Energy Recommendations Table of Contents

The following icons are used throughout the plan to quickly identify recommendations by type:

IP **Integrated Planning Recommendations**

LP **Critical Land Protection Recommendations**

RP **Land and Water Restoration and Protection Recommendations**

SP **Sustainable Practices Recommendations**

ES **Economic Incentives for Sustainability**

Introduction

General Context

The United States is one of the largest consumers of energy in the world, consuming roughly 100 quadrillion Btu of energy each year (Energy Information Administration, 2006). Fossil fuels, including petroleum (40% of supply), coal (22% of supply), and natural gas (23% of supply), account for 86 quadrillion Btu. U.S. consumption of oil in 2006 reached 7.6 billion barrels, with just under half of this amount coming from foreign sources.

Motor vehicles in the Unites States consume nearly 3.4 billion barrels of oil each year. In Minnesota, gasoline consumption is slightly higher than the U.S. average. Vehicles driven in Minnesota consumed nearly 2.6 billion gallons of gasoline in 2006. U.S. demand for coal reached 1.1 billion tons in 2007, over 90% of which was burned to generate electricity. Minnesota currently obtains 65% of its electricity from coal, 25% from nuclear power, 5% from natural gas and petroleum, and 5% from renewable sources, including solid waste, wood, wind, hydroelectric, and landfill gas.

There is increasing awareness of the adverse consequences of relying on fossil fuels. Petroleum supply is expected to decline within the next decade or two as the world reaches peak oil. Burning fossil fuels, including coal, produces large amounts of greenhouse gases (GHGs), which contribute to global climate change. Coal burning also produces mercury emissions, which pollute land and water, and accumulate in aquatic organisms. Minnesota burned 20.9 million tons of coal in 2006. Minnesota carbon dioxide (CO_2) emissions arise mainly from electrical production (35%) and transportation fuels (34%). Minnesota emissions of CO_2 now exceed 140 million metric tons.

Federal and state policies now actively promote renewable energy production in order to supplement and potentially replace a portion of the energy supplied from fossil fuels. Renewable energy now accounts for 7% of the U.S. energy supply. Major renewable sources of energy in the United States include hydroelectric power (36% of renewable supply), biomass (53%), wind energy (5%), geothermal energy (5%), and solar energy (1%). There is a significant desire and potential for future expansion of the energy supplied from biomass, wind, geothermal, and solar energy sources.

The Federal Energy Policy Act of 2007 mandates 36 billion gallons of ethanol from renewable sources, with 21 billion gallons from cellulosic feedstocks such as corn stover or perennial energy crops. Minnesota's Next Generation Energy Act of 2007 mandates an 80% reduction in GHG emissions by 2050. Minnesota also requires that all gasoline sold for motor vehicles include a 10% blend of ethanol, increasing to a 20% blend beginning in 2012. Xcel Energy will be required by law to generate 30% of its electricity using renewable sources by 2020, which could include biofuels used to generate electricity. These policies mean that agricultural and forest lands in Minnesota will increasingly be used to produce biomass-based fuels, leading to competition with other types of production and uses that occur on these lands, including food, fiber, animal feed, wildlife habitat (e.g., pheasants and waterfowl), and recreation. At the same time, it is unrealistic to expect that biofuel energy production practices alone can supply Minnesota's growing demand for energy. Thus, it is important to develop policies and

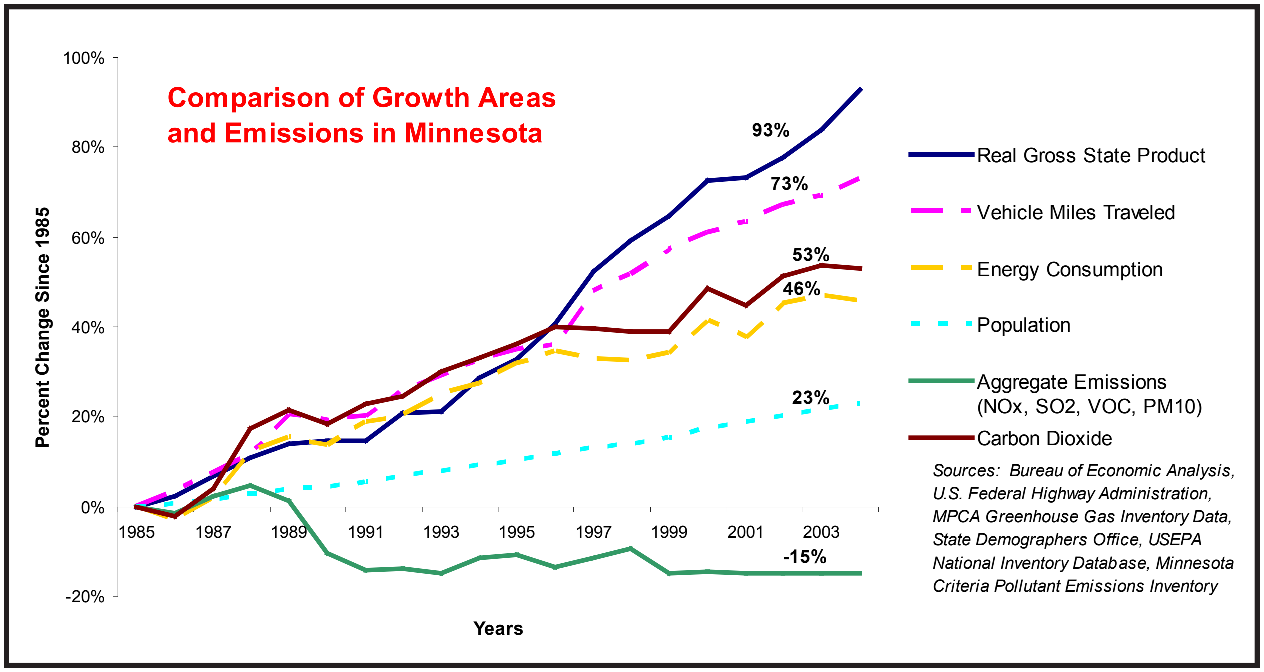

Figure E1. Trends in Minnesota population growth, energy consumption, vehicle miles traveled, and greenhouse gas emissions. Credit: Laura Schmitt Olabisi, UM Sustainability Initiative; MPCA.

strategies for significant conservation of fossil fuel sources in parallel with increased renewable energy production.

Minnesota has been very proactive in trying to develop strategies to combat climate change and promote renewable energy resources for electricity and transportation. Governor Pawlenty signed the Next Generation Energy Act in May 2007 to promote energy conservation, community-based energy development, and GHG reduction. Another outcome of this act was the establishment of a NextGen Board to develop bioenergy and biofuel policies and recommendations. Recommendations of the NextGen Board (MDA, 2008) were reviewed by the SCPP energy and mercury team. Some of the recommendations here are nearly identical with the NextGen Energy Board recommendations (e.g., improving energy and water-use efficiency in biofuel production). Most are complementary, and focus on mitigating impacts of renewable energy production on the environment.

Associated as well with the Next Generation Energy Act was the formation of a Minnesota Climate Change Advisory Group (MCCAG). MCCAG was asked to develop policy recommendations to reduce or sequester GHGs. MCCAG developed recommendations to reduce GHG emissions by 470 million tons by 2025 through changes in agricultural, forestry, and waste management; through residential, commercial, and industrial nonelectricity supply; through energy supply; through transportation and land use; and through cross-cutting or integrated strategies. Again, the SCPP energy and mercury team reviewed the MCCAG recommendations (Center for Climate Strategies, 2008). Some of our recommendations are nearly identical with MCCAG's recommendations (e.g., expanded use of biomass feedstocks for electricity), while others are complementary.

In 2003 the Minnesota Legislature asked the Legislative Electric Energy Task Force (LEETF) to develop recommendations (LEETF, 2005) concerning potential wind electric energy resources. Some energy and mercury team recommendations are very consistent with LEETF's recommendations, (e.g., develop mechanisms for better coordination of government efforts on renewable energy impacts). In contrast to the LEETF recommendations, the energy and mercury team's recommendations are less focused on wind energy sources, and more focused on biomass energy sources.

Given this context, the energy and mercury team has developed 25 recommendations for the SCPP that embody the following goals:

- Promote renewable energy production strategies that reduce reliance on fossil fuel consumption and create environmental cobenefits
- Promote a healthy economy based on renewable energy production strategies and environmental protection
- Promote efforts to conserve energy and improve energy use efficiency
- Promote strategies for significant reductions in mercury deposition

Trends

Energy Consumption

Over the last decade, Minnesota's population has increased by 23% (see Figure E1). The Twin Cities metropolitan area has expanded rapidly during this period, and people now commonly commute 20 or more minutes from home to work. Vehicle miles traveled (VMT) have increased 73%, leading to greater consumption of gasoline in motor vehicles. Overall, energy consumption in Minnesota has increased 46%, while CO_2 emissions have increased 53%.

Electricity Consumption

Electricity demand in Minnesota will climb exponentially in the coming decades if current growth continues (see Figure E1). Under the Renewable Energy Standards, an increasing portion of this electricity will come from renewable sources. Wind, solar, and deep geothermal energy would be best able to meet this growing demand with minimal impacts on the state's land resources. Wind is already deployed on a widespread basis in Minnesota, but further research and technological development are needed to overcome storage and intermittency concerns as a greater percentage of the state's electricity is generated with wind. More research is required on solar and deep geothermal energy sources to determine their potential for implementation and to overcome technological constraints. In some regions of Minnesota, municipal solid waste or waste streams from paper production, timber processing, or animal husbandry may play a role in renewable electricity production. Exclusive reliance on perennial crops to produce electricity would strain the state's land resources and would compete with agricultural land for the production of food, feed, and ethanol.

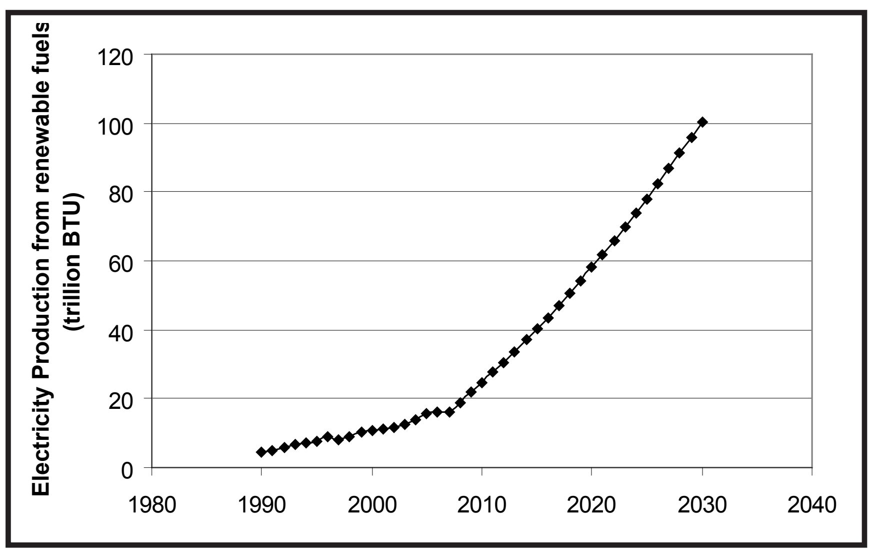

Figure E2. Historical and projected electricity production from renewable sources. Historical data from MPCA/Electric Power annual; future projections based on projected Minnesota electricity consumption and Minnesota Renewable Energy Standards. Credit: Laura Schmitt Olabisi, UM Sustainability Initiative.

Country	Consumption (MBtu/p)
Canada	436
Denmark	153
Finland	241.5
France	181.5
Germany	176
Italy	138.9
Japan	177
Norway	455.7
Russia	212
Spain	163.3
Sweden	259.9
United States	340.5

Table E1. Per capita energy consumption by country for 2005. Credit: EIA (www.eia.doe.gov/emeu/international/energyconsumption.html).

Energy Conservation

There is significant potential to reduce the energy consumption of the state by taking actions on industrial, commercial, and consumer levels. Study of usage patterns abroad indicates that the energy consumption per capita is very high in the United States compared to other industrial nations. In 2006, the U.S. per capita energy consumption was estimated to be 334 million HBtu per person, a slight improvement from 2005. The comparative consumption numbers for various industrialized countries is shown in Table E1. For Minnesota, the comparable number was 362.2 MBtu per capita.

Many industrialized countries have been significantly more aggressive in reducing the energy used by all sectors of their economy by establishing reuse and recycling practices for municipal waste that recaptures a significant portion of the energy content of this material for production of energy or for conversion into new manufactured products. Japan and Germany have established policies that try to maximize the benefit waste capture and have sound conservation practices. Germany's other European neighbors have also focused on improved conservation as a key energy policy. Additional conservation policies encourage the use of optimized architectural design practices for building construction that incorporate energy use optimization for both commercial and residential construction. Extensive use of shallow geothermal heating practices is being practiced in Germany for both commercial and new residential construction and in retrofitting existing commercial buildings where possible. In Japan and Germany, there is also a key emphasis on recovering the energy from waste heat sources from industrial operations in order to produce power and steam. Some cities also have instituted district steam heating practices to take advantage of combined heat and power situations.

On a consumer scale, energy can be conserved through adoption of energy efficient lighting, heating, and building materials. One notable example for building materials is the incorporation of encapsulated paraffin wax nodules in wallboard. The capsules soak up inside heat during the day and release it at night to help reduce air conditioning and heating requirements.

Waste recycling is also extensively used in Japan and Germany, as well as other European Union countries. Recycling programs maximize the reuse of materials in manufacturing products, reducing the need for new material. Alternatively, the materials energy value may be extracted from waste materials before they are landfilled. Some key recommendations are made for Minnesota to help the state reduce its energy consumption through improved conservation practices.

The capture and reuse of waste heat from the state's power and industrial sector should be encouraged. Technologies now exist (e.g., organic rankine cycle [ORC] engines and Kalina engines) for using low-temperature heat and directly converting this energy source to electrical power. The adoption of these recapture technologies could facilitate the amount of

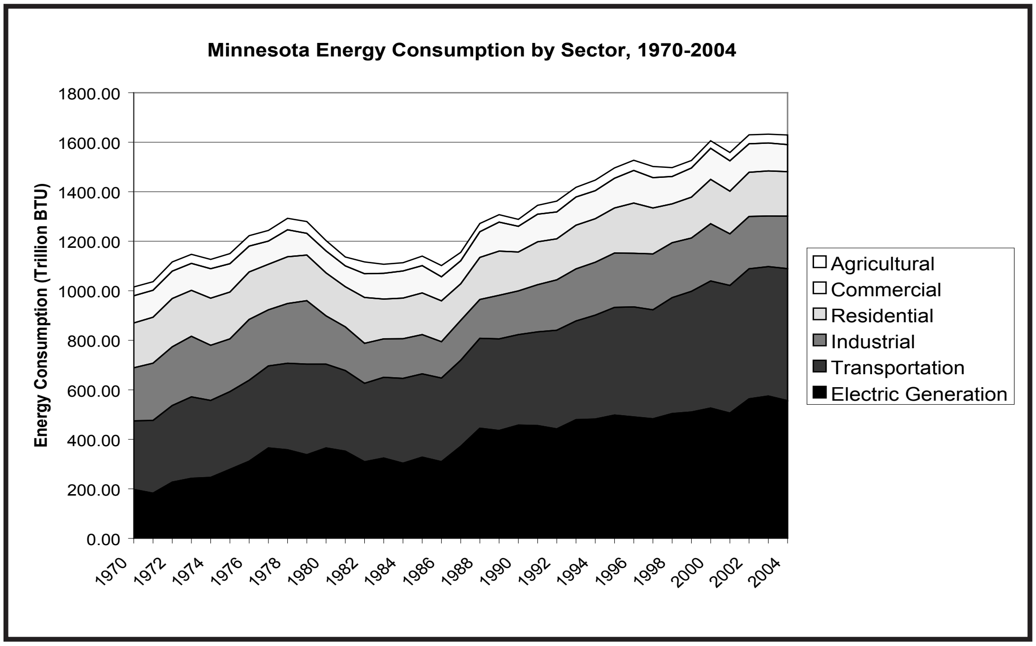

Figure E3. Energy consumption in Minnesota by economic sector, 1970–2004.
Credit: Laura Schmitt Olabisi, UM Sustainability Initiative; MPCA and Minnesota Utility Data Book.

electrical energy generation that could be attained from alternative, low GHG energy sources and also help meet the conservation mandates for industrial consumers that are outlined in existing Minnesota statutes on future electrical power generation.

Vehicle travel is responsible for one-third of Minnesota's energy consumption and GHG emissions (See Figure E3). Individuals can make choices to reduce energy demand for transportation by driving at lower highway speeds; commuting to work by bicycle, foot, or mass transit; and choosing to live close to where they work and shop. Programs designed to educate and raise awareness of carbon footprint, as described in one of the recommendations below, can help to inform individual choices.

Wind Potential

Wind energy potential in Minnesota is greatest in the southwestern portion of the state (see Figure E4). The south, southeast, west, and northwest regions also show high wind energy potential. Central, eastern, and northeastern Minnesota (except Minnesota areas of Lake Superior) show much lower wind speeds resulting in the lowest potential. It is also important to note that wind speed and energy potential increase with turbine height. Minnesota currently produces 1,300 MW of wind energy, with another 47 MW anticipated from current construction projects.

Of all the renewable energy sources in the state, wind generation potentially has the lowest overall impact on natural resources. No water is required for cooling in wind production, no GHGs are generated during the operations phase, and land requirements are relatively small. The largest barriers to increased wind produc-

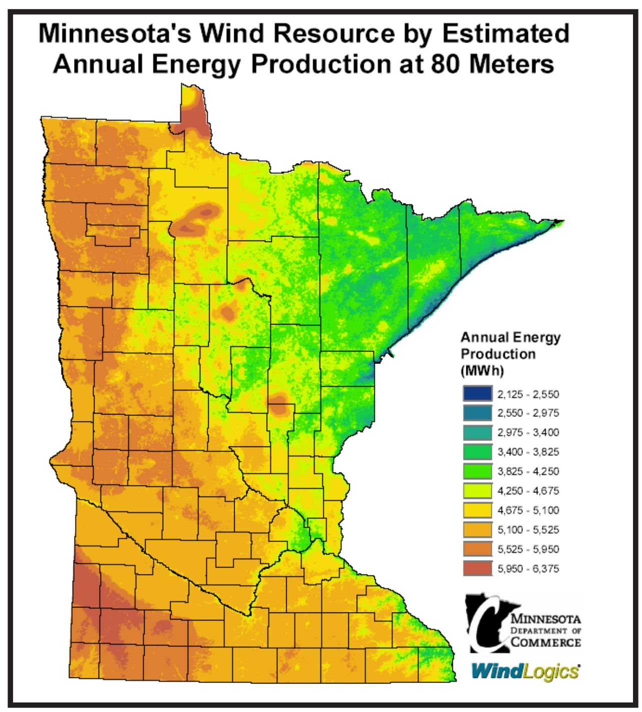

Figure E4. Minnesota's wind resource potential.
Credit: Minnesota Department of Commerce and WindLogics.

tion include storage needs (storage technologies, including various battery designs, currently exist but may be prohibitively expensive) and transmission.

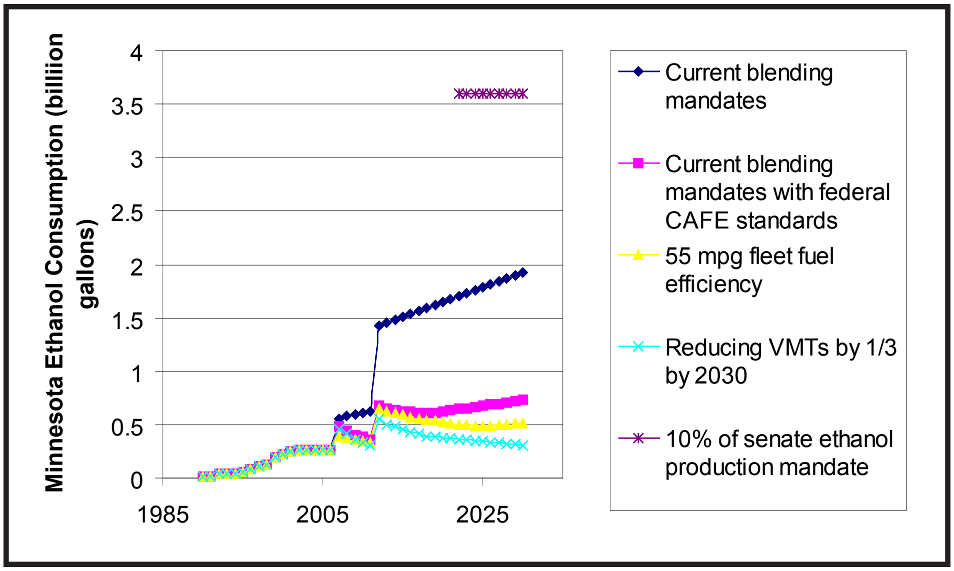

Figure E5. Historical and projected Minnesota ethanol production under a variety of future scenarios. Most of Minnesota's future ethanol production is likely to be exported. Future projections based on Minnesota vehicle miles traveled, current and future blending mandates, and recently enacted CAFE standards. Credit: Laura Schmitt Olabisi, UM Sustainability Initiative; MDA.

Wind turbine design and layout are important aspects of wind farm planning due to the differential impacts of the various designs on wind power and avian mortality. Wind power is affected by factors such as location, tower height, lattice or tubular tower, and tower alignment. The tubular tower design is most commonly used for today's wind farms; this design is simple and reduces areas where birds can perch and nest. It is also important to correctly determine where the wind farm will be located. There is a consensus in the literature that a preconstruction study should be done to determine if there are any important avian considerations near the construction site that would call for different design and construction techniques. For example, if the project is near a large nesting habitat for a certain bird species, construction should be put on hold during important breeding periods.

There is also a potential for using small wind turbine generation systems to help reduce local power requirements on a distributed basis where local wind conditions are favorable. The County Building in Duluth has installed six small turbines on the roof of the building that will provide a substantial amount of the electrical energy required for the building operation. The use of distributed, smaller-scale systems should be explored for locations that have good wind conditions. Many tall municipal structures may be good candidates for this type of application.

Another important consideration for wind and other renewable energy sources is the role they might play in the transportation sector. One of the recommendations in this section is to encourage a partial transition of Minnesota's vehicle fleet to electric power generated from wind, solar, or geothermal sources. This will have the benefit of reducing state GHG emissions, while alleviating pressure on the land resource to produce both food and fuel.

Biofuel Potential

Minnesota's population is expected to grow by an additional million people in the next two decades. A number of different policy options are available to mitigate the impact of this population growth on consumption of fossil fuels for transportation. Minnesota's demand for ethanol currently is 263 million gallons per year. With current ethanol blending mandates (10%, increasing to 20% by 2012) and anticipated increases in population and VMT, Minnesota vehicles will consume roughly 2 billion gallons of ethanol by 2025 (Figure E5). If corporate average fuel efficiency (CAFE) standards of 35 mpg are fully implemented by 2020, Minnesota's ethanol consumption will rise to roughly 750 million gallons. If fleet fuel efficiencies of 55 mpg are reached, ethanol consumption in 2030 would increase only slightly above current consumption. If VMT are reduced by one-third, ethanol consumption by Minnesota vehicles would be stabilized at roughly 300 million gallons per year. Regardless of changes in fuel efficiencies or vehicle miles traveled in Minnesota, Minnesota's ethanol production is likely to be strongly influenced by national trends, since Minnesota is a net ethanol exporter. The Federal Energy Policy Act of 2007 mandates 36 billion gallons of ethanol production. Minnesota currently produces roughly 10% of the nation's ethanol. Assuming that this trend continues, by 2025 Minnesota will produce roughly 3.6 billion gallons of ethanol, most of which will be exported from the state.

Minnesota has significant potential to produce ethanol from renewable resources. At present, these resources include corn grain, sugar beets, aspen trees, softwood timber, and smaller amounts of other resources. Future resources for ethanol production on agricultural cropland include high- input monocultures of row crops, monocultures of perennial crops, and low-input polycultures of perennial crops.

High-input monocultures of row crops would be based primarily on corn grain and corn stover in a corn-soybean or corn-corn-soybean rotation. Minnesota currently produces 2.2 billion bushels of corn grain and over 5 million tons of corn stover. If cellulosic ethanol production techniques become economically feasible, this stover could potentially produce 3.8 billion gallons of ethanol, compared to a potential ethanol production from corn grain of 6.3 billion gallons. These estimates assume that all of the corn grain and stover production in Minnesota would be used for ethanol, an extremely unlikely scenario.

Monocultures of perennial crops could include plantings of alfalfa, switchgrass, miscanthus, hybrid poplar, or willow. Research at the University of Minnesota (UM) Southern Research and Outreach Center across a wide range of soils and landscapes has shown that alfalfa produced 7.2 tons/ac, and switchgrass produced 2.7 tons/ac. In comparison, 3.3 tons/ac of corn stover were produced in the same experiment. More research is needed to optimize all aspects of production management for these crops.

Biomass Source	Current (t/yr)	Near Term Achievable (t/yr)	Future Potential (t/yr)	Notes
Roundwood	0	1,495,000	1,495,000	Current: 3.7 M cord harvest; future: 5.5 M cord harvest
Harvest Residues	750,000	1,155,000	1,155,000	
Red Pine	184,000	310,500	409,400	
Aspen Thinning	0	0	1,000,000	100,000 acres@ 10t/ac
Brushlands	0	400,000	400,000	
Energy Crops	0	0	5,600,000	3.5 t/ac/t yield, 1.6 M ac
Total	***934,000***	***3,360,500***	***10,059,400***	

Table E2. Summary of woody biomass resources. Credit: William Berguson, NRRI.

Research at the UM Natural Resources Research Institute (NRRI) has shown a large potential for producing cellulosic ethanol from forest biomass (See Table E2). Hybrid poplar plantations have the potential to produce approximately 5 tons/ac based on the current best clone materials. Potential sources of forest biomass for ethanol production include thinning of aspens and red pines, roundwood, harvest residue from logging operations, brushlands harvesting, and energy crop development based on woody biomass (e.g., hybrid poplar). The estimated biomass availability for the future from these sources is 10 million dry tons. These sources have the potential to produce 0.5 to 1 billion gallons of ethanol.

Polycultures of perennial crops are most commonly assumed to be represented by mixtures of native prairie grasses and legumes. These crops have the advantage of not requiring heavy inputs of fertilizer or pesticides, but they have the disadvantage of not producing as much biomass as monocultures of perennial crops that receive fertilizer and pesticides.

The use of biomass for commercial and residential heating applications is a growth industry in Europe and is starting to take off in various parts of the United States. In this case, pelletized wood and other biomass products are being converted to pellets and used in specially designed wood burner systems to provide the heat for the structure using the technology. In Europe, the logistics of pellet movement are handled by bulk trucks that move the pellets from the pellet plant to the consumer on a contract basis. In Minnesota, pellet production and furnace sales have already begun and in some situations, Minnesota wood is being pelletized and shipped to Europe for use in this type of heating system. The current costs for propane and fuel oil are high enough to allow conversion to a pellet fuel system with a reasonable payback for the consumer. As the price for other fuels continues to escalate, the biomass pellet heating systems may become even more attractive for other heating situations as well.

Biomass fuels are also finding increasing use as a natural gas and coal substitute in industrial applications. The Minnesota taconite industry now routinely substitutes various biomass materials for the natural gas commonly used in pellet induration kilns. In addition, Laurentian Energy in Hibbing and Virginia, Minnesota, is now routinely using biomass in combination with coal to generate significant amounts of electricity in northern St. Louis County. Minnesota Power at its Hibbard plant is fully fueled by biomass from a variety of sources. This plant produces the steam used by the local paper plant located in Duluth. Other examples of using biomass to produce electricity and fossil-fuel substitutes can be found throughout the state.

Other Renewable Sources

The potential for using solar and geothermal energy in Minnesota has not yet been thoroughly explored. Geothermal energy may be divided into two types: shallow and deep. Shallow geothermal applications already exist in Minnesota, and are typically used to mitigate heating needs in winter and cooling needs in summer. Deep geothermal power can potentially supply both electricity and heat, but more research is needed to determine whether this is a viable option in Minnesota. Passive solar systems (which use the sun's energy without mechanical devices) also seem to have significant potential for use in Minnesota for heating and cooling of both residential and commercial structures. While photovoltaic solar panels remain prohibitively expensive compared to wind turbines and are not likely to generate a significant portion of Minnesota's electricity in the coming decade, they may be appropriate for rooftop use. Shallow geothermal and passive solar heating systems for heating and cooling should be encouraged due to their low environmental and GHG footprints. Specific recommendations on the use of these technologies as well as the potential for establishing the utility of deep geothermal heat recovery are contained in this report.

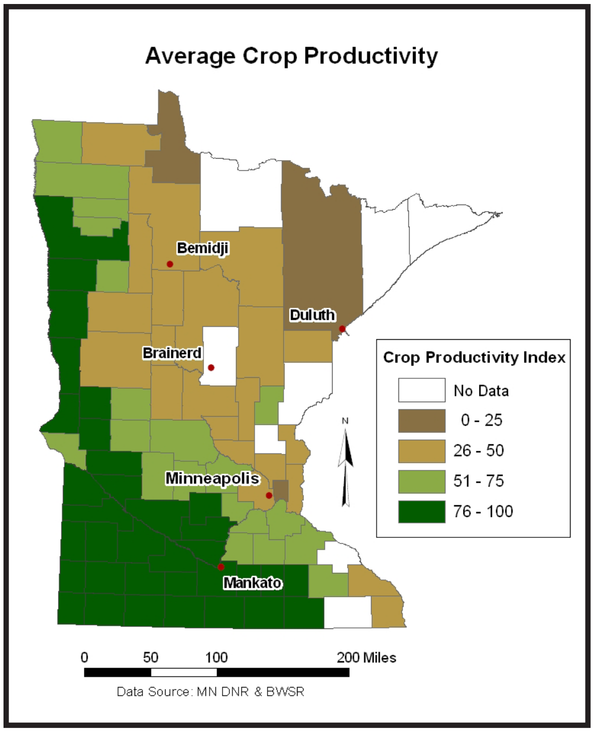

Figure E6. Average soil-based crop productivity index values for Minnesota counties. Crop biomass production potential increases as the value of the index increases. Credit: Aaron Spence, BWSR; Joel Nelson, David Mulla, UM; data from USDA-NRCS and BWSR.

Soil Productivity

Minnesota has a wide array of soil types. Seven soil orders occur, including Mollisols (32% of land area), Alfisols (27%) and Entisols (18%). Mollisols are the most productive, with deep topsoil and high organic matter content formed under prairie grassland. Alfisols are shallower, less productive soils formed under forest. Entisols are sandy soils without well-formed soil horizons.

The suitability of Minnesota soils for crop and biofuel production depends on a number of factors including available water capacity, bulk density, and pH. These factors have been used by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) and the Board of Water and Soil Resources (BWSR) to develop a soil crop productivity index for Minnesota. Soil productivity (Figure E6) ranges from 0 to 100, with 100 being the most productive soils in the state and 0 being the least productive soils (bedrock). The most productive soils are located in the southern and southwestern portions of the state. The effects of these differences in soil productivity across Minnesota's diverse landscapes have not yet been accounted for in estimating biofuel production potentials for different regions of the state.

Commodity Prices and Crop Acreage Changes

From 2005 to 2007, the price of corn doubled from \$2 to \$4 per bushel. Wheat increased from \$3.42 to \$6.65 per bushel. Soybeans increased from \$5.66 to \$10.40 per bushel. Increasing prices for commodities are due to a combination of factors, including speculation, prices of oil, drought, decreasing power of the U.S. dollar, and increasing demand for corn-based ethanol. Over the same time frame, oil prices increased from \$50 to \$64 per barrel, and prices surpassed \$130 per barrel in 2008.

In response to steep increases in the price of corn, Minnesota producers planted nearly 1.1 million more acres of corn in 2007 than in 2006 (Figure E7). This is a 15% increase in corn acreage, which was accompanied by increases in the application of fossil fuel–based fertilizer and crop protection products. Nearly all of this corn planting occurred on land that was planted to soybeans in 2006. Despite the large increases in corn acreage, corn production only increased by 3% between 2006 and 2007. This was largely due to an extensive drought that affected central Minnesota in 2007; of lesser importance is that some of the areas with the largest increases in corn planting are also lower productivity soils. Increases in corn-planting acreage were not uniformly distributed across the state. The largest increases in acreage occurred in the west-central, central, south-central, and northwestern portions of the

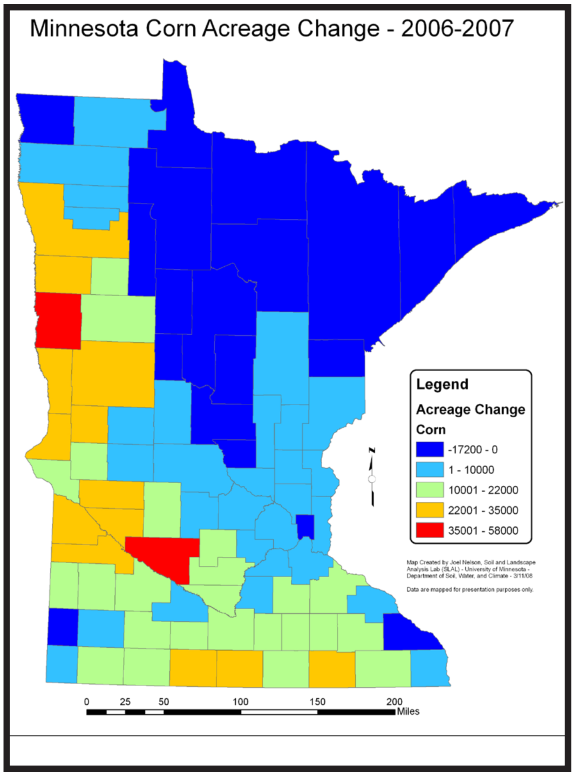

Figure E7. Change in Minnesota corn acreage between 2006 and 2007. Credit: Joel Nelson, David Mulla, UM, from USDA-NASS data.

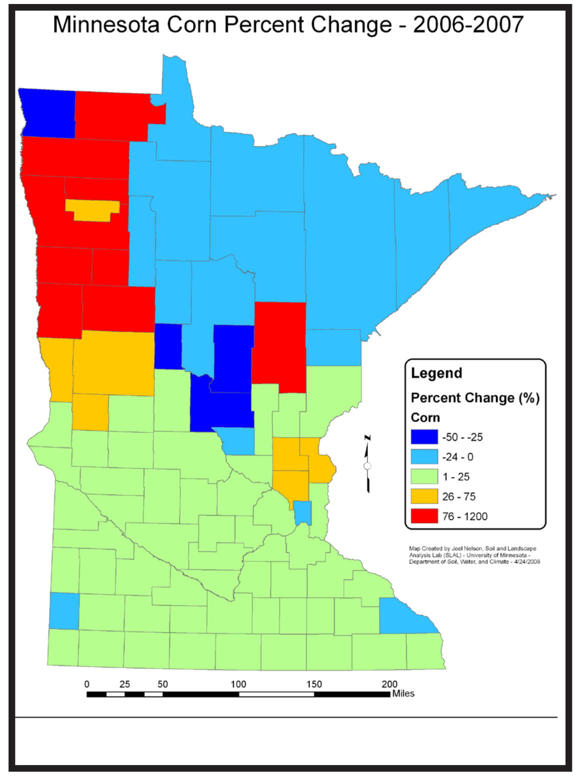

Figure E8. Percent change in Minnesota corn acreage between 2006 and 2007. Credit: Joel Nelson, David Mulla, UM, from USDA-NASS data.

state. The largest increases as a percent of corn acreage in 2006 occurred in the Red River of the North basin (Figure E8).

Environmental Impacts of Renewable Energy Production

Erosion Rates for Different Land Use Practices

Minnesota has a variety of climatic regions, soil types, cropping systems and agricultural management practices. All of these factors affect rates of wind and water erosion. Based on USDA Natural Resources Inventory (NRI) data, rates of wind and water erosion are greatest on cultivated cropland. Water erosion on cultivated cropland averages 2.1 tons per acre per year (See Figure E9), while wind erosion averages 4.3 tons per acre per year (See Figure E10). Rates of water erosion on pasture and Conservation Reserve Program (CRP) land average 0.25 and 0.22 tons per acre per year, respectively, much lower than rates of water erosion on cultivated cropland. Rates of wind erosion on pasture and CRP land average 0.15 and 0.08 tons per acre per year, respectively, much lower than rates of wind erosion on cultivated cropland. These results suggest that biofuel production strategies that favor perennial grasses rather than cultivated row crops will lead to large reductions in rates of wind and water erosion.

One of the concerns over use of corn stover for ethanol production is that removing corn stover increases the potential for soil erosion. Erosion rates by water are strongly affected by the percent of soil surface that is protected by living or dead (residue) vegetation. As rates of erosion increase, there is an increased potential for polluting nearby streams, rivers, and lakes with sediment and associated nutrients and

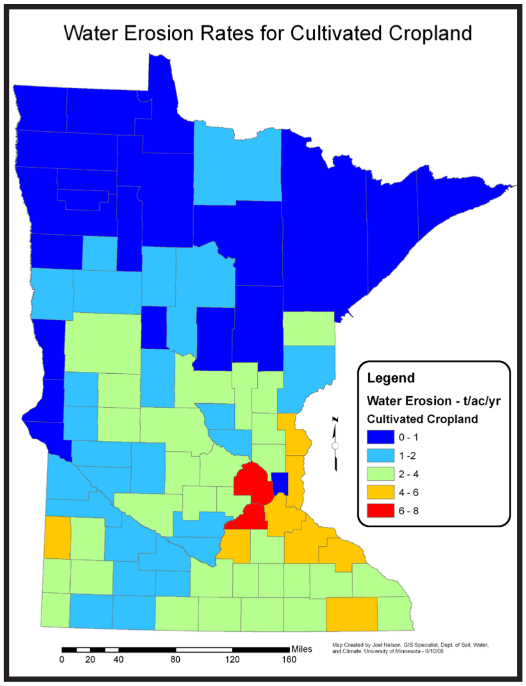

Figure E9. Water erosion rates for cultivated cropland in Minnesota. Credit: Joel Nelson, David Mulla, UM, from USDA-NRI data.

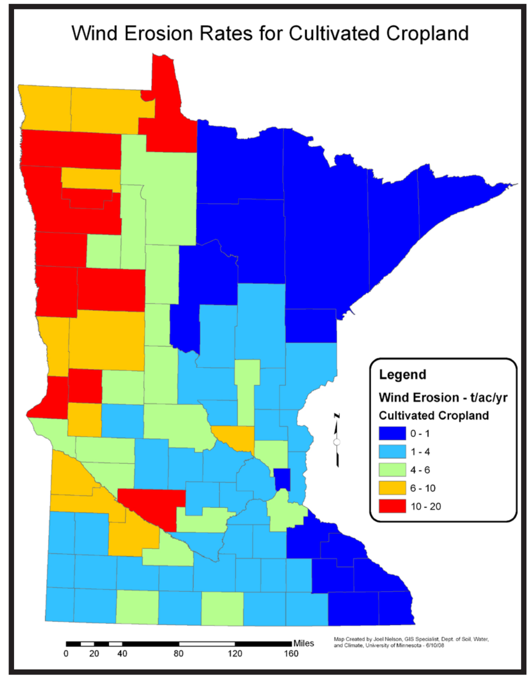

Figure E10. Wind erosion rates for cultivated cropland in Minnesota. Credit: Joel Nelson, David Mulla, UM, from USDA-NRI data.

pesticides that are bound to sediment. A modeling study currently being conducted by the University of Minnesota in the Le Sueur River watershed in the Minnesota River basin was used to evaluate the impacts of various rates of corn stover removal on delivery of sediment to streams by water erosion. The Le Sueur River is classified as an impaired water body for sediment, and roughly 30% of the sediment arises from upland agricultural sources. Results showed that with no corn residue removal and a corn-soybean rotation, the average amount of sediment delivered to the Le Sueur River was about 1 tons per acre per year. In contrast, if 60% of the corn residue was removed for cellulosic ethanol production, roughly 1.6 tons per acre per year of sediment was delivered to the river. These results clearly show the need for additional erosion control practices (such as riparian buffer strips or cover crops) under situations where corn residue is removed for ethanol production.

Carbon Sequestration

Another concern with removal of corn stover is the potential impact on soil organic carbon content. Stover contains carbon and nutrients that are returned to the soil over time by natural decomposition. These inputs of carbon and nutrients help maintain soil organic carbon and fertility. Research is underway at many locations in the Midwestern United States to estimate how much crop residue should be retained on the soil in order to maintain soil organic carbon. Results indicate that more crop residue has to be retained in order to maintain soil organic carbon than the amount that needs to be retained to control water erosion (Wilhelm et al., 2007). Roughly twice as much residue can be removed in a no-till continuous corn cropping system without affecting soil organic carbon than in a moldboard-plowed corn-soybean rotation.

Global climate change is partially driven by increasing amounts of CO_2 emitted to the atmosphere by burning fossil fuels. One of the reasons given for promoting energy production from biomass sources is the increased potential for sequestering CO_2 from the atmosphere. Perennial crops sequester more carbon than annual row crops. A recent report by the UM for the DNR (UM, 2008) suggests that converting row crops to short rotation woody tree crops (such as hybrid poplar) would sequester nearly 2 tons of carbon per year. In contrast, converting row crops to perennial grasses would only sequester about 0.4 tons carbon per year. Adding cover crops to annual row crop systems would sequester 0.2 tons carbon per year, while converting conventional row crops to conservation tillage row cropping would sequester only 0.1 tons carbon per year. These results suggest that producing cellulosic ethanol from perennial tree crops would sequester more atmospheric carbon than any other production technique.

Pesticides

Any expansion of corn acreage for ethanol production increases the risk of polluting surface and ground water resources with pesticides. The two pesticides most commonly applied to corn for control of weeds are acetochlor and atrazine. Some counties in southern Minnesota receive as much as 145,000 pounds of acetochlor and 70,000 pounds of atrazine applications annually, although per area rates of application are typically 2 pounds per acre or less.

The UM, working in partnership with the Minnesota Department of Agriculture, recently conducted a study to evaluate the risk of ground- water contamination in Minnesota from acetochlor and atrazine. Small regions throughout the state of coarse-textured soil and sediments were identified as having a high leaching potential. These regions were superimposed on maps showing the areas of the state that experienced large increases in the acreage of corn plantings between 2006 and 2007. An evaluation of the resulting maps indicate that for acetochlor (Figure E11), the areas of increased corn plantings did not generally occur in regions with a high risk for ground-water contamination by acetochlor. For atrazine, however, many areas of increased corn plantings were highly susceptible to ground-water

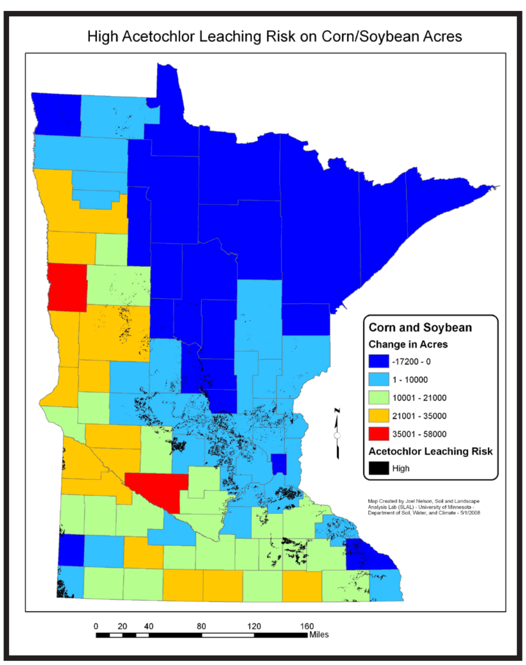

Figure E11. Areas of high acetochlor leaching risk on Minnesota corn-soybean land. Credit: Soloman Folle, Joel Nelson, David Mulla, UM.

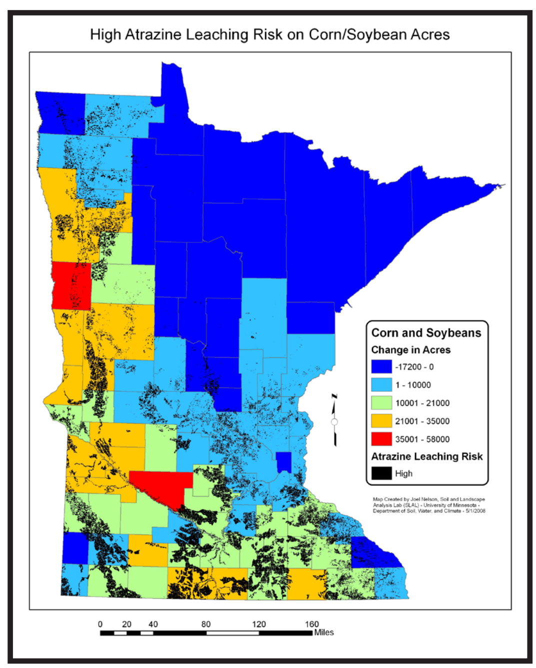

Figure E12. Areas of high atrazine leaching risk on Minnesota corn-soybean land. Credit: Soloman Folle, Joel Nelson, David Mulla, UM.

contamination (Figure E12). Thus, the increased corn plantings in 2007 had a much higher risk for contaminating ground water with atrazine than with acetochlor.

Conservation Reserve Program Land

Rising commodity prices have increased the likelihood that Minnesota producers will expand crop production into areas that have been protected by federal and state conservation programs such as CRP. CRP pays farmers to enroll their least productive and most environmentally sensitive land in practices that reduce erosion and improve wildlife habitat. Minnesota currently has roughly 1.7 million acres of land enrolled in CRP. CRP acreage is heavily concentrated in the Red River of the North basin and other portions of western Minnesota (Figure E13). These are areas that experienced large increases in corn planting between 2006 and 2007. Thus, there is a risk that as commodity prices increase, producers in the Red River basin and other portions of western Minnesota will plant their CRP land to agricultural crops when their contracts expire.

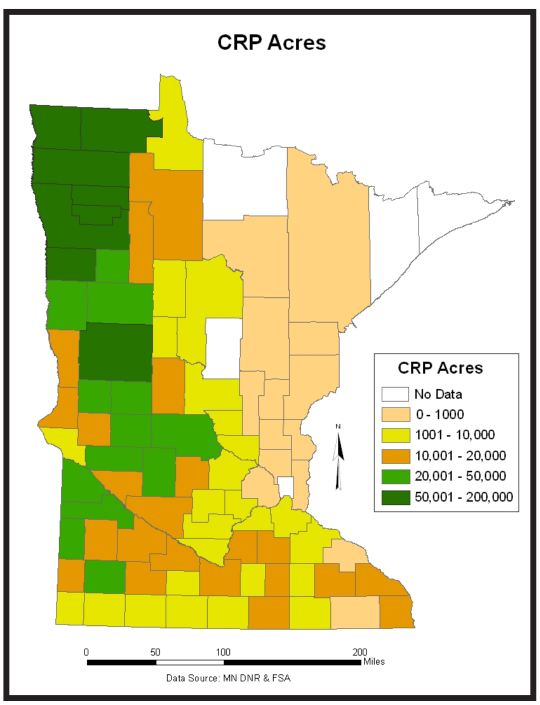

Figure E13. CRP acres in Minnesota. Credit: Joel Nelson, David Mulla, UM, using data from USDA.

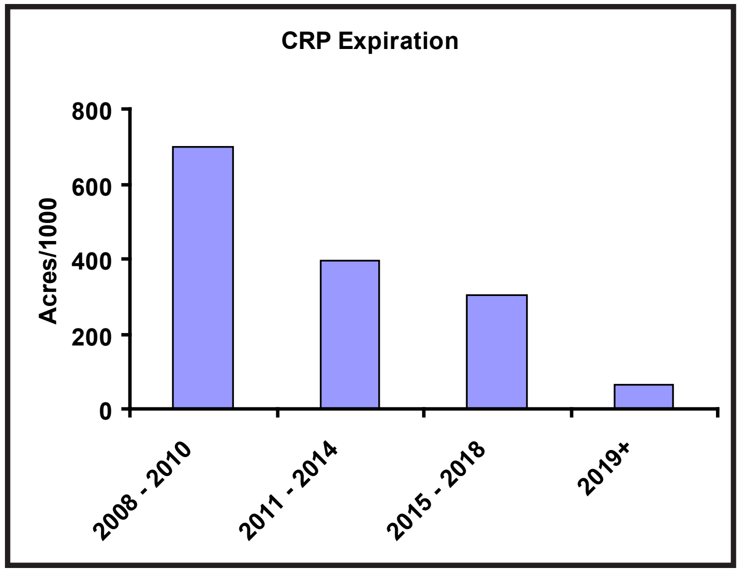

Figure E14. Acres of Minnesota CRP land with contracts expiring in different time intervals. Credit: Joel Nelson, David Mulla, UM, using data from USDA.

Contracts on large amounts of CRP land are going to expire in the next 10 years (Figure E14). From 2008 to 2010, nearly 700,000 acres of CRP land will retire. From 2011 to 2014, 400,000 acres will expire. From 2015 to 2018, 300,000 acres will expire. These lands are environmentally sensitive and provide valuable wildlife habitat. Measures are needed to ensure that expiring CRP lands are either re-enrolled or are used for perennial crop production to the greatest extent possible.

There is a significant potential for production of biofuel crops on Minnesota's expiring CRP lands. If all of Minnesota's CRP land were planted with switchgrass or hybrid poplar, and these crops produced 3 tons/ac of biomass, roughly 3.5 billion gallons of ethanol could be produced using cellulosic technology. However, it is not realistic to project that all of Minnesota's CRP land will be planted with biofuel crops, because some of the CRP lands may be re-enrolled after they expire. It is likely that only the most productive CRP lands will be taken out of retirement and planted with economic crops. Analysis of CRP lands (Figure E15) shows that 51% (900,000 acres) have a soil crop productivity index between 75 and 100 (average 86). A significant proportion of these lands have a high likelihood of being planted with economic crops after their contracts expire. Roughly 23% (400,000 acres) of CRP land has a soil crop productivity index between 50 and 75 (average 64). It would not make economic sense for producers to plant most of this land with economic crops. The remaining CRP acreage (25%, 440,000 acres) has a soil crop productivity index lower than 50, and is very likely to be re-enrolled when it expires.

Consumptive Use of Water

Minnesota cities and industries use roughly 339 billion gallons of ground water (Suh, 200X). In contrast, Minnesota's ethanol industry currently uses 2.9 billion gallons of water in the production process. Ground water supplies 96% of this consumptive use. There is concern that this rate of ground-water pumping will deplete aquifers that are used for public drinking supplies or will dry up streams fed by ground-water discharge. Research is underway to evaluate these potential problems, and more research is warranted to understand how regional ground-water supply and demand are related. Research is also needed to improve the water use efficiency of ethanol plants. Current ethanol plants use roughly 4 gallons of water for every gallon of ethanol produced. It is projected that cellulosic ethanol plants may use as much as 6 gallons of water per gallon of ethanol produced. As cellulosic ethanol production expands, ground- water supplies must be adequate to support the increased demand without affecting other uses and demands.

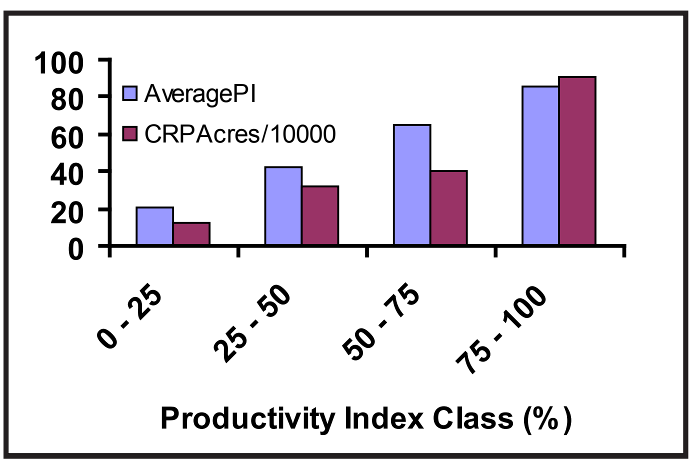

Figure E15. Average soil-based crop productivity index and acres of expiring CRP land for four crop productivity index classes. Crop biomass production potential increases as the crop productivity index increases. Credit: Joel Nelson, David Mulla, UM.

Mercury Pollution

Mercury deposition in Minnesota is responsible for extensive pollution of streams, rivers, and lakes, leading to widespread fish consumption advisories. In a state that values water and fish, mercury is a leading cause of impaired waters. Roughly 1,892 reaches of water are classified as impaired in Minnesota, and 66% of these are for mercury.

According to the Minnesota Pollution Control Agency (MPCA), mercury deposition in Minnesota was over 11,000 pounds per year in 1990. By 2005, mercury deposition in Minnesota decreased to 3,300 pounds per year. Mercury arises primarily (70%) from anthropogenic sources, and 90% of the mercury deposition in Minnesota arises from sources outside Minnesota. Minnesota's 10% share of mercury deposition arises mostly (56%) from electrical production plants that burn coal, while 22% is from processing of taconite ore.

In 1999, Minnesota's electrical utility plants voluntarily agreed to reduce annual mercury emissions by 275 pounds per year. In 2006, the Mercury Reduction Act was signed to obtain a 90% reduction in emissions of mercury from Minnesota's electrical production plants. The goal of this act is to cap mercury emissions from Minnesota coal-burning plants at 789 pounds per year by 2018. Taconite-processing plants are considering a proposal to reduce their mercury emissions by 50% in 2025. There is also the potential to substitute biomass for fossil fuel in both coal-burning and taconite- processing plants in order to reduce emissions of mercury.

The impacts of these mercury reduction strategies on concentration of mercury in fish are negligible. For example, the average mercury concentration in northern pike during 1990 was 0.248 parts per million (ppm). The projected concentration of mercury in northern pike after full implementation of the Mercury Reduction Act in 2018 is expected to be 0.228 ppm. If mercury emissions from outside Minnesota were reduced by 50%, mercury concentrations in northern pike would drop to 0.190 ppm. These projections show the importance of promoting policies that reduce mercury emissions from coal-burning plants in regions that border Minnesota.

Drivers of Change

The 25 recommendations from the energy and mercury team are intended to promote:

- Renewable energy production strategies that reduce reliance on fossil-fuel consumption and protect the environment
- A healthy economy based on renewable energy production strategies and environmental protection
- Efforts to conserve energy and improve energy use efficiency
- Strategies for significant reductions in mercury deposition

Each recommendation addresses a different driver of environmental change. Figure 4 in the introduction summarizes the potential impact of each recommendation.

Recommendations

Goal A

Promote alternative energy production strategies that balance or optimize production of food, feed, fiber, energy and other products with protection or improvement of environmental quality, including:

- water quality and water resource supply
- wildlife habitat
- greenhouse gas emissions
- soil quality and critical landscapes

Energy Recommendation 1: Develop coordinated laws, policies, and procedures for governmental entities to assess renewable energy production impacts on the environment

IP

Develop laws, policies, and procedures for governmental entities to assess and manage the cumulative impacts on the environment of proposed and established energy production facilities, focusing on both individual and combined impacts. Information from this effort should be used to develop a biennial report to the legislature that informs the direction of the statewide conservation planning strategy.

Description of recommended action. Minnesota Statutes 116D.10-.11, require state agencies and the governor to prepare a biennial report to the legislature on efforts to address Minnesota's energy and environmental policies, programs, and needs. This requirement provides an ongoing vehicle within state government for internalizing, integrating, and tracking implementation of recommendations developed by the SCPP. Further, while the SCPP lays much of the foundation for future strategy reports, these reports will need to address other issues and describe how SCPP recommendations fit with them. For example, biofuel production initiatives are one component of a proposed package for meeting state greenhouse gas emission reduction goals. In addition, they are potentially a significant vehicle for addressing impaired waters. The biennial strategy report must ensure that these efforts complement one another (along with other state goals, such as enhancement of wildlife habitat) and that they are kept on track. This report would integrate information coming out of the permitting process for individual biofuel plants to paint a statewide picture of how energy production in Minnesota impacts state resources.

Two actions are needed. First, the law should be amended to explicitly reference the SCPP and to streamline requirements. Second, strategic investments are required to build state capability to develop biennial assessments and track progress across issues. A third package of actions, those investments needed to follow up on other conservation strategy recommendations, will contribute to the foundation upon which biennial assessments will be based.

Description of impact on natural resources. A vast and diverse array of interrelated initiatives is required to protect Minnesota's environment and meet society's energy demands. Despite the law, no one has taken the initiative to make certain these efforts pull in the same direction and are adequately supported. Progress is not routinely monitored, nor are adjustments considered in a comprehensive manner. By ensuring that the state aggressively follows through on SCPP recommendations, potentially huge benefits should accrue for Minnesota's natural resources. In turn, failure to do so will likely mean spotty, inefficient, and, ultimately, ineffective resource management and protection.

Relationship to existing programs, laws, regulations. This recommendation is consistent with LEETF's recommendation for better government coordination on energy issues. The law governing the biennial energy and environmental strategy report is in place, but needs renewed focus and attention.

Time frame. The state and its conservation plan partners should complete an energy and environmental strategy by October 1, 2009.

Geographical coverage. The strategy is statewide in scope.

Challenges. Funding and staffing may become a barrier if additional support cannot be acquired. Single issue advocacy, politics, and interorganizational competition also pose challenges to successful strategy development.

Energy Recommendation 2: Invest in farm and forest preservation efforts to prevent fragmentation due to development guided by productivity and environmental vulnerability research

LP

Description of recommended action. Farm and forest fragmentation is a serious threat to wildlife habitat and ecosystem biodiversity. Expansion of urban and agricultural areas often produces fragmentation of forests, and urban expansion reduces the land resource available for producing food, feed, fiber, and fuel. Strategies and policies are needed to protect farms and forests, and prevent fragmentation. The 2008 legislature provided a $53,000 grant to the Minnesota Forest Resources Council (MFRC) to match $150,000 in funding from the Blandin Foundation and Iron Range Resources for a study of forest parcelization and development, an assessment of available policy responses, and policy recommendations to the 2010 legislature. The 2007 legislature provided a $40,000 grant to the UM Institute on the Environment that built on earlier MFRC research to assess potential impacts of parcelization and development on wildlife habitat and biodiversity in northern Minnesota. The state should consider recommendations from these studies relative to potential changes in policy or law, and relative to potentially funding specific proposals to prevent forest and farmland fragmentation due to development.

Description of impact on natural resources. Parcelization and development of forests and farmland continues to occur statewide, despite the recent downturn in the housing market and the economy in general. Investments in appropriate policy approaches to reduce adverse impacts of parcelization and subsequent development and habitat fragmentation would result in protection of wildlife habitat, water quality, recreational access, timber availability, and land resources critical to producing food and, increasingly, renewable energy crops.

Relationship to existing programs, laws, regulations. This recommendation is consistent with MCCAG's recommendations AFW-6 and AF-5. The study mentioned above will assess diverse existing programs, laws, and regulations (e.g., fee title ownership of public lands, public land acquisition and exchange, land use planning and zoning, conservation easements, tax policy, technical and financial assistance, education/information/awareness). Policy recommendations will recommend potential changes to some of these programs and laws to reduce adverse impacts of parcelization and subsequent development and fragmentation.

Time frame. Policy recommendations will be made to the 2010 legislature relative to forestland.

Geographical coverage. The area affected by the recommended action is statewide, with particular focus on forested regions of northern, central, and southeastern Minnesota.

Challenges. Continuing development of forestland and farmland is inevitable, and there will be numerous political, institutional, financial, and other barriers to implementing recommended actions to protect these lands. The most significant barriers may be cultural resistance to rural land use planning and financial constraints on public fee title land acquisition and conservation easements.

Energy Recommendation 3: Invest in perennial biofuel and energy crop research and demonstration projects on a landscape scale

SP

Invest in research and demonstration projects on a landscape scale to evaluate management and harvest techniques and yield potentials for various perennial biofuel crops (including monocultures of perennial grasses or woody biomass and polycultures) on different soils and agroecoregions throughout the state. These research and demonstration projects should accomplish the following goals:

- Improve yields through genetic, fertility, or pest management trials
- Develop best management practices (BMPs) for perennial crops that maximize environmental and wildlife benefits (including water and soil quality, fire and pest reduction, wildlife habitat, and decreased flooding)
- Determine which soils, landscapes, and agroecoregions of the state are best suited to various biofuel crops and are most resilient to climate change
- Study the economic costs, benefits, and barriers and develop strategies for minimizing the economic costs for growers pertaining to the time lag between perennial crop establishment and maturity, and maximizing the economic benefits of biofuel production
- Evaluate biomass resource availability and sustainable production rates by agroecoregion and landscape characteristics under various climate change scenarios

Description of recommended action. Based on nationwide analyses of potential biomass resources done by the U.S. Department of Energy (DOE) and USDA, energy crops are expected to play a major role in development of biomass resources for next-generation biofuels or carbon-neutral electrical generation. Coordinated research and policy experimentation should be carried out to develop and refine renewable energy production systems based on diversified biomass farming that emphasizes perennial biomass crops. This initiative has great potential to improve environmental quality and support economic revitalization in rural Minnesota, while providing large amounts of biomass for renewable energy and bio-products. Developed properly, diversified biomass farming can help support current production agriculture while enhancing rural economic opportunities, producing locally grown renewable energy, and addressing important statewide water quality and environmental issues. In order to make energy crops a practical reality in the state, work is needed to improve yields through genetics and through identification of the optimal sites and BMPs for these crops. The state should support demonstration projects that bracket the various parts of the state so both yield and environmental questions associated with perennial crop production for given state locations can be ascertained in a timely manner. Existing data generated by the MFRC on forestry issues and county-based agricultural production data developed by the Center for Energy and Environment may be used to determine biomass availability. Opportunities and limitations associated with use of these resources should be identified. The effects of various assumptions about environmental impacts and biomass availability should be analyzed.

To move forward on commercial-scale pilot renewable-energy projects based on diversified biomass farming, it will be necessary to take a comprehensive approach to establish a bio-refining system that integrates production, processing, feedstock conversion/refining, and end-use market applications including but not restricted to energy production. In particular, development of these projects will need to integrate the following elements:

- Public investment to overcome technical and economic risk and establish appropriate infrastructure
- Applied research to troubleshoot technical barriers
- Private investment and development, community support, and shared ownership
- A progressive local and state policy/regulatory framework that provides incentives to reward innovation

Description of impact on natural resources. Diversified biomass farming has potential to be highly multifunctional. This form of farming can function in two ways: first, to produce biomass for energy and other bio-industrial purposes, and also to provide other valuable goods and services, such as control of agricultural pests, improved recreation, hunting and fishing, cleaner water, protection of biodiversity, and protection against destructive flooding. In essence, multiple benefits come from putting the right plants in the right places in farm landscapes. In Minnesota, biomass can be produced from a range of perennial crops that are adapted to many regions of the state and to many different areas in farm landscapes. Biomass cropping options include mixtures of native prairie grasses, fast-growing trees and shrubs such as willows and poplars, and wetland species. The information developed as part of this project is central to planning the development of a renewable energy industry in the state. The research and demonstration projects would identify sources of feedstock available for production of renewable, low-carbon energy and determine the costs and environmental considerations related to using these resources.

Relationship to existing programs, laws, regulations. This recommendation is consistent with MCCAG's recommendation AFW-3 and with NextGen Board's recommendation to conduct technical analysis on the environmental impacts of biofuel production. Energy crop development is ongoing in the state through the work of the NRRI on woody crops (native poplar and hybrids), UM on prairie polymixes, and the USDA and UM on switchgrass. For the most part, these crops have been tested on a limited scale in specific locations in the state and work has not been widespread enough to make recommendations for their widespread application. Research on wildlife impacts of these crops has been done in the past but not on large plantings and over a sufficient time frame to fully understand potential benefits and impacts. The UM has performed research related to biomass production in forested zones. Also, this project will build on information developed by the Center for Energy and Environment on potential biomass availability across the state.

Time frame. This work would be done over a 10- to 15-year time frame. Development of new genotypes and adequate testing of new genetic material requires a relatively long time. Work on environmental benefits and impacts can be done over 5 years on preexisting sites.

Geographical coverage. The geographic range of this project would include all of Minnesota, including agricultural and forested regions.

Challenges. For farmers, biomass farming must be profitable and economically efficient, and profitability and efficiency will likely depend critically on augmenting income from biomass with payments for a variety of ecological services produced by multifunctional biomass farms (e.g., carbon and nutrient credits).

To meet needs of rural communities and regions, renewable energy production based on agricultural biomass must neither increase nor continue unacceptable economic, environmental, or social effects of current agricultural land use. It is clear that diversified biomass farming has excellent potential to reduce such unacceptable effects, but landscape-scale planning, efforts to retain value in rural communities, and other new management and policy initiatives will be needed to ensure these outcomes. The DNR's Working Lands Initiative is a very promising example of such policy innovation.

More broadly, renewable energy production based on diversified biomass farming has the potential to create significant economic value for many different community and regional stakeholders. These opportunities include production of goods and services such as water-quality protection, wildlife habitat, and carbon storage at relatively low cost; community-based production and use of sustainable renewable energy; development of local value-added supply chains for agricultural products; and creation of new industries that retain wealth in communities through living-wage jobs and local ownership. To build support for development of diversified biomass farming, new policy initiatives will be needed that capitalize on at least some of these opportunities for value creation.

Moreover, development of commercial-scale pilot renewable energy projects based on diversified biomass farming must be well coordinated. A number of lines of work must be pursued in a concurrent and highly interdependent manner. The bottlenecks to implementation of diversified biomass projects are strongly interrelated and mutually reinforcing. For example, local and regional planning to promote land use shifts to diversified biomass farming will likely be highly sensitive to market demand for ecological goods and services provided by these production systems. Conversely, a multifunctional landscape must meet the needs of multiple stakeholders and therefore actual production of any particular ecological service will be affected by the interests and concerns of multiple stakeholders. Consequently, planning and market development efforts cannot be undertaken independently or sequentially. Thus, it will be important to begin implementation by forming and facilitating the work of a multistakeholder implementation team.

Energy Recommendation 4: Develop policies and incentives to encourage perennial crop production for biofuels in critical environmental areas

SP

Invest in research and develop policies and financial incentives to encourage perennial crop production for biofuels on expiring CRP lands and other environmentally sensitive or low-productivity lands.

These research efforts, policies, and incentives should result in a balance between profitability and productivity on one hand, and benefits to the environment and wildlife habitat on the other hand.

Description of recommended action. The state should develop firm policies that would encourage the growth of energy crops on conservation lands and marginal farmlands and also reflect environmental and ecological needs for animal habitat and water resource conservation. There is currently an economic incentive for producers to plant productive expiring CRP land with row crops and small grains. Currently, there do not appear to be economic incentives for farmers or growers to grow perennial energy crops on these expiring environmentally sensitive lands. Policies and incentives are needed to encourage perennial biofuel crops on the most productive expiring CRP lands. Managers of low-productivity CRP lands should be encouraged to re-enroll them in conservation programs.

Description of impact on natural resources. Multiple environmental benefits would result from implementation of this recommendation. These benefits would be similar to those detailed under energy recommendation 3, more specifically applied to CRP lands and adjacent waterways.

Relationship to existing programs, laws, regulations. This recommendation is consistent with MCCAG's AFW-4 recommendation and with the NextGen Board's recommendation to increase the supply of biomass through farm incentive programs. Various laws govern the use of conservation lands under different jurisdictions. New policies are needed to allow prudent use of these lands for energy crop production while maintaining their other beneficial attributes.

Time frame. This is a high priority area. In order to meet future raw material needs for biomass material production, guidance is required on what practices will be permitted on the land in question. In addition, the establishment of energy crops is predicted to take from three to five years before the crop is available for its first harvest.

Geographical coverage. This impacts CRP lands across the state.

Challenges. The financial barrier to energy crop production is substantial, whereas other crop types have known federal subsidies to encourage their production. In addition, restrictions on conservation lands currently limit what can be done with these lands.

Energy Recommendation 5: Invest in data collection to support the assessment process

SP

Invest in data collection to support the assessment process described in energy and mercury recommendation 1.

Data collection is needed in the following areas:

- Water quality
- Water resource sustainability (surface and ground water)
- Wildlife habitat and biodiversity
- Invasive species
- Land use changes
- Soil compaction, cover, and residue levels
- Infrastructure and storage needs for alternative fuel strategies
- GHG emissions

Description of recommended action. Minnesota needs a comprehensive approach to monitoring the cumulative impact of its energy production on the state environment. Data collection to support the monitoring and assessment of energy production should cover every step of the production process, and has the potential to inform the biennial report described in energy recommendation 1. Currently, many of the data needs listed above are incomplete or lacking entirely. Minnesota should fund data collection in these categories in locations around the state.

Description of impact on natural resources. Data collection to inform a biennial report on Minnesota's energy production will help direct the state towards an energy infrastructure that is less harmful to the state's natural resources. Ongoing monitoring efforts will catch potential problems before they become too large, and will allow the state to adapt its energy production strategy to changing environmental conditions (e.g., climate change). This will have a beneficial effect on all natural resource categories.

Relationship to existing programs, laws, regulations. Current data collection efforts should be assessed for their ability to inform the biennial energy report, and new collection efforts should be targeted at the gaps in current collection schemes. The MPCA is currently monitoring water quality in some locations. The DNR and Metropolitan Council are monitoring deep and shallow ground water in wells at various locations in the state, and two research projects at UM are working on methodologies to assess Minnesota's ground- water sustainability. The DNR keeps geographical databases of many wildlife species and invasive plant and animal species. The UM is monitoring some land use changes using satellite imagery. Some research groups at the UM (e.g., the Industrial Ecology Lab) are analyzing the infrastructure and transportation needs of biofuel production facilities. The MPCA keeps a database of greenhouse gas emissions in the state, but new data on non-fossil fuel–related emissions (e.g., GHG flux from agricultural soils) is needed.

Time frame. This is part of an ongoing monitoring effort, with no end date.

Geographical coverage. These data are needed statewide.

Challenges. Coordination of current and future data collection efforts is a challenge. Finding appropriately qualified persons to carry out the data collection, and allocating time and money to these efforts, may also be barriers.

Energy Recommendation 6: Invest in research to determine sustainable removal rates of corn stover and to establish incentives and Best Management Practices (BMPs)

SP

Invest in research to determine sustainable removal rates of corn stover for animal feed and biofuel production, and to establish incentives and BMPs for mitigating the adverse impacts of corn stover removal on soil carbon and erosion.

Description of recommended action. There is currently a debate among researchers and practitioners regarding how much corn stover may be removed from a field for biofuel or animal feed processing without significant negative impacts on soil carbon and erosion rates. Since the corn stover biofuel industry is close to being operational, the answer to this question in the Minnesota context is needed as soon as possible. If negative impacts of corn stover removal may be mitigated through farmer-installed BMPs (riparian buffer strips or cover crops), the state should encourage adoption of these BMPs.

Description of impact on natural resources. Understanding and mitigating the negative ecological impacts of corn stover removal could have positive effects on land, water, air, and fish resources. Water quality and fish populations are impacted when eroded soil enters waterways. Air quality is negatively affected by wind erosion. The integrity of the agricultural land base is threatened if soil carbon declines or erosion increases.

Relationship to existing programs, laws, regulations. Comprehensive environmental impact reviews are currently being required for biofuel plants, but these reviews do not include the impacts of corn stover removal. Researchers at the USDA Agricultural Research Service (ARS) in Morris and at Iowa State University have done some research on stover removal rates and soil carbon effects. These research projects are limited in geographic scope.

Time frame. Two to three years for data collection and analysis

Geographical coverage. Research plots should be located wherever corn is being grown as an energy crop or for animal feed in the state. A diverse range of state climates should be represented, since temperature and precipitation can affect soil carbon and erosion processes.

Challenges. Research that could lead to limits on corn stover removal may be met with push-back from the biofuel industry, the livestock industry, and corn farmers. The challenge of selecting appropriate research sites that will inform biofuel production in all major climate regions of the state is another barrier.

Energy Recommendation 7: Invest in research to review thermal flow maps for Minnesota

SP

Invest in research to review current thermal flow maps for Minnesota to assess their validity/accuracy, and if necessary develop improved thermal flow maps, with the goal of informing geothermal power development in Minnesota

Description of recommended action. As a first step, the existing heat flow map for the state that was produced some years ago should be critiqued by experts from the Minnesota Geological Survey and their counterparts at the NRRI. Recent investigations of the current map seem to indicate that the existing projections for heat flow may be significantly underestimated due to the sampling technique used in the original data collection effort. Other countries at similar or higher latitudes, most notably Germany and Denmark, are adopting deep geothermal energy systems in order to produce necessary electrical power while reducing GHG emissions. A critical tool for assessing the viability of deploying this environmentally friendly energy technology is a thermal flow map for the state that relates the depth of the resource to the expected energy capture that may be possible.

In addition, organic rankine cycle (ORC) engines are often used in conjunction with deep geothermal mining to extract the heat for energy generation. These same engines can be used to recover waste heat from industrial facilities and power generation stations in order to generate supplemental electrical energy. The adoption of this technology on a broad basis should reduce the need for fossil fuel-based electrical energy production and also lower the energy footprint of many industrial plants in the state. Once the geothermal power development potential in Minnesota is assessed, funding should be made available to study the potential adoption of ORC engines for various industrial applications in the state (including taconite mines, corn-based alcohol plants, steam boiler plants, paper mills and chemical plants that have waste heat as a by product of operations).

Description of impact on natural resources. The use of geothermal energy will tap the energy lost every day as natural heat moves from the interior of the earth to the earth surface and then to space. Others are capturing this energy and using it to generate steam and power. The use of this renewable resource will decrease the need for coal- and nuclear- generated electric power, and decrease the amount of GHG generated in meeting the state's electrical energy requirements.

The recovery of waste heat from industrial plants and electrical energy power stations is another way to conserve energy and reduce GHG generation. The wide adoption of energy capture through newly installed heat exchange technology coupled with the ORC electrical generation technologies (or equivalent) will help the state meet its power generation targets as noted in existing statutes. It will also distribute electricty-generation capacity and help reduce the need for significant power transmission infrastructure improvements by allowing electrical energy to be used at the source of power generation.

Relationship to existing programs, laws, regulations. Current laws mandate significant renewable electrical generation capacity increases by the year 2025. Both approaches if proven to be viable could become a significant part of the energy solution if the heat flow characteristics prove favorable for the sources noted.

Time frame. This work should be done as soon as possible so that effective energy planning can incorporate this technology if the results of the assessment show significant potential.

Geographical coverage. Deep geothermal energy can be captured statewide. The recovery of waste heat from industrial operations and the subsequent conversion of the waste heat to electricity can be done throughout the state.

Challenges. Poor heat-flow data for various regions of the state exist at the present time. This limits our understanding of how this technology now adopted elsewhere in the world could be used here. A better database for expected heat flow from deep geothermal sources is needed to overcome this barrier. A complete understanding of the ORC technology and its applicability to our industrial and power generation facilities must be developed.

Energy Recommendation 8: Invest in applied research to reduce energy and water consumption and green house gas emissions in present and future ethanol plants, and enact policies to encourage implementation of these conservation technologies

SP

Description of recommended action. Minnesota should invest in applied research and demonstration projects that reduce water consumption, energy use, and CO_2 emissions at corn-based ethanol plants.

Description of impact on natural resources. A chief criticism of Minnesota corn-based ethanol plants is the small net gain of energy output from the energy expended to produce ethanol from current operations. At the same time, criticism has also focused on the high water-resource needs that accompany current production techniques in these plants. Current ethanol processing technology consumes from 4 to 5 gallons of water per gallon of ethanol, while future cellulosic technologies are expected to consume 6 gallons of water per gallon of ethanol. Finally, current production methods lead to significant generation of CO_2 in addition to ethanol and dried distillers grains.

Relationship to existing programs, laws, regulations. There are 17 ethanol plants operating in the state and more are being planned and implemented. The state and our rural communities have large investments in the existing plants and it is important to determine ways that overall plant efficiency in terms of both water use and energy consumption can be reduced through introduction of new technologies that can be integrated into existing plant structures. In addition, there is current development effort going on to demonstrate the potential use of CO_2 sources as a feedstock for alcohol production using both biological and thermochemical conversion. If the CO_2emissions from the plants can be converted into additional useful chemical and fuel agents, then the criticisms in terms of net GHG emissions impacts from existing operations will also be lessened.

Time frame. This recommendation is consistent with NextGen Board's recommendation to improve the efficiency of ethanol plants. This work would be done over five years. Development of engineering improvements for existing plants based on applied research and design for water and energy consumption reduction should be conducted as soon as possible. It is important to then test promising approaches at the pilot and demonstration level so that the best approaches can be adopted quickly by our existing industry and the approaches can be made part of the engineering design for new plants.

Geographical coverage. All areas of the state where ethanol plants exist and/or are contemplated for future installation.

Challenges. Technical approaches need to be brought out of the laboratory and tested at the pilot level and beyond. Specific applied research and development funding needs to be focused on taking proven laboratory concepts to the next level as soon as possible.

Energy Recommendation 9: Invest in research to determine the life cycle impacts of renewable energy production systems

SP

Invest in research to determine the life-cycle impacts of renewable energy production systems on the rural economy, greenhouse gas emissions, water sustainability, water quality, carbon sequestration, gene flow risks, and wildlife populations at landscape and regional scales while building on previous studies. This research should be used to direct the development of the renewable energy industry in Minnesota, including the storage and infrastructure needs associated with alternative fuels.

Description of recommended action. This recommendation is compatible with energy recommendations 1 and 5 in that it aims to estimate the cumulative impact of Minnesota's renewable energy development through data collection and analysis. Basically, the recommendation is that energy policy and incentives at the state level take a systems view, accounting for the resource benefits and impacts associated with each stage of energy production, transport, consumption, and associated waste processing. Research will be needed for legislators, citizens, and industry to make informed decisions about these benefits and impacts. Language to this effect should be added to legislation relevant to alternative energy development.

Description of impact on natural resources. If this recommendation is adopted, particularly with energy recommendations 1 and 5, Minnesota will position itself as a national leader in structuring its renewable energy economy for the benefit of both the economy and the natural resource base. Directing energy development toward beneficial activities and away from activities that significantly harm natural resources will have positive effects on all natural resource categories in the state.

Relationship to existing programs, laws, regulations. There is a large body of literature on the life cycle impacts of renewable energy strategies, including ongoing research efforts by UM faculty. This literature should be used as a guide to framing the issues in the Minnesota context. Current data collection efforts by various state agencies and researchers are described under Energy and Mercury Recommendation 4. The state has a goal of reducing its GHG emissions 80% by 2050, which may be informed by this research.

Time frame. This is an ongoing monitoring and assessment effort, with no endpoint.

Geographical coverage. The entire state should be considered.

Challenges. Perhaps the most challenging aspect of life- cycle analysis is drawing the system boundary. For example, energy production for out-of-state markets may have negative impacts on Minnesota's natural resources; alternatively, Minnesota might export its energy production and the associated resource impacts. These dynamics and their implications for renewable energy development should be considered in consultations involving scientists, policy makers and citizen stakeholders. Another barrier concerns' directing the state's energy production according to a life-cycle systems point of view, which is not currently being done.

Energy Recommendation 10: Invest in research and demonstration projects to develop, and incentives to promote, combined wind power/biomass, wind power/ natural gas, and biomass/coal co-firing electricity projects

S P

Description of recommended action. Integration of various energy production techniques that can help optimize the energy production system is an important opportunity for local communities, medium-size commercial and industrial users, and institutions in the state. As shown with the energy modeling work at the UM Morris, campus, a combined wind and biomass energy system allows overall optimization of energy production and the potential of almost complete energy self-sufficiency for the institution. The adoption of combined systems allows energy storage, peak loading, and stable energy generation issues to be addressed in a holistic fashion. For rural applications where biomass availability is high and wind conditions are favorable, systems can be envisioned where a wind turbine system is coupled with a biomass gasification system to enhance the storage of off-peak power through generation of hydrogen and oxygen using water electrolysis. The produced gases then can be utilized to help facilitate improved gasifier operations. The stored oxygen can be used to displace air in the gasifier combustion process, and the hydrogen can be added to the producer gas to enhance its chemical potential to produce a syngas for natural gas replacement or additional power generation. The enhanced syngas can also be utilized to produce liquid fuels for use locally. Additionally, wind power/natural gas and biomass/coal electrical generation projects should be demonstrated that will allow GHG reductions while stabilizing electrical generation capacity in the state.

Description of impact on natural resources. The combined use of biomass with wind resources allows a significant stabilization of alternative energy products that can be utilized to reduce GHG production and the need for coal in electrical power generation. Additionally, the potential enhancement of the syngas from the combination gives more use options for the producer gas than from a gasifier implemented alone. The placement of gasification facilities in rural areas near wind power generation sites also helps minimize transportation logistics for the biomass material and should aid in overall system economics. The use of wind/natural gas–based power generation systems allows stabilization of electrical generation from the turbine sites through incorporation of smaller natural gas turbine electrical power generation systems that can be brought up and down when wind conditions are insufficient to meet load demands. The use of biomass in coal-based power systems allows displacement of coal and incrementally reduces GHG generation from these facilities.

Relationship to existing programs, laws, regulations. The various combinations noted will directly help Minnesota meet its statutory targets for energy production from renewable resources and its GHG reduction targets. In addition, the combination of wind/biomass gasification and water electrolysis for hydrogen and oxygen generation and storage should facilitate production of syngas that can be converted to liquid fuels or used as a replacement for natural gas.

Time frame. This recommendation should be implemented on a short-term basis in order to allow demonstration of the combined systems in the near future. The experience generated from the combined systems should then be shared broadly in order to facilitate widespread adoption throughout the state.

Geographical coverage. The technology combinations should be demonstrated throughout the state where conditions for biomass supply and/or wind conditions are suitable.

Challenges. The technologies noted have been developed on an individual basis to a high degree. The key to future success is the integration of the facilities, which has not been done on a commercial scale. The technical risk of implementation of the technology combinations is a key barrier. Financial incentives that will help mitigate risk should be provided in order to demonstrate these potentially valuable technology systems.

Energy Recommendation 11: Invest in research and enact policies to protect existing native prairies from genetic contamination by buffering them with neighboring plantings of perennial energy crops

RP

Description of recommended action. In developing Minnesota's perennial biofuel industry (see energy recommendation 3), varieties may be selected for widespread planting that are not native to Minnesota, or that have been genetically modified from native plants. These biofuel plantings have the potential to genetically contaminate the state's native prairie remnants if they are close to these ecosystems. Research should be undertaken on the potential for this contamination, and policies should be developed to prevent it through mandated buffer plantings.

Description of impact on natural resources. Preservation of remnant native prairie is an important conservation goal in Minnesota, and the genetic integrity of native plants is necessary for the persistence of prairie remnants. Native prairie has significant cultural and ecological significance in Minnesota, providing habitat for a variety of plant and animal species.

Relationship to existing programs, laws, regulations. A number of prairie restoration projects are ongoing throughout the state. While these projects have not explicitly addressed genetic contamination from nonnative biofuel feedstocks, BMPs for native prairie will inform the work performed under this recommendation.

Time frame. The research could take place over two to three years, concurrent with the development of perennial bio-feedstocks. Policy would be developed based on the research findings.

Geographical coverage. Regions of the state with native prairie remnants.

Challenges. Aside from the cost of the research, there is a risk that implementing this recommendation will not prevent genetic contamination of native prairie remnants. This risk should be carefully assessed using appropriate methodologies, and weighed against the benefits of developing a perennial biofuel industry in Minnesota.

Energy Recommendation 12: Invest in efforts to develop sufficient seed or seedling stocks for large-scale plantings of native prairie grasses and other perennial crops

RP

Description of recommended action. If perennial crops are to become a significant component of biofuel production in Minnesota, sufficient genetic stock for large-scale plantings will be necessary.

Description of impact on natural resources. Implementing this recommendation will be necessary for the implementation phase of energy recommendations 3 and 4, including all of their positive effects on natural resources. These would include biodiversity preservation, watershed protection/flood prevention, and low-carbon fuel provision.

Relationship to existing programs, laws, regulations. This recommendation is consistent with the NextGen Board's recommendation to establish a biomass production infrastructure. Agronomic research on native plant breeding is ongoing at the UM.

Time frame. Seed and seedling stocks would be built up over three to five years and maintained while perennial biofuels are grown in Minnesota.

Geographical coverage. All regions of the state, including agricultural and forest regions

Challenges. Expert personnel and facilities for these seed/seedling banks must be provided. Also, the question of which plants should be grown in which part of the state (see energy recommendations 17 and 18) must be answered at least in part before seed banks are developed. However, widescale plantings of perennial biofuels cannot proceed without seed-bank development. This recommendation is therefore intimately connected with energy recommendations 3 and 4, and they should be funded and implemented together.

Goal B

Promote a healthy economy, including strategies that promote local ownership of alternative energy production and processing infrastructure, where appropriate.

Energy Recommendation 13: Invest in research and policies regarding "green payments"

SP

Invest in research and policies on implementation strategies and optimal pricing schemes for green payments. These payments may be applied to perennial energy crop production on expiring CRP land, in impaired watersheds, on environmentally sensitive or low-productivity land, on DNR working lands, and on annual cropland. Multiple tiered payments for water quality, carbon, wildlife, fuel production, and other benefits may be considered, and special attention should be paid to helping producers through the transition period for perennial energy crop production. Knowledge and insights gained from previous multifunctional fuelshed experiments (at Waseca, Madelia, and UM Morris, for example) should be applied.

Description of recommended action. This recommendation fits well with energy recommendation 2. If adopted together, these two recommendations would strengthen the state's efforts to protect environmentally sensitive land from intensive production, while providing benefits to farmers, local communities, natural resources, and wildlife. A green payment program should be informed by the most up-to-date scientific information on how biofuel production strategies impact natural resources. Farmers should be encouraged to plant perennial energy crops appropriate to their region (see energy recommendation 1).

Description of the impact on natural resources. An effective green payment program could have positive impacts on land, water, air, fish, wildlife, and recreation resources by reducing erosion, creating habitat, improving soil quality, sequestering carbon, and creating recreational opportunities.

Relationship to existing programs, laws, regulations. This recommendation is consistent with NextGen Board's recommendation to create a supply of biomass through farm incentive programs. The Reinvest in Minnesota (RIM) program currently pays farmers to enroll their land in conservation easements. However, this program may be less effective when high commodity prices dissuade farmers from renewing their contracts. A green payment program, on the other hand, would allow farmers to leverage the multiple environmental benefits of removing their land from intensive production. Ongoing research efforts at the UM are exploring how farmers might take advantage of Chicago Climate Exchange payments for sequestering carbon.

Time frame. This would be an ongoing program with no end date.

Geographical coverage. These actions should be focused on areas of the state with high amounts of expiring CRP or other environmentally sensitive land.

Barriers. Adopting this recommendation could have unintended negative consequences, such as driving up land costs or encouraging more intensive production on some agricultural lands. Periodic monitoring and assessment of the program could identify these problems and mitigate them to some extent. Public opinion regarding the production energy crops on environmentally sensitive lands may not be entirely positive.

Energy Recommendation 14: Investigate opportunities to provide tax incentives for individual investors in renewable energy (e.g., individuals who wish to install solar panels)

ES

Description of recommended action. The state should make it easy and cost effective for individual homeowners or businesses to get their electricity from solar, geothermal, or wind power sources they install themselves. The specific financial mechanism needed to accomplish this goal should be developed in consultations between economists, policy makers, and citizen stakeholders. Other states (such as Massachusetts) have programs that might serve as an example.

Description of impact on natural resources. Assisting interested individuals to invest in renewable energy technologies could have a snowball effect that would lead to widespread adoption of these technologies in Minnesota. This would reduce emissions of GHG, mercury, and other harmful air pollutants from coal-fired plants. It would also reduce water consumption in the electricity-generation sector, and could reduce the pressure on Minnesota's land resources to provide biofuels for electricity generation.

Relationship to existing programs, laws, regulations. This recommendation is consistent with the Minnesota Climate Change Advisory Group (MCCAG)'s RCI-4 recommendation. Minnesota already encourages community-based wind electricity through the community-based energy development (C-BED) program. Another state model may be seen in Massachusetts, which has developed a state rebate program which allows homeowners to pay off the cost of solar panel installation within five years, and targets extra assistance at low-income households.

Time frame. This program would continue until a given renewable energy option (for example, solar panel installation) becomes economically competitive on the open market.

Geographical coverage. Entire state.

Challenges. Finding the funds for such a program could be a challenge. Massachusetts has financed its program through electric bill taxes. In addition, increasing demand for individual renewable energy technologies (solar panels, wind turbines) could outpace supply, driving up costs in the short term.

Energy Recommendation 15: Invest in efforts to develop, and research to support, community-based energy platforms for producing electricity, transportation fuels, fertilizer, and other products that are locally/cooperatively owned

SP

Description of recommended action. Many renewable energy sources (e.g., wind, biomass, and solar power) are located in the rural parts of the state. The localized development of alternative energy systems that can be placed at the source or nearby the source of the biomass materials will reduce the problems associated with logistical movement of unconsolidated biomass and reduce the transportation costs for biomass energy conversion. At the same time, the production and use of energy and energy products on a local basis will reduce infrastructure costs associated with power and fuels distribution. Both factors should allow localized development of smaller scale alternative energy systems that will benefit the local rural communities and add valued products to their economies. The state should encourage the development of these localized alternative energy systems by adoption of policies and incentives to facilitate their adoption. In addition, research and demonstration for systems that can facilitate the implementation of this localized energy solution should be supported. Part of this support will involve transferring the lessons learned from successful community-based energy platforms (e.g., at UM, Morris; and Madelia, Coleraine Minerals Laboratory) to other communities interested in developing their own renewable energy platforms. The integration of local waste streams into energy production mechanisms is a key part of this recommendation.

Description of impact on natural resources. The primary effect of this recommendation is economic, in promoting community renewable energy over corporate ownership and shielding local communities from the rising costs of fossil fuels. Direct benefits for the air resource will result from decreased fossil-fuel burning. Indirect benefits for natural resources may result from communities being able to observe the impacts of their energy production and consumption patterns in their immediate surroundings. This may lead to more responsible energy and natural resource practices on a local scale. For example, capturing and reusing waste streams for energy may be easier on a local scale than statewide. In addition, the availability of new power and fuel sources generated at the local level will avoid substantial investments in new infrastructure that could delay adoption of useful technologies that can be implemented in the short and medium term and lessen the current energy issues facing Minnesota.

Relationship to existing programs, laws, regulations. Minnesota's C-BED establishes a tariff to promote community-based wind power.

Time frame. Ongoing

Geographical coverage. Entire state

Barriers. Community-owned energy may be difficult to integrate into the existing electricity grid, although this problem may be overcome through targeted investments. Start-up costs are likely to be great compared to corporate owned power operations. Distributing electricity and other energy generation throughout the state may also lead to some citizen discontent, since more people would be living near an energy plant.

Goal C

Promote efforts to improve energy conservation and energy efficiency among individuals, businesses, communities, and institutions.

Energy Recommendation 16: Provide incentives to transition a portion of Minnesota's vehicle fleet to electrical power, while simultaneously increasing renewable electricity production for transportation

ES

Description of recommended action. Powering Minnesota's current transportation fleet solely with biofuels or fossil fuels is not feasible in the long term. Fueling our vehicles predominantly with ethanol would place enormous pressure on the state's land resources, and would take land out of food production and conservation. Gasoline -powered vehicles contribute substantially to global climate change, and the rising price of gasoline creates an economic burden for Minnesota residents and businesses. Therefore, a state goal should be to transition the vehicle fleet away from dependence on both fossil fuels and biofuels. Powering vehicles with electricity derived from renewable sources makes sense from an ecological and sustainability standpoint, but is not yet economically viable. Several automakers have announced plans to sell electric vehicles within the next two years. However, the up-front cost for these vehicles will likely be more than for a conventional gas-powered vehicle. Minnesota should therefore provide appropriate incentives to encourage state residents and businesses to purchase electric vehicles, with the goal of creating a robust electric vehicle sector in the state. The use of electric vehicles for commuting to work and while shopping locally in metropolitan environments where the commuting distances are relatively short should especially be encouraged.

These vehicles will require more capacity in the electricity sector, which should be provided with renewable sources (wind, solar, and geothermal). Some of this excess capacity may be mitigated by encouraging electric vehicle owners to charge their vehicles during off-peak hours (i.e., at night).

Description of impact on natural resources. Transitioning a substantial fraction of Minnesota's vehicle fleet to renewable electricity would have a beneficial impact on the state's air quality, and would help to reduce GHG emissions and stabilize food prices (by removing competition for land between food and fuel needs).

Relationship to existing programs, laws, regulations. Minnesota's renewable energy standards require state utilities to produce progressively higher fractions of state electricity from renewable fuels. Some of this renewable electricity could be directed to the state's transportation needs. This recommendation would also help the state accomplish its GHG reduction goal of 80% below 2005 levels by 2050.

Time frame. Electric vehicle phase-in would occur over 10 to 20 years.

Geographical coverage. Entire state

Barriers. Electricity production will need to be ramped up to accommodate a growing electric vehicle fleet. This may present capital investment and infrastructure constraints. Financing and public support for an incentive program are also an issue. Current technology does not allow electric vehicles to travel more than 40 miles on electric charge only (beyond that point, a gasoline motor charges the battery), so for long trips electric vehicle owners will still have to use a small amount of gasoline.

Energy Recommendation 17: Promote policies and incentives that encourage carbon-neutral businesses, homes, communities, and other institutions with an emphasis on learning from institutions already working toward this goal (e.g., UM, Morris)

SP

Description of recommended action. Energy conservation and renewable fuel goals should be advanced simultaneously in Minnesota. Much more could be done to encourage businesses, homes, communities, and other institutions in Minnesota to dramatically reduce their carbon footprint through energy conservation and low-carbon fuel use. This recommendation fits well with energy recommendation 14—providing incentives for individuals to take advantage of solar, wind, and geothermal technologies would help them to become carbon neutral. Most likely, achieving carbon neutrality will require a portfolio of energy technologies and lowered energy consumption like that seen at UM, Morris (wind, biomass, etc.). Policies and incentives should be targeted to help individuals, businesses, communities, and institutions develop renewable energy portfolios appropriate for their situation.

Description of the impact on natural resources. Policies and incentives aimed at reducing the carbon footprint of individuals, businesses, and communities would have beneficial impacts on state land, air, and water resources. Reduction in energy consumption would lower water needs for electricity generation. Carbon-neutral businesses, homes, and communities would reduce state GHG emissions and would have secondary benefits for air quality. Reduced energy consumption could lower pressure on land resources to provide fuels.

Relationship to existing programs, laws, regulations. This recommendation is consistent with MCCAG's RCI-4 recommendation. Minnesota building codes are some of the country's most stringent in terms of energy conservation, and state-funded construction of affordable housing and new state buildings must incorporate green materials and construction. Assisting businesses, homes, and communities with further progress toward carbon neutrality would help the state achieve its GHG reduction goals.

Time frame. 10 to 20 years

Geographical coverage. Entire state

Barriers. Educating individuals, businesses, and communities about the need to reduce carbon footprint is one barrier (see energy recommendation 22). Improving individual and community access to renewable energy technologies and tools for carbon planning is another (see energy recommendation 14).

Energy Recommendation 18: Implement policies and incentives to lower energy use of housing stock while monitoring the performance of improvements and calling on the utility industry to join in the effort

SP

Description of recommended action. The envisioned housing improvements should consist of locally manufactured building material resources, especially those that use industry byproducts as their primary production feedstock. It is further recommended that the state develop specific policies and incentives to greatly improve construction practices for new residential homes. This can be accomplished by employing regional, sustainable building materials, and promoting the application of breakthrough systems approaches to new housing construction in an effort to drive down residential energy consumption. The UM has developed new technologies that present alternative means and methods for achieving vastly improved energy code compliance; these technologies should be further investigated to overcome implementation barriers.

Description of impact on natural resources. Execution of the recommended actions will markedly reduce the energy consumption of homes in the state. Creating a call-to-action to improve the existing housing stock will reduce energy consumption, thereby reducing our dependence on all fuel sources. Promoting continuous improvement and best practices in systems building will ultimately lead toward the goal of net-zero-energy new homes. Improvements in energy conservation at the micro-level of every household will reduce dependence on all fuel sources. In addition to energy savings for the homeowner, as local building material supply chains develop there will be a dramatic reduction in transportation energy related to building materials distribution. Greatly improving the energy efficiency and long-term durability of existing and new housing stock reduces the load on Minnesota's highly prized forest resources.

Relationship to existing programs, laws, regulations. The conservation improvement program of the past has faded away. The current state energy code is in place, but less than 30% of existing homes meet this code. The home-remodeling and home- building industry needs the know-how to improve the performance of residential housing on an ongoing basis.

Time frame. The recommendations should be acted on immediately. The result will begin reducing the state residential energy demand on all fuels within the first year of implementation. Our action is not short term; the solution should become a long-term initiative that results in standardized housing performance expectations.

Geographical coverage. Putting these actions into practice will impact all regions of the state. The actions will especially improve the economic conditions for those who live in older housing.

Challenges. The greatest challenge is to train the remodeling and new construction contracting industry. State-of-the-art methods, materials, and technology are never easy to implement in a standardized fashion. These industries are already stressed, so creating interest in the early stages is critical. It will be most helpful to demonstrate the benefits so these industries are aware of the important role they play in improving housing. Demonstration projects that showcase what can be done should be funded to allow potential practitioners to see what can be done on a firsthand basis.

Energy Recommendation 19: Promote policies and strategies to implement smart meter and smart grid technologies

SP

Description of recommended action. Smart meter and smart grid technology is the next generation of electrical distribution technology. It provides for more local management and control of the energy used in the region and on site.

- The use of both smart meter and grid technology requires a series of advancements and changes in the current distribution practices. On a national level, there should be a uniform interconnection standard that would allow for a more robust mix of distributed and central-based power generation.
- At a state level, guidelines should be established for purchase of backup and supplemental power so that distributed combined heat and power (CHP) plants are not put at an economic disadvantage when negotiating with investor-owned utilities.
- At a state level, investor-owned and electric cooperatives should be encouraged to move to smart grid technology and economic studies should be carried out to determine the benefit of incorporating distributed generation into the state's transmission grid.

Description of impact on natural resources. The best outcome for distributed smart grid smart meters is a more efficient use of generated power. With conventional central-based power generation, the conversion of energy to power is as low as 30% at the end user site. Any gains at the end of the grid will have significant impacts on the amount of energy used to produce the power at the plant. Thus, fewer natural resources will be consumed, and less pollution will be generated. Distributed generation could provide economic incentives for local energy producers.

Relationship to existing programs, laws, regulations. Smart meter/smart grid implementation depend on changes in both the national and state regulations.

Time frame. Fiscal incentives or cost avoidance will be the driver of the implementation of this technology.

Geographical coverage. This technology would affect the entire state, but would have the greatest benefit in the southwest, where transmission infrastructure is already congested and impeding the development of additional wind resources.

Challenges. Challenges include costs to both power generators and power users, because both will be impacted to install an integrated technology distribution system that has two-way communications, next-day pricing, and digital control networks with in the building operations; standard interconnection regulations and reasonable charges and actual costs of accommodating the use of distributed generation on the grid; and regional studies to understand the best opportunities for advancement of this technology.

Energy Recommendation 20: Develop incentives to encourage the widespread adoption of passive solar and shallow geothermal heat pump systems in new residential and commercial building construction; invest in research to develop improved technology for storing renewable energy

SP

Description of recommended action. It is recommended that policies be adopted to encourage the widespread adoption of passive solar and shallow geothermal heat pump systems in new residential and commercial construction. Furthermore, it is recommended that incentives be developed to allow more widespread adoption of these technologies in existing structures where it is deemed to be a practical method for reducing water and habitat heating and cooling requirements. Utilities should be asked to incorporate specific programs to encourage structure owners to adopt these technologies in order to help meet the state's conservation goal as noted in existing Minnesota statutes.

Description of impact on natural resources. Beneficial resource and economic impacts include: (1) avoids need for expanding coal based electricity to provide electric power for vehicles, (2) reduces GHG emissions, (3) improves water quality and quantity, (4) opens up new labor markets and business opportunities, (5) reduces in mercury emissions, (6) offers health benefits to people who consume fish, and (7) reduces fuel bills for consumers.

Relationship to existing programs, laws, regulations. This recommendation is tied directly to Minnesota Statutes 216B.241, "Energy Conservation Improvement." The goal of this statute is to drive energy conservation improvements in the state. Specific targets have been set for various utilities, depending on the service provided. The incorporation of the adoption of alternative heating technologies on a distributed basis will help reduce the demand for the utilities' products and satisfy the targets noted in this statute.

Time frame. The recommended actions should be taken over the next biennium in order to achieve results in a timely manner. Discussions with architectural and engineering experts to develop recommended practices for wide-scale adoption should be undertaken as a first step.

Geographical coverage. These actions can be done statewide.

Challenges. Incentives must be created to facilitate conversion to these technologies by existing structure owners. Policies that allow routine adoption of these passive energy technologies into new structures need to be defined and codified in order to have reliable adoption of the technologies on a broad basis. Potential disadvantages of these incentives include: (1) cost of research, (2) cost of technology, (3) cost of technology implementation, (4) cost of fuel, and (5) cost of permitting and code development.

Relationship to Preliminary Plan drivers. This fits in with the need to use non-GHG-generating and renewable energy sources as a principal vehicle to reduce overall fossil fuel energy reduction.

Energy Recommendation 21: Develop standards and incentives for energy capture from municipal sanitary and solid waste, and minimize landfill options for MSW

ES

Description of recommended action. A state mandate should be established that requires the capture of energy units from municipal solid waste (MSW) or municipal sanitary waste generated in the state. Appropriate statutory actions should be taken to establish targets for MSW use and minimization of landfill options for this waste material.

Description of impact on natural resources. A significant and underutilized source of energy exists in most communities today that, if utilized, could reduce the need for new energy production. This is municipal sanitary waste or MSW products that remain after recycling and reuse options are exhausted. Municipal sanitary waste is potentially useful for growing algae that can generate bio-oils for energy. MSW contains many paper, wood, gas by-products, and other biomass waste that could be used for energy production. The reduction of material volumes that need to be processed in sanitary landfills and certified disposal facilities should be a priority both at the state and local level. Other states and countries are now routinely implementing waste-to-energy programs that are highly beneficial to the reduction in GHG emissions while also resulting in valuable energy production.

Relationship to existing programs, laws, regulations. This recommendation is consistent with the NextGen Board's recommendation to promote the installation of methane digestors. MSW is a consequence of our collective use of a variety of commercial products in everyday life. It is very important to extract as much use as possible out of the material goods produced for human consumption. Others have recognized MSW as a valuable product that can be tapped for energy production. The use of this material on a regular basis is a fundamental conservation technique that should allow the state to meet its renewable energy targets.

Time frame. Current environmentally acceptable technologies have been developed and implemented in other localities for capturing energy products from MSW. Policies in statutory form should be implemented to encourage the adoption of these technologies in Minnesota.

Geographic coverage: All areas of the state

Challenges. Challenges include lack of knowledge of available options, current disposal methods that center around landfill practices, and challenges related to transportation and storage.

Energy Recommendation 22: Invest in public education focusing on benefits and strategies for energy conservation targeted toward individual Minnesota residents and businesses

SP

Description of recommended action. Individual action is critical in reducing state energy demand, which will lower GHG emissions and reduce pressure on the land resource to provide alternative fuels. Specific examples of actions that should be encouraged may be found in the MCCAG recommendations. These include bicycle/pedestrian/public transit commuting, slower highway driving speeds, and purchasing energy-efficient appliances. There is a need to educate the public about lifestyle choices to reduce their energy consumption, particularly related to homes and transportation. Advertising and communications experts should be brought into this effort to disseminate the carbon reduction message in a creative way that reaches the broadest segment of the population possible.

Description of impact on natural resources. If individuals reduce their energy use, it will have beneficial effects on air and land resources, through reducing emissions associated with fossil-fuel burning and lowering pressure on land resources to provide ethanol and other biofuels. Secondary benefits might include reduction in urban sprawl as individuals choose to live closer to their workplaces/city centers (this would benefit land, water, fish, recreation and wildlife resources).

Relationship to existing programs, laws, regulations. This recommendation is consistent with the NextGen Energy Board's recommendation to promote education and training programs on renewable energy. Some public education efforts are targeted at the Twin Cities metropolitan area (for example, ads for Metro Transit transportation). Energy audits are available for individual homeowners through the RES, and information about this program has been advertised. These efforts should be greatly expanded and directed toward a broader state audience.

Time frame. 5 to 10 years

Geographical coverage. Entire state

Challenges. There may be some pushback against this effort from some industrial sectors. Any public education effort runs the risk of being ineffective.

Goal D (see related Appendix III)

Promote regulations, policies, incentives, and strategies to achieve significant reductions in mercury deposition in Minnesota.

Energy Recommendation 23: Develop mercury reduction strategies for out-of-state sources

I P

Minnesota state agencies should work closely with the U.S. Environmental Protection Agency (USEPA) to develop mercury reduction strategies and assessment tools for the state, with the goal of meeting federal Clean Air Act and Clean Water Act standards. A mercury-reduction strategy should be developed that includes reduction of in-state demand for coal-powered electricity, and addresses mercury deposited in Minnesota from out-of-state sources.

Description of recommended action. Development of the national program that regulates mercury emissions from existing and future sources is very important in addressing the overwhelming contribution by sources from outside of Minnesota to the Minnesota environment (e.g., Minnesota water bodies). A federal mercury emissions program would minimize competitive disadvantage that regulations on the state levels potentially could create. Coordinated and joint efforts between the state agencies and the EPA would strengthen existing laws and reduce environmental loads of mercury.

Description of impact on natural resources. Mercury cycles through the air, water, land, and biota as a result of natural and human activities. It accumulates in the aquatic food web. Predatory fish species usually have the highest mercury concentrations. Most mercury that accumulates in the fish muscle tissue is in the form of methylmercury, a potential neurotoxin. Humans who eat contaminated fish may be exposed to dangerous concentrations of methylmercury. A national reductions program would greatly reduce mercury deposition in the state, and its concentrations in the environment.

Relationship to existing programs, laws, regulations. Currently there is no federal mercury emissions program. This recommendation supports the creation of a new federal policy that deals with mercury emissions.

Time frame. It may take up to several years to establish and create a national mercury emissions program. It may take several more years to enforce/bring into compliance mercury emissions because some plants may need to be retrofitted with new control technologies.

Geographical coverage. Regional and/or national mercury emission reductions would have a great impact on the deposition rates in Minnesota; because about 90% of mercury deposition comes from sources outside of Minnesota.

Barriers. Development of the national program would require cooperation and coordination with a number of state and federal government institutions. It may prove to be very timely and costly to establish this program. It may also take a lot of time, money, and effort to bring polluters into compliance.

Energy Recommendation 24: Continue state enforcement programs to reduce mercury loads

I P

The MPCA should be provided with adequate resources to continue to enforce/support existing mercury regulations and programs that lead to reduced emissions of mercury in Minnesota through market restrictions, pollution control techniques, and disposal requirements.

Description of recommended action. Existing regulations reduce product-sector emissions. The MPCA works closely with and provides education to the industry sectors on mercury reduction strategies and new control technologies. The voluntary/enforcement programs have been successful in reducing mercury air and water emissions.

Description of impact on natural resources. Mercury cycles through the air, water, land, and biota as a result of natural and human activities. It accumulates in the aquatic food web. Predatory fish species usually have the highest mercury concentrations. Most mercury that accumulates in the fish muscle tissue is in the form of methylmercury, a potential neurotoxin. Humans who eat contaminated fish may be exposed to dangerous concentrations of methylmercury. Reduced mercury loads into the environment would positively impact air and water quality and human health.

Relationship to existing programs, laws, regulations. This recommendation is a continuation of existing policies.

Time frame. This is an ongoing effort to reduce mercury pollution and emissions in the environment.

Geographical coverage. Mercury reductions will benefit Minnesota, neighboring states, and Canada, where up to 50% of Minnesota emissions are deposited.

Challenges. None

Energy Recommendation 25: Develop public education on actions that individuals and communities can take to reduce mercury loads

SP

Minnesota should develop a strong public education and outreach effort focusing on the health risks associated with mercury pollution and on techniques for reducing mercury loads (including energy conservation and proper disposal of light bulbs) in the environment.

Description of recommended action. Currently there are a number of state-sponsored and community-based public education and outreach programs addressing mercury emissions. They are specific to certain industries (e.g., energy producing facilities), activities (e.g., disposal of light bulbs) or public health advisories (e.g., mercury fish concentrations). Although beneficial, the programs are often inaccessible by many Minnesota citizens because they are not greatly publicized. Creation of a single, large, well-coordinated interagency public-outreach and education program could potentially address many issues more effectively and efficiently. Promotion and recognition of a single program may be easier to achieve.

Description of impact on natural resources. Mercury cycles through the air, water, land and biota as a result of natural and human activities. It accumulates in the aquatic food web. Predatory fish species usually have the highest mercury concentrations. Most mercury that accumulates in the fish muscle tissue is in the form of methylmercury, a potential neurotoxin. Humans who eat contaminated fish may be exposed to dangerous concentrations of methylmercury. Greater awareness of dangers posed by mercury will reduce human health risks and environmental emissions.

Relationship to existing programs, laws, regulations. A number of government agencies and community-based organizations already have public education and outreach programs in place. They usually address specific industry sectors, activities, or communities and rarely reach all levels of population. It may be more beneficial to develop a strong interagency/community outreach program. This would contribute to better organization and communication of the information.

Time frame. It may take up to a couple of years to identify, coordinate, and unify existing mercury public outreach and educational programs.

Geographical coverage. The citizens of Minnesota and the state environment would benefit from reduced mercury risks and lower concentrations in the environment.

Challenges. Coordination and unification of a number of interagency and community-based programs may be timely and costly to achieve. It may prove impossible to unify different types of outreach programs without losing some valuable participants and partners.