonds (IDRB)

- State
- Incentive Type: Direct Financing Bond
- Target Sector: Industrial Development Revenue Bonds (IDRB) can be used as a financing vehicle for manufacturers, solid waste/cogeneration companies and certain private or non-profit corporations.

Singles Business Tax

- State
- Incentive Type: Tax Abatement
- Description: The SBT was instituted in 1975 to consolidate and streamline the tax system for businesses. Businesses with gross receipts of less than $250,000 are not required to file the SBT

Michigan Smart Zones

- State
- Incentive Type: Tax
- Target Sector: The Michigan Economic Development Corporation designated Smart Zones throughout the state. The zones are intended to stimulate the growth of technology-based businesses.
- Description: To stimulate the growth of technology-based businesses and jobs by aiding in the creation of recognized clusters of new and emerging businesses, those primarily focused on commercializing ideas, patents, and other opportunities surrounding universities.
- Source: Michigan Economic Development Corporation

Urban Land Assembly Program

- State
- Incentive Type: Indirect Financing Loan
- Target Sector: Priority is given to proposed projects that have the greatest immediate economic impact.
- Description: The Urban Land Assembly Program is a revolving fund directed toward revitalizing the economic base of cities experiencing distress and decline. It provides loans to eligible municipalities in the acquisition of certain retail property for economic development purposes.

- Source: Michigan Legislature

Michigan Life Sciences Corridor

- State
- Incentive Type: Direct Financing
- Target Sector: Forty percent of the fund (Category I) is allocated for basic research, to be distributed on a competitive basis to Michigan universities or Michigan non-profit research institutes for basic research in health-related areas.
- Description: The purpose is to create, over the next two decades, a Michigan Life Sciences Corridor encompassing the best of academic science along with a robust, entrepreneurial private sector of new and established firms, thereby enhancing economic opportunities and health and well-being.

Economic Adjustment Assistance

- Federal
- Incentive Type: Project Grants
- Target Sector: State, city, county or other political subdivisions
- Description: To address the needs of distressed communities experiencing ad verse economic changes that may occur suddenly or over time, and generally result from industrial or corporate restructuring , new federal laws or requirements; reduction in defense expenditures, depletion of natural reSource: s, or natural disasters.
- Source: http://www.eda.gov/

Indian Employment Assistance

- Federal
- Incentive Type: Direct Payments
- Target Sector: Federally recognized Indian Tribal Governments and Native American Organizations authorized by Indian Tribal Governments may apply to administer the program. Individual American Indian applicants must be a member of a Federally Recognized Indian Tribe, be in need of financial assistance, and reside on or near an Indian reservation under the jurisdiction of the Bureau of Indian Affairs.
- Description: Members of Federally Recognized Indian Tribes who are unemployed, underemployed, or in need of training to obtain reasonable and satisfactory employment. Complete information on beneficiary eligibility is found in 25 CFR, Parts 26 and 27.

Economic Development Technical Assistance

- Federal
- Incentive Type: Project Grants
- Target Sector: Recipients are private or public nonprofit organizations and educational institutional units of political subdivisions, or a consortium, and Economic Development District organization, a private or public nonprofit organization or association.
- Description: EDA oversees three technical assistance programs (national, local and University Center) that promote economic development and alleviate unemployment, underemployment, and out-migration in distressed regions. These programs provide funds to: 1) invest in institutions of higher education to meet the goal of enhancing local economic development; 2) Support innovative approaches to stimulate economic development in distressed regions; 3) Disseminate information and studies of economic development issues of national significance; and 4) Finance feasibility studies and other projects leading to local economic development.
- Source: http://www.eda.gov/

Grand for Public Works and Economic Development Facilities

- Federal
- Incentive Type: Project Grants
- Target Sector: State, city, county or other political subdivisions of a state or a consortium of such political subdivision, an institution of higher education or a consortium of institutions of higher education; an Economic Development District organization, a private or public nonprofit organization or association, an Indian Tribe, or a consortium of Indian Tribes.
- Description: To enhance regional competitiveness and promote long-term economic development in regions experiencing substantial economic distress. ED.A. provides Public Works investments to help distressed communities and regions revitalize, expand, and upgrade their physical infrastructure to attract new industry, encourage business expansion, diversify local economies, and generate or retain long-term private sector jobs and investment. Current priorities include proposals that help support existing industry clusters, development new emerging clusters, or attract new economic drivers.
- Source: http://www.eda.gov/

Economic Development Support for Planning Organizations

- Federal
- Incentive Type: Project Grants
- Target Sector: District Organization, Indian Tribe or a consortium of Indian Tribes; State, city or other political subdivision of a state, including a special purpose unit of a state or local government engaged in economic or infrastructure development activities, or a consortium of political subdivisions; institution of higher education or a consortium of institutions of higher education; or public or private non-profit organizations or associations acting in cooperation with officials of a political subdivision of a state.
- Description: Support short-term planning efforts and state plans designed to create and retain higher-skill, higher-wage jobs, particularly for unemployed and underemployed in the nation's most economically distressed regions

Trade Adjustment Assistance

- Federal
- Incentive Type: Direct Payments
- Target Sector: A petition for Trade Adjustment Assistance may be filed by a group of adversely affected works and be signed by at least three workers; alternatively, a petition may be filed by a company official.
- Description: To provide adjustment assistance to qualified workers adversely affected by foreign trade this will assist them to obtain suitable employment.

Appendix I
Shared Automotive Team Assemblers and Chemical Occupational Skills

Knowledge

Production and Processing — Knowledge of raw materials, production processes, quality control, costs, and other techniques for maximizing the effective manufacture and distribution of goods.

Skills

Quality Control Analysis — Conducting tests and inspections of products, services, or processes to evaluate quality or performance.

Active Learning — Understanding the implications of new information for both current and future problem-solving and decision-making.

Operation Monitoring — Watching gauges, dials, or other indicators to make sure a machine is working properly.

Reading Comprehension — Understanding written sentences and paragraphs in work related documents.

Abilities

Oral Comprehension — The ability to listen to and understand information and ideas presented through spoken words and sentences.

Oral Expression — The ability to communicate information and ideas in speaking so others will understand.

Information Ordering — The ability to arrange things or actions in a certain order or pattern according to a specific rule or set of rules (e.g., patterns of numbers, letters, words, pictures, mathematical operations).

Near Vision — The ability to see details at close range (within a few feet of the observer).

Control Precision — The ability to quickly and repeatedly adjust the controls of a machine or a vehicle to exact positions.

Problem Sensitivity — The ability to tell when something is wrong or is likely to go wrong. It does not involve solving the problem, only recognizing there is a problem.

Deductive Reasoning — The ability to apply general rules to specific problems to produce answers that make sense.

Work Activities

Controlling Machines and Processes — Using either control mechanisms or direct physical activity to operate machines or processes (not including computers or vehicles).

Communicating with Supervisors, Peers, or Subordinates — Providing information to supervisors, co-workers, and subordinates by telephone, in written form, e-mail, or in person.

Identifying Objects, Actions, and Events — Identifying information by categorizing, estimating, recognizing differences or similarities, and detecting changes in circumstances or events.

Inspecting Equipment, Structures, or Material — Inspecting equipment, structures, or materials to identify the cause of errors or other problems or defects.

Getting Information — Observing, receiving, and otherwise obtaining information from all relevant sources.

Performing General Physical Activities — Performing physical activities that require considerable use of your arms and legs and moving your whole body, such as climbing, lifting, balancing, walking, stooping, and handling of materials.

Monitor Processes, Materials, or Surroundings — Monitoring and reviewing information from materials, events, or the environment, to detect or assess problems.

Work Context

Wear Common Protective or Safety Equipment such as Safety Shoes, Glasses, Gloves, Hearing Protection, Hard Hats, or Life Jackets — How much does this job require wearing common protective or safety equipment such as safety shoes, glasses, gloves, hard hats or life jackets?

Importance of Being Exact or Accurate — How important is being very exact or highly accurate in performing this job?

Face-to-Face Discussions — How often do you have to have face-to-face discussions with individuals or teams in this job?

Sounds, Noise Levels Are Distracting or Uncomfortable — How often does this job require working exposed to sounds and noise levels that are distracting or uncomfortable?

Contact With Others — How much does this job require the worker to be in contact with others (face-to-face, by telephone, or otherwise) in order to perform it?

Work Styles

Attention to Detail — Job requires being careful about detail and thorough in completing work tasks.

Dependability — Job requires being reliable, responsible, and dependable, and fulfilling obligations.

Cooperation — Job requires being pleasant with others on the job and displaying a good-natured, cooperative attitude.

Integrity — Job requires being honest and ethical.

Initiative — Job requires a willingness to take on responsibilities and challenges.

Self Control — Job requires maintaining composure, keeping emotions in check, controlling anger, and avoiding aggressive behavior, even in very difficult situations.

Achievement/Effort — Job requires establishing and maintaining personally challenging achievement goals and exerting effort toward mastering tasks.

Adaptability/Flexibility — Job requires being open to change (positive or negative) and to considerable variety in the workplace.

Shared Automotive Team Assemblers and Chemical Occupational Skills Matrix

Knowledge

Skills

Work Abilities

Category	Automotive Team Assemblers	Chemical Occupational Skills
Problem Sensitivity	X	X
Near Vision	X	X
Selective Attention		X
Information Ordering	X	X
Oral Comprehension	X	X
Oral Expression	X	X
Auditory Attention		X
Control Precision	X	X
Deductive Reasoning	X	X
Far Vision		X
Manual Dexterity	X	
Arm-Hand Steadiness	X	
Finger Dexterity	X	

Work Activities

Category	Automotive Team Assemblers	Chemical Occupational Skills
Monitor Processes, Materials, or Surroundings	X	X
Controlling Machines and Processes	X	X
Getting Information		X
Communicating with Supervisors, Peers, or Subordinates	X	X
Inspecting Equipment, Structures, or Material	X	X
Making Decisions and Solving Problems		X
Identifying Objects, Actions, and Events	X	X
Performing General Physical Activities	X	X
Evaluating Information to Determine Compliance with Standards		X

Work Context

Category	Automotive Team Assemblers	Chemical Occupational Skills
Wear Common Protective or Safety Equipment such as Safety Shoes, Glasses, Gloves, Hearing Protection, Hard Hats, or Life Jackets		X
Indoors, Environmentally Controlled		X
Face-to-Face Discussions	X	X
Consequence of Error		X
Contact With Others	X	X
Frequency of Decision Making		X
Importance of Being Exact or Accurate	X	X
Telephone		X
Exposed to Hazardous Conditions		X
Sounds, Noise Levels Are Distracting or Uncomfortable	X	X
Spend Time Using Your Hands to Handle, Control, or Feel Objects, Tools, or Controls	X	
Spend Time Making Repetitive Motions	X	
Spend Time Standing	X	
Time Pressure	X	
Work With Work Group or Team	X	

Work Styles

Category	Automotive Team Assemblers	Chemical Occupational Skills
Attention to Detail	X	X
Dependability	X	X
Cooperation	X	X
Initiative	X	X
Integrity	X	X
Self Control	X	X
Adaptability/Flexibility	X	X
Stress Tolerance		X
Achievement/Effort	X	X
Analytical Thinking		X
Independence	X	
Concern for Others	X	

* Highlighted skills apply to both Automotive Team Assemblers and Chemical Occupational Skills

Source: O*NET OnLine. Retrieved February, 2008, from http://online.onetcenter.org

Appendix J
Commercial Annual Average Daily Traffic (CAADT)
by County

Ingham County

Route	To	CAADT
Lansing Rd	JCT M-99	5,370
JCT M-99	E. JCT 1-96 BL Lansing	5,536
E JCT 1-96 BL Lansing	JCT I-496, US 127	5,536
JCT I-496, US 127	Okemos Rd	6,179
Okemos Rd	Williamston Rd	6,179
Williamston Rd	JCT M-52	6,179
JCT M-52	Fowlerville Rd	5,437
W of I-96 BL, Cedar St	Trowbridge Rd	5,163
Trowbridge Rd	Dunce Rd	5,163
Dunckel Rd	E JCT I-96	5,163

Clinton County

Route	To	CAADT
JCT Connector 96	Airport Rd	5,470
Airport Rd	Dewitt Rd	5,470
Dewitt Rd	JCT Old US-27	5,470
JCT Old US-27	JCT US-127	5,470
JCT US-127	Webster Rd	5,758
Webster Rd	E. JCT I-69 BL Lansing	5,758
E. JCT I-69 BL Lansing	Woodbury Rd	5,978
JCT M-100	JCT. Connector 96	5,759

Eaton County

Route	To	CAADT
N Drive North	JCT M-78	5,659
JCT M-78	Ainger Rd	5,659
Ainger Rd	S JCT I-69 BL Charlotte	5,659
S JCT I-69 BL Charlotte	JCT M-50	5,659
JCT M-50	S JCT I-69 BL Charlotte	5,659
S JCT I-69 BL Charlotte	JCT M-100	5,691
JCT M-100	Lansing Rd	5,691
Lansing Rd	W JCT I-96	5,691
J I-69 (Clinton/Eaton Co. LN)	JCT M-43	8,030
JCT M-43	JCT I-496	7,962
JCT I-496	S JCT I-69	7,894
S JCT I-69	Lansing Rd	5,370
Lansing Rd	JCT M-99	5,370

Source: MDOT Bureau of Transportation Planning.

Appendix K
Biofuel Market Development

Cellulose-based ethanol for motor fuel is expected to become a major market by 2020.

The current U.S. corn-based ethanol market is growing. Production reached 778.8 million gallons in May, 2008, up 47% from the 2007and up 10% from the preceding month, according to the U.S. Energy Information Administration's (EIA) latest Oxygenate Production report. Total ethanol fuel production for 2007 was 6.498 billion gallons according to the Renewable Fuels Association (RFA) and 6.521 billion gallons according to the EIA.[a]

In a 2007 economic study conducted by the U.S. Department of Commerce International Trade Administratio,[b] U.S. consumption expenditures in 2020 would be 0.08% higher (or $12.6 billion) with the use of cellulosic ethanol (19.5 billion gallons). These are substantial gains, the report emphasized. The yearly reduction in U.S. oil imports would be $8.4 billion (in 2004 dollars) and the price of gasoline would be reduced by 2% than what it would otherwise have been by 2020. These projections were predicated on the assumption that the price of motor vehicle gasoline would be $2.08 per gallon.

The production of 19.5 billion gallons of cellulosic ethanol would lower both the domestic cost of fuel and worldwide price of oil and would lower U.S. crude oil imports by 4.1% over baseline projections, or 460,000 barrels per day, in 2020. The U.S. crop producing sector would see a 4.3% rise in output over baseline projections. As U.S. demand for crude falls, U.S. petroleum producers would see their output fall as prices decline.

In a best-case scenario based on annual ethanol production of 60 billion gallons in 2020, specific benefits would include:

- Annual U.S. consumption would increase by about $33.5 billion in 2020.
- U.S. fuel prices would fall by 5.2%
- World oil prices would decline by 3.1%.
- U.S. oil imports would decline by 10.7%, or 1.2 million barrels per day.
- U.S. agriculture would gain 54,000 jobs.

The study's baseline oil price assumption was $50 per barrel and the predicted economic benefits would be even greater with higher petroleum prices.

Federal ethanol fuel mandates of 7.5 billion gallons in the U.S. vehicle fuel supply by 2012 and at least 16 billion gallons of cellulose ethanol by 2022 are providing a powerful impetus to the rapid development of ethanol fuel markets. These mandates are now matched too by significant levels of federal research expenditures to overcome the technical barriers in achieving viable commercial production of cellulosic ethanol in the next few years.

The federal Department of Energy's road map for biomass-based alternative renewable fuel calls for displacing 30% of U.S. gasoline consumption by ramping up biofuel production to 60 billion gallons by 2030.[c] After years of minuscule actions by the Administration and Congress, the Department of Energy has mapped out an extremely ambitious strategy to take meaningful steps to reduce the country's dependence on foreign oil by creating new U.S. markets in renewable, low-carbon fuels and reduce adverse impacts on global climate change.

a Green Car Congress. *U.S. Fuel Ethanol Production Up 47% in May from Year Prior*. Retrieved July 31, 2008, from http://www.greencarcongress.com/2008/07/us-fuel-ethanol.html

b United States Department of Commerce International Trade Administration. (2007, November). *Energy in 2020: Assessing the Economic Effects of Commercialization of Cellulosic Ethanol* (pp. 12-14).

c United States Department of Energy and U.S. Department of Agriculture. (2005, April). *Biomass as Feedstock for a Bioenergy and Bio-Products Industry: The Technical Feasibility of a Billion-Ton Annual Supply*.

Appendix L
Tri-County Regional Forage and Forest Data

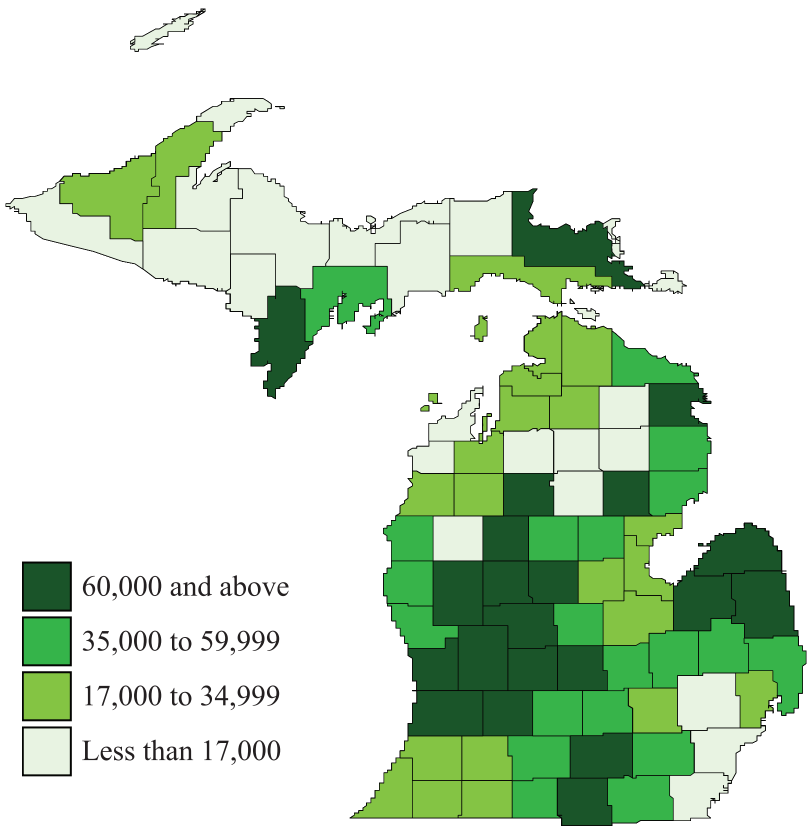
Forage Yield
2002

County	Tons
Clinton	78,089
Eaton	51,876
Ingham	56,550
Michigan Average	**42,866**

Source: United States Department of Agriculture. (2002). *2002 Census of Agriculture*.

Forage Yield
(in Tons)

2002

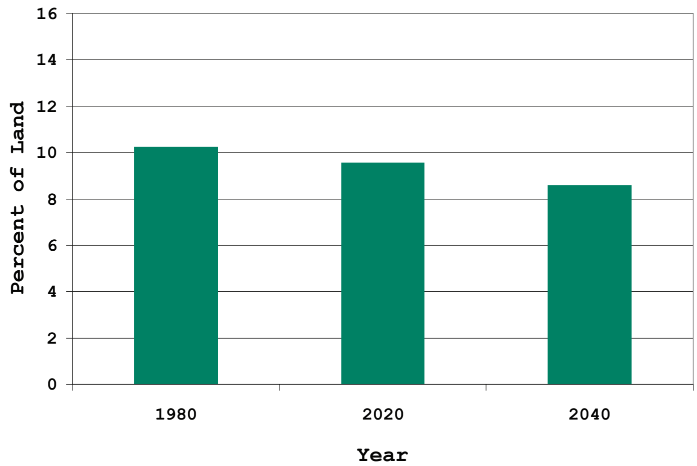


Source: United States Department of Agriculture. (2002). *2002 Census of Agriculture*.

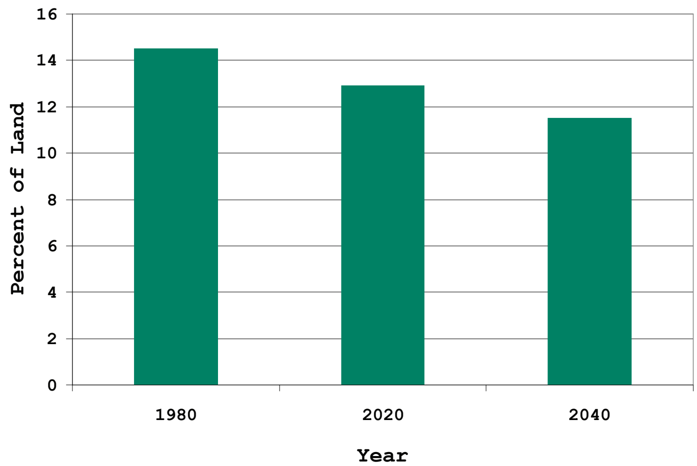
Tri-County Projected Forest Resources
(in Acreage)

County	2020	2040
Clinton	35,190	31,580
Eaton	48,150	43,350
Ingham	41,520	35,100
Michigan Average	203,619	203,338

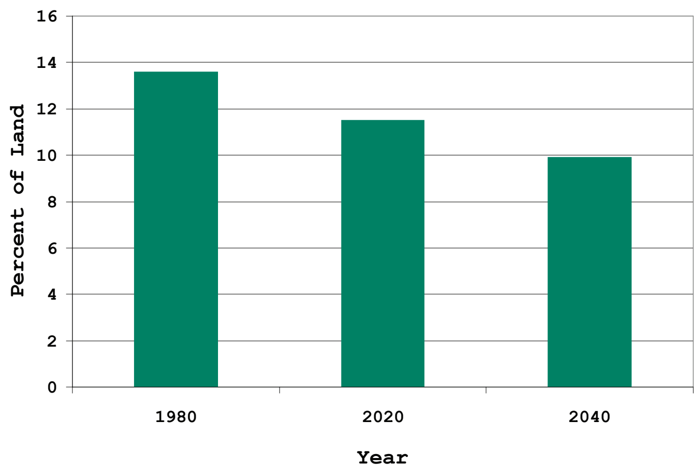
Clinton County Forest
(as % of Land)



Eaton County Forest
(as % of Land)



Ingham County Forest
(as % of Land)



Source: Picture Michigan Tomorrow.

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