Project Name: Large Dairy Concentrated Animal Feeding Operations WPDES General Permit
County: Statewide

PRELIMINARY DECISION

In accordance with s. 1.11, Wis. Stats., and Ch. NR 150, Wis. Adm. Code, the Department is authorized and required to determine whether it has complied with s. 1.11, Wis. Stats., and ch. NR 150, Wis. Adm. Code.

The Department has made a preliminary determination that the Environmental Impact Statement process will not be required for this action/project. This recommendation does not represent approval from other DNR sections which may also require a review of the action/project.

Signature of Evaluator	Date Signed
	04/04/2011

FINAL DECISION

The public review process has been completed. The Department received and fully considered more than 150 responses to the news release or other notice.

Pursuant to s. NR 150.22(2)a., Wis. Adm. Code , the attached analysis of the expected impacts of this proposal is of sufficient scope and detail to conclude that this is not a major action, and therefore the environmental impact statement process is not required prior to final action by the Department.

The Department has determined that it has complied with s. 1.11, Wis. Stats., and ch. NR 150, Wis. Adm. Code. This decision does not represent approval from other DNR sections which may also require a review of the action/project.

Signature of Environmental Analysis Program Staff	Date Signed
	04/04/2011

NOTICE OF APPEAL RIGHTS

If you believe that you have a right to challenge this decision, you should know that the Wisconsin statutes and administrative rules establish time periods within which requests to review Department decisions must be filed. For judicial review of a decision pursuant to sections 227.52 and 227.53, Wis. Stats., you have 30 days after the decision is mailed, or otherwise served by the Department, to file your petition with the appropriate circuit court and serve the petition on the Department. Such a petition for judicial review must name the Department of Natural Resources as the respondent.

To request a contested case hearing pursuant to section 227.42, Wis. Stats., you have 30 days after the decision is mailed, or otherwise served by the Department, to serve a petition for hearing on the Secretary of the Department of Natural Resources. All requests for contested case hearings must be made in accordance with section NR 2.05(5), Wis. Adm. Code, and served on the Secretary in accordance with section NR 2.03, Wis. Adm. Code. The filing of a request for a contested case hearing does not extend the 30 day period for filing a petition for judicial review.

Environmental Assessment Comment Summary and Response for the
Large Dairy Concentrated Animal Feeding Operation WPDES General Permit

April 4, 2011

Introduction:
During the public comment period, the Department of Natural Resources ("the Department") received over 150 comments on the Large Dairy Concentrated Animal Feeding Operation WPDES General Permit and associated Environmental Assessment. Comments on the Environmental Assessment are included or summarized below.

Comment #1.: With over 200 pages of information and analysis, the EA generated for the proposed CAFO WPDES GPs adequately evaluates all potential environmental and socioeconomic impacts associated with issuing the proposed CAFO WPDES GPs. The EA satisfies the requirements under the Wisconsin Environmental Policy Act, Wis. Stat. § 1.11, and Wis. Admin. Code ch. NR 150.
Response: Comment noted.

Comment #2.: The EA properly concludes that agricultural production and development in Wisconsin, including CAFOs, contributes to valuable agricultural land conservation efforts, provides hundreds of thousands of jobs, and contributes substantial inputs to the state economy. Stringent regulation and oversight under the proposed CAFO WPDES GPs will provide adequate environmental protection while providing socioeconomic benefits to hundreds of communities in Wisconsin.
Response: Comment noted.

Comment #3.: There is only one entity who would benefit, and that would be the factory owners. Bringing new business and income to the area is not a valid statement of what would happen. It is a known and well documented fact that large factory farms are a negative impact on the sociology of a region. In the face of the resurrection of these factories, the small farmer, upon whom this country was proudly built, is dealt the unfair hand of closing shop for financial reasons. In the face of these factories increasing in number yearly, we, as proud Americans, are faced with eating unhealthy food, drinking unhealthy and sometimes dangerous e-coli laden water and breathing toxic and dangerous air. And we, the proud Americans, do not seem to have any say in these matters any more. Where is democracy?
Response: As stated in the EA, the Department's position is that use of the GP's will enhance permit oversight by reducing individual permit review workload. The EA indicates that there is some evidence of locally negative socioeconomic effects resulting from the presence of CAFOs. The Department does not have siting authority, and cannot deny specific or general WPDES permits based on socioeconomic concerns. The Department is not aware of evidence of the claim of unhealthy food, nor could the D make a permit decision on the basis of such information. The EA indicates that groundwater contamination has at times occurred (there are instances associated with permitted and nonpermitted operations) and that some individuals have been adversely affected. Evidence of widespread groundwater contamination and public health concerns does not exist, however. The EA identifies air contaminants associated with CAFOs, and the human health concerns with those contaminants. The EA also discusses potential air emission mitigating and control measures. Use of GP's is not anticipated to result in changes to the rate of growth in CAFO numbers, their geographic distribution, nor their size.

There were a number of comments that expressed concerns about the lack of and importance of local input in the permitting and EA process. A sample of these comments is included below.

Comment #4.: By removing the requirement for an Environmental Assessment, they rescind what little opportunity the public had at the local level to influence the permitting process.
Response: The public has had an opportunity to comment on the two EAs for the GPs. The public will continue to have the opportunity to comment on the use of the GPs for specific projects (both the decision to grant coverage of an operation under a GP and the operation's NMP). The EA process does not influence the permitting process beyond the Department's WPDES permit authority.

Comment #5.: It was with dismay that I learned about the possibility of a General Permit being available to CAFO, allowing them to locate and operate with very limited local input. It is essential that the public have a say in conditions that affect them financially (reduced property values), physically (air and water pollution) and emotionally (stress caused by living in an area of a CAFO.
Response: Use of GPs does not change the fact that the Department does not have siting authority over CAFOs. See also the previous two comment responses.

Comment #6.: Because all CAFOs under 5720 animal units (4000 cows) would receive coverage under this single permit and its generic Environmental Assessment, citizens would not get to comment on or influence permit terms or request an Environmental Assessment for new dairies on an individual basis.
Response: See the previous two comment responses.

There were a number of comments that expressed concerns that the single EA completed by the Department did not adequately address unique environmental features associated with an individual site. A sample of these comments is included below.

Comment #7.: Environmental assessments would no long be required for CAFOs under 5720 animal units, thus treating everywhere in the state as the same.
Response: The EA process does not affect the site specific nature of the permitting process. The EAs developed for the GPs disclose information regarding environmental conditions, resources and concerns in the various regions of the state.

Comment #8.: We must always get an environmental assessment, especially in the Driftless Area of the state where there is karst and breaks in the rock layers. The proposed one size fits all or one environmental impact study for the state is a bad idea and I hope I am wrong in suspecting that you may support it.
Response: See the previous comment responses.

Comment #9.: I understand that approval of a general permit means that only one environmental assessment (EA) will be done for all the permit applicants if this passes. Of course, the large agri-business interests want this, but is this good for the citizens of WI? With the individual CAFO, at least the applicant has to get an EA for their particular site. With a general permit, what about sites that are on land with high KARST geology where an accident would be catastrophic to the groundwater?
Response: See the previous comment response.

Comment #10.: Will there be only one Environmental Assessment for the entire state? It is not appropriate to apply a generic environmental review to widely dissimilar geographical regions and situations. Detailed study and research needs to be conducted on the environmental and social impacts to the surrounding area of each individual CAFO before the permit application is approved. This would make it possible for the Department and the CAFO to better recognize and protect unique regional resources.
Response: See previous comment responses.

Comment #11.: The Department should require an Environmental Impact Statements (EIS) as part of the CAFO permit process.
Response: There is no content requirement difference between an EA and an EIS under Chapter NR 150, Wis. Adm. Code. Under that code, less public involvement is required for the EA process than for the EIS process, but the Department chose to employ an EIS-level of public review opportunity for the GP EAs. The GP EAs are highly detailed, and include all the information that would be covered in an EIS.

Comment #12.: Why does the Department include an economic assessment in the EA? Department is not qualified to do such an assessment and should not be included in the ecological impacts.
Response: An environmental assessment (EA) is not strictly an ecological impact analysis. Rather it is an analysis of impacts to the "human environment". As such, both Chapter 1.11 of the State Statutes and Chapter NR 150, Wisconsin Administrative Code require analyses that include potential economic effects. The Department relies on socioeconomic literature in presenting information about potential economic effects.

Environmental Assessment for a General WPDES Permit for Large CAFOs

Environmental Analysis process

To the Reader:

This Environmental Assessment (EA) fulfills part of the Wisconsin Department of Natural Resources (DNR) requirements under the Wisconsin Environmental Policy Act (WEPA), Wis. Stat. § 1.11, and Chapter NR150, Wis. Adm. Code. WEPA requires state agencies to consider environmental factors when making major decisions. The purpose of this EA is to provide the decision makers, the public, and other stakeholders with an analysis of the economic, social, cultural, and environmental impacts that could result from the construction and operation of large dairy concentrated animal feeding operations permitted under a proposed general Wisconsin Pollutant Discharge Elimination System permit.

Comments received during the public comment period will be used by the Department to make its final decisions on this proposed general permit. You are encouraged to comment on this analysis. The analysis document is available on the Department website at: http://dnr.wi.gov/org/water/wm/ww/drafts/pubnot.htm.

The comment period on this analysis document ends on Friday, April 23, 2010. Written comments should be addressed to:

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The Department will also issue a public notice regarding the public informational hearings, where interested parties may provide verbal comments for the record on the proposed general permit. All comments received during the hearings and written comments received before the end of the comment period will be considered by the Department before issuance of a record of decision under s. NR 150.24, Wis. Adm. Code.

List of Contributors

Name	Responsibility
Gordon Stevenson/Tom Bauman	Permitting, project description, alternatives
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Terms & acronyms

AU	Animal Unit
“T”	Tolerable Soil Loss
AD	Anaerobic Digester
BCT	Best Conventional Technology
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CAFO	Concentrated Animal Feeding Operations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CO	Carbon Monoxide
DATCP	Wisconsin Department of Agriculture, Trade and Consumer Protection
DHS	Wisconsin Department of Health Services
DNR	Wisconsin Department of Natural Resources
DOC	Dissolved Organic Carbon
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ERW	Exceptional Resource Water
ES	Enforcement Standard for substances in groundwater under NR 140, Wis. Adm. Code
ESA	ethane sulfonic acid
GCC	Groundwater Coordinating Council
GHG	Greenhouse Gas
GP	General Permit
H2S	Hydrogen Sulfide
IC	Internal Combustion
LDCAFO	Large Dairy CAFO
LiDAR	Light Detection and Ranging
MACT	Maximum Achievable Control Technology
MCL	Maximum Contaminant Level of a substance in drinking water under the Safe Drinking Water Act
mg/ L	milligrams per liter
MOL	Maximum Operating Level
MOS	Margin of Safety
MRPO	Midwest Regional Planning Organization
MST	Microbial Source Tracking
NAAQS	National Ambient Air Quality Standards
NASS	National Agricultural Statistics Service

NASS	National Agricultural Statistics Service
NAWQA	National Water Quality Assessment
NESHAP	National Emission Standards for Hazardous Air Pollutants
ng /L	nanograms per liter
NH3	Ammonia
NHI	Natural Heritage Inventory
NMP	Nutrient Management Plan
NOCs	N-nitroso compounds
NOD	Notice of Discharge
NOX	Oxides of Nitrogen
NPDES	National Pollutant Discharge Elimination System
NRCS	U.S. Natural Resources Conservation Service
O&M	Operation and Maintenance
ORW	Outstanding Resource Water
P2	Pollution prevention
PAL	Preventive Action Limit for substances in groundwater under NR 14, Wis. Adm. Code
PM	Particulate Matter
PM10	Particulate matter with an aerodynamic diameter smaller than 10 µm
PM2.5	Particulate matter with an aerodynamic diameter smaller than 2.5 µm
SCORP	DNR Statewide Comprehensive Outdoor Recreation Plan
SNA	Wisconsin State Natural Area
SO2	Sulfur Dioxide
TMDL	Total Maximum Daily Load
TPAD	Temperature-Phased anaerobic digester
TSP	Total Suspended Particulate
UIC	Underground Injection Control
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geologic Service
UWEX	University of Wisconsin Extension
VOC	Volatile Organic Compound
WAP	DNR Wildlife Action Plan
WDNR	Wisconsin Department of Natural Resources
WDOA	Wisconsin Department of Administration
WEPA	Wisconsin Environmental Policy Act
WPDES	Wisconsin Pollutant Discharge Elimination System

I. Proposed project description

The Wisconsin Pollutant Discharge Elimination System (WPDES) permit program is a water quality protection program designed to limit pollutant discharges from point source discharges to waters of the state which includes, among other things, paper mills, municipal wastewater treatment plants and Concentrated Animal Feeding Operations (CAFOs). Livestock operations in the state of Wisconsin that have at least 1,000 animal units (see table below for animal numbers equivalent to 1,000 animal units) are considered large CAFOs under ch. NR 243, Wis. Adm. Code. WPDES permits for CAFOs have permit restrictions unique to this type of point source which rely primarily on the implementation of best management practices (BMPs) outlined in ch. NR 243, Wis. Adm. Code, to protect water quality. Ch. NR 243 outlines the water quality protection requirements that apply to large CAFOs. Revisions to ch. NR 243, Wis. Adm. Code, promulgated in July of 2007, facilitated the issuance of a large CAFO General Permit (GP) by 1) outlining the GP application process for livestock operations, and 2) creating more standardized and protective permit requirements that lend themselves to inclusion in a GP.

This environmental assessment is associated with the first time issuance of a WPDES General Permit for Large Dairy Concentrated Animal Feeding Operations (LDCAFO). Under state and federal law, livestock operations of this size are considered "point sources" with regard to water quality protection and are required to obtain a WPDES permit. As of February of 2010, there are 189 permitted CAFOs in Wisconsin, most of which are dairy operations with 1,000 animal units or more.

The Department currently issues individual WPDES permits to all of these operations. To provide a streamlined mechanism to regulate water quality impacts from some of these operations, the Department is proposing to issue a WPDES GP for LDCAFOS. Only large dairy operations of a certain size are eligible for coverage under the proposed LDCAFO GP (see Applicability Criteria in the LDCAFO GP attached as Appendix A).

The Department is proposing to limit the use of the LDCAFO GP to: 1) brand new or expanding dairy operations that are for the first time reaching or exceeding the 1000 AU threshold, but are not planning to expand beyond 5,720 AUs; 2) currently permitted dairy operations that have 5,720 animal units or less; and 3) currently permitted dairy operations that are looking to expand but will stay at or below 5,720 animal units. Table 1, below, equates AU to the number of head, if there were only one kind of animal present at an operation. Wisconsin livestock operations often have a number of different animal types present at a given operation so the actual total number of head will vary from operation to operation. An operation must have at least 80% of all its animals fall under the dairy animal type (in terms of animal units) in order to be deemed a dairy, under the GP, as listed in Table 1. This is intended to avoid questions concerning whether a mixed animal type operation is eligible for the proposed LDCAFO GP.

Table 1 - CAFO GP-Eligible animal numbers for dairies

Animal Type	No. Head equal to 1,000 AU (minimum No. of animals needed for permit coverage)	No. Head equal to Maximum allowable 5720 AU
Milking Dry Cows	700	4,000
Heifers	1,000	5720
Dairy Calves	5,000	28,600

Similar to the process for the issuance or reissuance of an individual CAFO WPDES permit, the WDNR will public notice the proposed issuance of the LDCAFO GP. The Department is not currently proposing coverage of any individual operations under the GP as part of this notice. Unlike an individual CAFO WPDES permit which is public noticed in the area where the operation will be located, the WDNR will notice the LDCAFO GP on a statewide basis. During the public comment period the WDNR will accept comments on the proposed GP and Environmental Assessment. The WDNR will also hold public hearings throughout the state to obtain comment on the proposed GP. Once the LDCAFO GP is issued, the WDNR can begin covering operations under the permit. Prior to conferring coverage to a given operation under the LDCAFO, the WDNR will need to public notice the decision to convey coverage and the operation's Nutrient Management Plan. Operations that are covered under the GP that wish to expand beyond the allowable number of animal units identified in the GP, must apply for and obtain an individual permit prior to expanding beyond the animal unit numbers outlined in the "Applicability Criteria" of the GP.

The proposed LDCAFO GP and associated Fact Sheet describing the types of operations regulated by the permit are attached in Appendices A and B (Section VIII).

II. Project purpose and need

II.A. Role of CAFO permitting

CAFO WPDES permits set out the terms and conditions under which a facility must operate, primarily by outlining required BMPs for the storage, handling and land application of manure and process wastewater as well as requirements to self-monitor and self-report. While permits allow pollutants to be discharged to waters of the state, they allow discharges only in amounts deemed acceptable after application of the best science available. Failure to comply with permit conditions, and permittee actions that result in discharges to waters of the state that are not in compliance with permit conditions, are subject to Department enforcement action and, if necessary, referral to the state Department of Justice to obtain forfeitures for violations. Permit noncompliance is subject to forfeitures up to $10,000 per day of violation.

There are two primary reasons the WDNR is pursuing issuance of a WPDES General Permit for Large Dairy CAFOs. The first reason is that with the July 2007 revisions to ch. NR 243, CAFO individual WPDES permits became very standardized. The second reason is that the WDNR believes using the LDCAFO GP will save time during the permit issuance process and will allow WDNR staff to focus additional time on compliance monitoring efforts.

CAFO permits can be broken into the following key areas which can be seen in the attached LDCAFO GP (Appendix A):

- Production Area Discharge Limitations: CAFOs covered under a WPDES permit are not allowed to have discharges of pollutants from the animal production area (where animals are housed and manure, process wastewater and raw materials such as feed are handled and stored), except under certain storm events.

- Nutrient Management Plan: Restrictions on when, how and in what amounts manure and process wastewater may be land applied on cropped fields, including general and winter spreading restrictions.

- Monitoring and Sampling Requirements
    - Self-monitoring and inspection
    - Nutrient sampling of manure and process wastewater

- Compliance Schedules (most not included in the LDCAFO GP)

- General Conditions: Outlines requirements that apply to all WPDES permittees

- Livestock Operation General Requirements

The requirements of these sections are intended to protect water quality by prescribing BMPs and performance expectations for LDCAFOs.

For most operations, the only unique sections of an individual WPDES permit are the areas identifying outfalls and sampling points unique to an operation and the inclusion of compliance schedules to install permanent structures for runoff control or manure storage. To address

outfall/sampling point identification, the GP includes a standard identification system for sampling points and outfalls. These sampling points would be identified in the cover letter sent to the permittee conveying coverage under the GP. In addition, the GP does not allow for the use of compliance schedules for installation of structures, and requires that all these structures/systems are in place and in compliance with permit requirements prior to permit coverage.

Members of the public may be concerned that the LDCAFO GP will promote CAFO expansions and limit the WDNR's or their ability to stop a CAFO from locating at a given site. However, it should be noted that the WPDES permit is not a siting permit that dictates whether an operation can expand or locate in a given area. Rather, it is an operational permit that sets forth the conditions needed to protect water quality based on where an operation has chosen to locate. The WPDES program has been issuing and re-issuing WPDES permits since 1974 (to CAFOs since 1985) to the roughly 1200 wastewater dischargers in the state. Over that period of time, the number of **individual** permits that have been issued or re-issued numbers over 7500. In this 30+ year history of the permit program, the Department is unaware of an instance where a WPDES permit has been denied. That is not to say that permit denials are not legally possible, only that permit denials have not been made.

The absence of permit denials is not an oversight nor is it a product of lax enforcement of water quality laws and regulations. The WPDES program has been implemented and administered by highly qualified and respected WDNR staff. It is a program that is overseen by the U. S. Environmental Protection Agency, and one that has been enforced and defended by the Wisconsin Department of Justice. There is a significant difference between simply denying someone the opportunity to discharge wastewater and, conversely, allowing discharges but under precise, legally and technically defensible conditions. It is up to the permittee to determine if these water quality based conditions restrict an operation's ability to operate at a given location.

Members of the public are often critical of the fact that the Department does not deny permits based on potential concerns and impacts on the human environment other than water quality, such as noise, odor/air issues, traffic and socioeconomic concerns. Opponents of the siting of a CAFO in a given location have often tried to use these concerns in an attempt to stop the location or expansion of a large CAFO operation. The Department does not have authority to deny WPDES permits on the basis of non-water quality concerns.

II.B. Advantages of GP approach

Beginning in 2000, the Department began to see a rapid increase in the number of CAFOs in the state, primarily in the dairy sector. In order to make the most efficient use of staff resources, the Department has chosen to issue an LDCAFO GP. Wisconsin is one of the few states, if not the only state, that does not currently use GPs to implement the NPDES permit program for CAFOs.

GPs provide for a streamlined permit process by reducing the time needed to issue what has become a very standardized WPDES permit template for each permitted operation. The level of WDNR review of an operation's WPDES permit application as it relates to water quality will not change. However, the permit document does not need to be redrafted for each operation and the environmental analysis work has already been done associated with the issuance of the general permit. Not needing to repeat the permit drafting process for each operation will allow Department staff to spend less time on permit issuance and more time on other activities such as permit compliance and inspections, enforcement actions where needed, and addressing impacts from smaller-scale operations that do not have permits.

One of the most significant concerns expressed by public advocacy groups with respect to the use of GPs for CAFOs, is a potential reduction in public input on proposed DNR CAFO permit

actions. However, in response to federal CAFO rule revisions that were promulgated in November 2008, the Department will need to public notice any operation proposed for coverage under the LDCAFO GP and public notice its NMP. This will allow members of the public to comment and request a hearing on the Department's proposed coverage of an operation under the LDCAFO GP, as well as the operation's NMP.

III. Authorities & approvals

III.A. DNR WPDES authority regarding livestock operations

The Department has the following WPDES Permit authority for CAFOs, under s. 283.31, Stats., and ch. NR 243, Wis. Adm. Code.

- A WPDES permit contains a number of restrictions designed to address potential water quality impacts from the proposed operation. Requirements include: 1) proper design, construction and operation of structures associated with manure and process wastewater handling at the site; 2) development and implementation of an emergency response plan; 3) restrictions on the amount, location, and timing of applications of manure and process wastewater through a nutrient management plan; 4) restrictions on runoff from animal housing, feed storage and manure storage facilities; 5) self-monitoring of production and land application areas; and 6) reporting of land application activities and results of animal production area inspections.

- Operations covered under a WPDES permit are required to conduct: 1) daily inspections of water lines to discover and correct any significant leakage; 2) weekly inspections of stormwater diversions and storage structures; 3) quarterly inspections of raw material storage areas (*e.g.* feed storage areas); and 4) periodic calibration and leak inspection of landspreading equipment. The Department evaluates the construction of structures related to manure handling in conjunction with potential water quality concerns to determine if additional monitoring is necessary.

- Nutrient Management Plan review, ch. NR 243, Wis. Adm. Code, and NCRS technical standard 590.

- Review and approval authority under s. 281.16, Stats, for manure storage facilities, transfer systems, feed storage and runoff control systems and other DNR reviewable structures.

Storm water discharges from any livestock operation disturbing one or more acres as a result of construction are regulated under ch. 283, Wis. Stats, ch. NR 216, Wis. Adm. Code, and in accordance with WPDES General Permit No. WI-S067831-3, Construction Site Storm Water Runoff.

III.B. DNR authority to issue GPs

The Department's authority to implement a general WPDES permit program is a follows.

DNR authority to issue GPs: Ch. 283, Stats., outlines the authority for Department implementation of the WPDES permit program. s. 283.35, Stats., outlines the authority to issue general WPDES permits.

GP issuance process: Ch. NR 205, Wis. Adm. Code, outlines the permit issuance process for individual and general WPDES permits. s. NR 205.08, outlines the issuance process for a WPDES GP. The GP issuance process is similar to the issuance process for an individual permit (*e.g.* notice and hearing requirements), with the exception that a general permit itself is public noticed on a statewide basis, rather than only in the area where a given operation is located.

CAFO GP issuance and application process: s. NR 243.121, Wis. Adm. Code, further outlines the Department's authority to issue a CAFO WPDES GP and outlines the application requirements for a GP.

III.C. GP Issuance process

Similar to the process for the issuance or reissuance of an individual CAFO WPDES permit, the WDNR is currently public noticing the proposed issuance of the LDCAFO GP. Unlike an individual CAFO WPDES permit which is public noticed in the area where the operation will be located, the WDNR will notice the LDCAFO WPDES GP on a statewide basis. During the public comment period the WDNR will accept written comments on the proposed GP (and this EA). The WDNR is also holding five public hearing (Eau Claire, Viroqua, Fitchburg, Grand Chute and Wausau) throughout the state to provide additional opportunities for public comment. The Department will include a response to comments and a Notice of Final Determination on the issuance of the permit.

Once the LDCAFO GP is issued, the Department can begin covering operations under the GP. Ultimately, coverage under the proposed LDCAFO GP is dependent on the Department's determination that the GP is appropriate for a given operation based on the information submitted as part of the permit application package.

The process for coverage will be similar to the CAFO individual permit process. The process outlined below is a basic explanation of how the Department expects the GP permit coverage process to work. There may be changes made to this process on a case-by-case basis or based on changes to how the GP program is implemented. An operation must submit a complete permit application in accordance with s. NR 243.12, which consists of a basic application form, a complete NMP, engineering evaluations of existing structures (if they exist at the site), and plans and specifications for any proposed structures that are subject to Department review under ch. NR 243. If the application does not contain any of these required components, the applicant will typically be given a short timeframe to submit the missing components. Failure to submit necessary information in the specified timeframe will result in the entire application being returned to the permittee.

For operations that have submitted all the necessary components, the Department will typically inform the applicant via e-mail that it has made an initial determination of whether or not the operation meets the basic GP eligibility criteria (*e.g.* correct animal type and size of operation). The Department will then begin review of the components of the permit application to determine if the components are complete and comply with the requirements of ch. NR 243. This is of particular importance for the nutrient management plan, and plans and specifications for proposed structures and evaluations of existing structures. If review of these individual components is deemed incomplete, the Department will again provide the applicant a short period of time to submit necessary information. Failure to submit necessary information in the specified timeframe will result in the entire application being returned to the applicant. In addition, if the Department determines that existing structures do not meet current standards which will require a permit compliance schedule, the applicant will be informed via e-mail that it is no longer eligible for coverage under the GP and that the operation will be considered for an individual permit.

If the operation's WPDES permit application is complete and complies with ch. NR 243, the Department will issue the necessary approvals for plans and specifications for proposed structures and will issue a completeness determination for the NMP to the permittee. The Department will then public notice its proposed decision to cover the operation under the WDPES LDCAFO GP. Upon completion of the public notice period and after responding to comments (and hearing comments if applicable), the Department will grant coverage via letter to the permittee under the

LDCAFO GP. The letter authorizing coverage will identify runoff control systems and manure storage facilities authorized to be used by the permittee under the GP. For operations that are constructing 180-day liquid manure storage, the Department cannot grant coverage under the GP until the operation has verified that construction of the storage is complete. Once the Department has issued the letter granting coverage, the dairy can begin operating under the GP.

It should also be noted that certain changes to the NMP, such as addition of landspreading acreage, will require additional public notice.

III.D. Other DNR authorities related to livestock operations

III.D.1. Drinking and groundwater authorities

Safe Drinking Water Act standards

The Department's Bureau of Drinking Water and Groundwater is responsible for insuring that drinking water and groundwater is protected and that community and private wells can provide clean, safe water to Wisconsin citizens. Because groundwater replenishes lakes, rivers and wetlands, groundwater quality also affects surface water bodies and aquatic life.

Wisconsin has primary enforcement responsibility for enforcing Safe Drinking Water Act standards which are codified in chapter NR 809, Wis. Adm. Code. Standards must be met for all community and non-community wells serving more than 25 people for more than 60 days of the year (see diagram: http://dnr.wi.gov/org/water/dwg/public/publicdiagram.pdf). Owners of wells regulated under chapter NR 809 Wis. Adm. Code, which include non-transient non-community wells that serve most CAFO employees, are required to monitor drinking water. For more information on monitoring requirements for this type of well see: http://dnr.wi.gov/org/water/dwg/Forms/Operator.pdf.

Chapter NR 811, Wis. Adm. Code, Requirements for the Operation and Design of Community Water Systems, sets separation distances from new wells to potential sources of contamination. If CAFOs are constructed too close to community wells, the wells can be out of compliance and more easily contaminated. An attempt was made to insure that this would not happen by incorporating separation distances in chapters NR 243 and ATCP 51 Wis. Adm. Code. However, the separation distances are not included in NRCS 590 which is codified by reference in chapter NR 151, Wis. Adm. Code.

Chapter NR 812, Wis. Adm. Code, Well construction and Pump Installation, regulates placement of private wells in relation to potential sources of contamination. If CAFOs are constructed too close to public or private wells, the wells can be out of compliance and more easily contaminated. NR 243 is consistent with the separation distances in NR 812. While these restrictions are not mirrored in NRCS 590, they are required under subchapter ATCP 51.12(5), Wis. Adm. Code.

Wisconsin's groundwater legislation

This section looks at state regulatory authority for groundwater related to CAFOs. For a more complete review of Wisconsin's regulations please see the Wisconsin Groundwater Coordinating Council Annual Report to the Legislature (http://dnr.wi.gov/org/water/dwg/gcc/rtl/gccreport.htm).

1983 Wisconsin Act 410 - Wisconsin's Comprehensive Groundwater Protection Act

Act 410 created Chapter 160 Wis. Statute which provides a multi-agency comprehensive regulatory approach including two-tiered numerical standards for substances found in groundwater. For each standard there is an enforcement standard (ES) which determines when a violation has occurred and a preventive action limit (PAL) which is set at a percentage of the ES. The PAL serves as a trigger for possible remedial action. The standards apply to all groundwater in the state. The standards are contained in chapter NR 140 Wis. Adm. Code (http://www.legis.state.wi.us/rsb/code/nr/nr140.pdf) and are updated continuously in response to new substances and health concerns. All state agencies must manage their regulatory programs to comply with groundwater standards. Standards important for CAFOs include nitrate, bacteria, copper, zinc, agrichemicals related to crop production for CAFOs, and arsenic. However, not all of these standards are necessarily regulated under a CAFO WPDES permit. There are currently no groundwater standards for phosphorus, hormones, or antibiotics.

Act 410 clarified the powers and responsibilities of local government to protect groundwater in partnership and consistent with state law. Provisions that are important for CAFOs include:

- Cities, villages, towns and counties have expanded zoning authority to encourage protection of groundwater.

- Counties can adopt ordinances regulating disposal of septage on land (consistent with DNR requirements). Cities, villages or towns may adopt ordinances if the county does not. There is limited authority under NR 151 Wis. Adm. Code for adoption of local restrictions for land application of manure and waste.

2003 Wisconsin Act 310 - Wisconsin's Groundwater Protection Act

Act 310 expanded the State's authority to consider environmental impacts of high capacity wells and established a framework for addressing water quantity issues in rapidly growing parts of the state. This legislation recognized the link between groundwater and surface water and the impact wells may have on groundwater and surface water. Passage of Act 310 led to development of chapter NR 820, Wis. Adm. Code. Components of NR 820 that affect CAFOs are:

- Owners must get prior approval from the DNR Bureau of Drinking Water and Groundwater for construction of high capacity wells. An application fee of $500 must be included with the application. A High Capacity well system is defined under NR 812 as one or more wells, drillholes, or mine shafts that have a combined approved pump capacity of 70 or more gallons per minute. The law requires all high capacity well owners to report water use annually.

- Act 310 directs DNR to consider the environmental impacts of pumping on wells located within 1,200 feet of an Outstanding or Exceptional Resource Water or Trout stream; wells that may impact a spring with a flow of at least one cubic foot per second for at least 80% of the year; and wells where more than 95% of the amount of water withdrawn will be lost from the surface water basin.

Great Lakes Compact and 2007 Wisconsin Act 227

The Great Lakes Compact addresses water quantity management in the Great Lakes – Saint Lawrence River Basin. It sets requirements for withdrawal registration, reporting, permitting and water conservation and efficiency. It prohibits diversion of water outside the Great Lakes – Saint Lawrence Basin with limited exceptions. Act 227 requires that the DNR develop and implement a

water conservation and efficiency program with voluntary measures to apply across the state, additional mandatory elements that apply in the Great Lakes Basin and the most stringent requirements for communities applying for approval of a diversion or water uses with high rates of water loss. Water use permits and mandatory water conservation and efficiency measures will be required for all high capacity wells and other types of withdrawals within the Great Lakes Basins including those serving CAFOs.

Well Permits

High capacity well permits

Under Chapter NR 820, Wis. Adm. code:

- Owners must get prior approval from the DNR Bureau of Drinking Water and Groundwater for construction of high capacity wells. An application fee of $500 must be included with the application. High Capacity wells are those that pump more than 100,000 gallons per day. The law requires all high capacity well owners to report water use annually.

- Act 310 directs DNR to consider the environmental impacts of pumping on wells located within 1,200 feet of an Outstanding or Exceptional Resource Water or Trout stream; wells that may impact a spring with a flow of at least one cubic foot per second for at least 80% of the year; and wells where more than 95% of the amount of water withdrawn will be lost from the surface water basin.

Class V injection wells

The Underground Injection Control (UIC) program is a requirement of the federal Safe Drinking Water Act of 1974. The purpose of the UIC program is to protect underground sources of drinking water (a.k.a. groundwater) from contamination that may result from the use of injection wells. Each state is required to establish a UIC regulatory program that enforces rules that are at least as stringent as those published in the Code of Federal Regulations. Any state that fails to establish its own UIC program will be subject to the direct enforcement of federal injection well regulations by the United States Environmental Protection Agency (EPA). A septic system is required to meet UIC requirements and is considered a Class V well if:

- The septic system, regardless of size, receives any amount of industrial or commercial wastewater; or

- The septic system receives solely sanitary waste from multiple family residences or a non-residential establishment and has the capacity to serve 20 or more persons per day (also known as large-capacity septic systems).

Large CAFOs that employ more than 20 people or that produce industrial or commercial wastewater are required to be in compliance with Chapter NR 815, Wis. Adm. code. For more information on requirements on Wisconsin's Underground Injection Well program requirements see: http://dnr.wi.gov/org/water/dwg/uiw/

III.D.2. Air emission authorities

Air emission limitations from s. NR 415.04, Wis. Adm. Code, covering fugitive dust sources

This chapter applies to all air pollutant sources that have the potential to emit particulate matter. Requirements covering fugitive dust sources generally require that the owner or operator of a source take precautions to ensure that operations do not cause particulate manner from becoming airborne. These precautions can include applying water, chemicals or covers to control dust.

Air emission limitations from ch. NR 445, Wis. Adm. Code, regarding control of hazardous pollutants

This chapter applies to all air pollutants that have the potential to emit hazardous air pollutants. It contains standards and control requirements that apply to sources that can emit pollutants above threshold amounts listed in the chapter. It is designed to ensure that air pollutant sources do not emit pollutants in a quantity, concentration or for a duration that is injurious to human health, plant or animal life.

Odor control requirements may be imposed by order of the Department if it determines that a violation of s. NR 429.03 – Malodorous Emissions, Wis. Adm. Code, occurs.

This chapter applies to an air containment source capable of emitting pollutants is such quantities that an objectionable odor results. It includes criteria for determine whether an odor is objectionable and requirements to reduce or eliminate the odor. These requirements include control of emissions, changes in handling or elimination of the material causing the odor.

III.D.3. Waterway & wetland permits

Chapter 30 Permit

A chapter 30 permit from the Department is needed for construction within navigable waterways (including stream crossings), diverting water, changing stream course, grading, installing culverts, *etc*.

Water Quality Certification

This permit is for filling and grading wetlands. A wetlands permit may also be required by the Army Corps of Engineers.

III.E. Other Wis. authorities regarding livestock operations

Grade A Milk Permit: DATCP

III.F. Local governmental authorities regarding livestock operations

In addition to the state's requirements, municipalities (cities, villages, towns, counties) may regulate construction site erosion and post-construction storm water runoff to minimize impacts associated with construction activities.

The following information (Table 2) is from the Department of Agriculture, Trade and Consumer Protection's website on existing local laws (town/county) that may apply to a livestock operation (http://www.datcp.state.wi.us/arm/agriculture/land-water/livestock_siting/pdf/0612/ExistingStateAndLocalLaws.pdf)

Table 2 - Local Authorities

Regulation	Purpose	Who is covered	Resources
Road weight limits and clean-up (349.16, Wis. Stats.)	Prevent road damage and protect safety	All vehicles using the road. Exemptions or limitations exist for public health and safety reasons.	http://www.legis.state.wi.us/rsb/stats.html
Shoreland zoning (NR 115)	Limits building near waterways to prevent and control water pollution; protect spawning grounds, fish and aquatic life.	All activities located 1,000 feet from a lake, pond or flowage; and 300 feet from a river or stream or to the landward side of the flood plain, whichever distance is greater.	http://dnr.wi.gov/org/water/wm/dsfm/shore/title.htm
Floodplain zoning (NR 116)	Limit building in floodplains for public health and safety	All activities located within the floodplain.	http://dnr.wi.gov/org/water/wm/dsfm/flood/title.htm; and http://dnr.wi.gov/org/water/wm/dsfm/flood/communities.htm
Manure storage structures *	Protect water quality by proper design, construction, and closure	Farms of all sizes that construct a new manure storage facility. May cover unused or existing manure storage facilities.	http://www.datcp.state.wi.us/arm/agriculture/land-water/conservation/local_ordinances.jsp Lisa Schultz, DATCP Ordinance Specialist (608) 224-4604
Feedlot *	Protect water quality by proper design and construction.	Farms of all sizes that construct a new feedlot.	Lisa Schultz, DATCP Ordinance Specialist (608) 224-4604
Generally applicable building, electrical and plumbing codes	Ensure safe construction.	Everyone.	Check with local government.

*In some cases

Other town or county regulations that may apply include:

- Construction Site Erosion Control and Post-Construction Storm Water Management permits: In addition to the state's requirements, municipalities (cities, villages, towns, counties) may regulate construction site erosion and post-construction storm water runoff to minimize impacts associated with construction activities.

- Approval of on-site domestic wastewater system.

- Wisconsin Livestock Facility Siting Law and Rule (s. 93.90 and ATCP 51): The Livestock Facility Siting Law consists of a state statute (s. 93.90) and rule (ATCP 51) that change how local governments regulate the siting of new and expanded livestock operations. It establishes procedures local governments must follow if they decide to issue conditional use or other local permits for siting livestock facilities. The statute limits the exclusion of livestock facilities from agricultural zoning districts. It also created the Livestock Facility Siting Review Board to hear appeals concerning local decisions on permits. The Livestock Facility Siting Law does not require local governments to regulate the siting of individual livestock facilities. This is a local decision. If a local government chooses to continue to regulate or begin to regulate the siting of livestock operations, the law limits how they can do this.

Local governments regulate livestock facilities through ordinances. The Livestock Facility Siting Law affects local ordinances that require conditional use or other similar permits, but does not affect other ordinances such as shoreland and floodplain zoning. Under the livestock facility siting law, local governments retain the authority to approve or deny siting and expansion requests, but must use the state siting standards when making their decisions.

Effective on May 1, 2006, the rule establishes standards that local governments must follow if they decide to issue local permits. Local governments must use the application and worksheets in the rule to determine if a proposed facility meets these standards:

- Property line and road setbacks
- Management plans
- Odor management
- Manure management
- Manure storage facilities
- Runoff management

The siting standards **only** apply to new and expanding livestock facilities in areas that require local permits, and then **only** if they will have 500 animal units (AU) or more and expand by at least 20% (unless a lower local threshold approved prior to July 19, 2003 applies or an applicant exceeds a limit expressed in a previous permit approval).

There is an interactive web map to identify if a local government has a zoning or licensing ordinance that requires permit approval to expand or build a new livestock facility. Local governments (mostly counties and towns) have the option to require a "siting" permit. Ordinances that require a siting permit must follow the requirements of the Wisconsin Livestock Facility Siting Law and Rule (s. 93.90 and ATCP 51). This interactive map is intended for general use to help you learn:

- If a local government requires a permit,
- The animal unit (AU) threshold at which a permit is necessary, and
- Contact information for local officials who can provide additional information about how to obtain a permit

This map is only as accurate as the information provided to the Department of Agriculture, Trade and Consumer Protection (DATCP), and may not be all inclusive. This map does not identify other local, state and federal regulations applicable to livestock operations. It only identifies whether a livestock facility siting permit is required by a local ordinance. Users should contact local governments to confirm current and specific regulations.
Open the web map application at: https://datcpgis.wi.gov/livestock

III.G. Federal authorities regarding livestock operations

USEPA - National Pollutant Discharge Elimination System (NPDES) Permits for Concentrated Animal Feeding Operations (40 CFR). This program is implemented through the Wisconsin DNR's delegation of the NPDES Permit program.

IV. Current operations

IV.A. Description

IV.A.1. Dairies

Dairy operations in Wisconsin can be specialized in milking cows, raising heifers/calves, or they can have mixed operations with cows, heifers and calves. Sometimes other animal types may be present at the site. Table 3, below, shows a typical animal size distribution for mixed operations of approximately 1000 AUs and 5720 AUs in comparison to an operation that only has milking and dry cows.

Table 3 - Typical dairy animal size distribution

Dairy Type	No. of Animals	Equiv. AUs	No. of Animals	Equiv. AUs	No. of Animals	Equiv. AUs	No. of Animals	Equiv. AUs
Milking & Dry	460	644	700	1000	2636	3690	4000	5720
Heifers >800 lbs	230	253	-	-	1318	1450	-	-
Heifers 400-800 lbs	138	83	-	-	791	475	-	-
Calves	92	18	-	-	527	105	-	-
Total	**920**	**998**	**700**	**1000**	**5272**	**5720**	**4000**	**5720**

Operations with only milking cows typically have all cattle contained within covered large freestall barns. Operations with heifers and calves often have outside dirt or concrete lots upon which animals are raised. Sources of stored and land applied materials include:

- Manure that accumulates in alleys within the barns is either scraped or flushed into reception tanks in or near the freestall barns. Manure accumulated in the reception tanks is then piped to a manure storage facility(ies) via gravity flow or a pump.

- Process wastewater from milking centers at dairies also produce process wastewater which consists of cleaning wastes, waste milk and some manure deposited by animals being milked at the milking center.

- Solid manure from special needs areas which includes pens for sick animals or cows giving birth (sometimes referred to as “pen pack” manure.

- Runoff from open lots or exercise areas. These areas tend to be small because of issues associated with compliance with runoff control requirements.

- Feed storage leachate from haylage and corn silage stored in feed bunkers, or feed bags, which are growing in popularity.

Most liquid waste streams from these operations (manure from freestalls, milking center wastes and feed storage leachate) are directed to storage facilities. WPDES permits require a minimum of 180-days of storage for materials combined with liquid manure. For a 700 head milking operation (1000 AU), which produces approximately 8.2 million gallons of manure a year, over a 4 million gallon storage structure would be needed to meet the 180-day storage requirement. For a 4,000 head milking operation (5720 AU), which produces approximately 46.7 million gallons of manure a year, over 23 million gallons of manure storage would be needed to meet the 180-day storage requirement.

IV.A.2. CAFO Storage structures

Manure (solid or liquid) or process wastewater storage at livestock operations are constructed out of one of four materials: 1) clay, 2) synthetics (polyethylene), 3) geosynthetic clay and 4) concrete. Which structure an operation constructs at a given site is site specific and is often based on the availability of clay at or near the CAFO site, the cost of a given liner, as well as unique siting issues (*e.g.* depth to groundwater or bedrock). Design criteria and proper operation and maintenance requirements for storage structures are contained in NRCS Standard 313 and s. NR 243.15.

For solid manure that is stackable, operations have the option of stacking manure out in cropped with Department approval fields in lieu of storage during winter months provided stacking site criteria can be met. Stacking is defined as temporary, unconfined stacks outside of the animal production area. For very solid manure (>32% solids), operations may stack during non-winter months, with Department approval, provided additional criteria are met.

Operations have increasingly looked for ways to reduce hauling costs associated with manure, either by using new technologies to reduce the amount of liquid that is contained in the manure, or reducing the amount of manure that is hauled or land applied, and/or creating products such as compost that can be handled more easily or sold as a product. See the discussion on technologies in Section IV.E. of this document.

IV.A.3. CAFO Feed storage

Feed can be stored in a number of ways based on the type of feed and the amount of moisture in the feed. Beef and dairy operations typically store haylage and corn silage in concrete feed bunkers or plastic silage bags. These types of feed can produce very strong leachate, particularly if the feed is put into bunkers or bags when it has a moisture content of 70% or more. These feed sources can produce significant amounts of leachate, primarily in the period of time shortly after they are harvested and placed in storage.

IV.A.4. CAFO Mortality management

Historically, animal mortality at CAFOs has been dealt with by sending dead animals to rendering plants. However, due to increasing costs and regulations associated with the rendering of dead animals, operations are looking for other options. One of the options that some farmers are choosing is the composting of animal mortality.

IV.A.5. CAFO Manure & process wastewater land application

While operations are continually exploring new ways of using and marketing manure and process wastewater from their operations (see Section IV.E. of this document), most operations rely on land application of these materials. CAFO land application practices must be done in accordance with NRCS Standard 590 and s. NR 243.14 Wis. Adm. Code to ensure that manure is applied at proper times and in proper amounts to minimize potential for water quality impacts. Application of these materials can occur in a number of ways (injection, incorporation, surface application) using any number of application equipment (tanker trucks, drag lines hooked up to tanker trucks, spray irrigation, travelling guns). Application methods are very operation-specific and are outlined in an operation's NMP.

Stored materials are typically applied in the spring prior to planting and in the fall after harvest. Some operations that have greater 180-day storage may only land apply once per year in the

spring or fall. In addition, some operations top dress applications on cut alfalfa fields throughout the summer.

IV.A.6. Groundwater monitoring structures & equipment

For certain operations, groundwater monitoring may be necessary due to concerns about how structures were built because of unique environmental concerns. These operations would not be eligible for the LDCAFO GP and would require coverage under an individual WPDES permit. Where required, groundwater monitoring wells must be constructed as required under chapter NR 141, Wis. Adm. Code. Groundwater sampling should be conducted as described in the WDNR Groundwater Sampling Field Manual. (http://dnr.wi.gov/org/water/dwg/gw/pubs/field.PDF)

IV.B. Statistics

IV.B.1. Current

Size distribution

While the Department has seen an increase in the number of dairy operations with greater than 2,500 AUs (see Table 4, below), the vast majority of dairy CAFOs in this state have 2,500 AU or fewer, with the highest number of CAFOs in the 1,000 to 1,500 AU range.

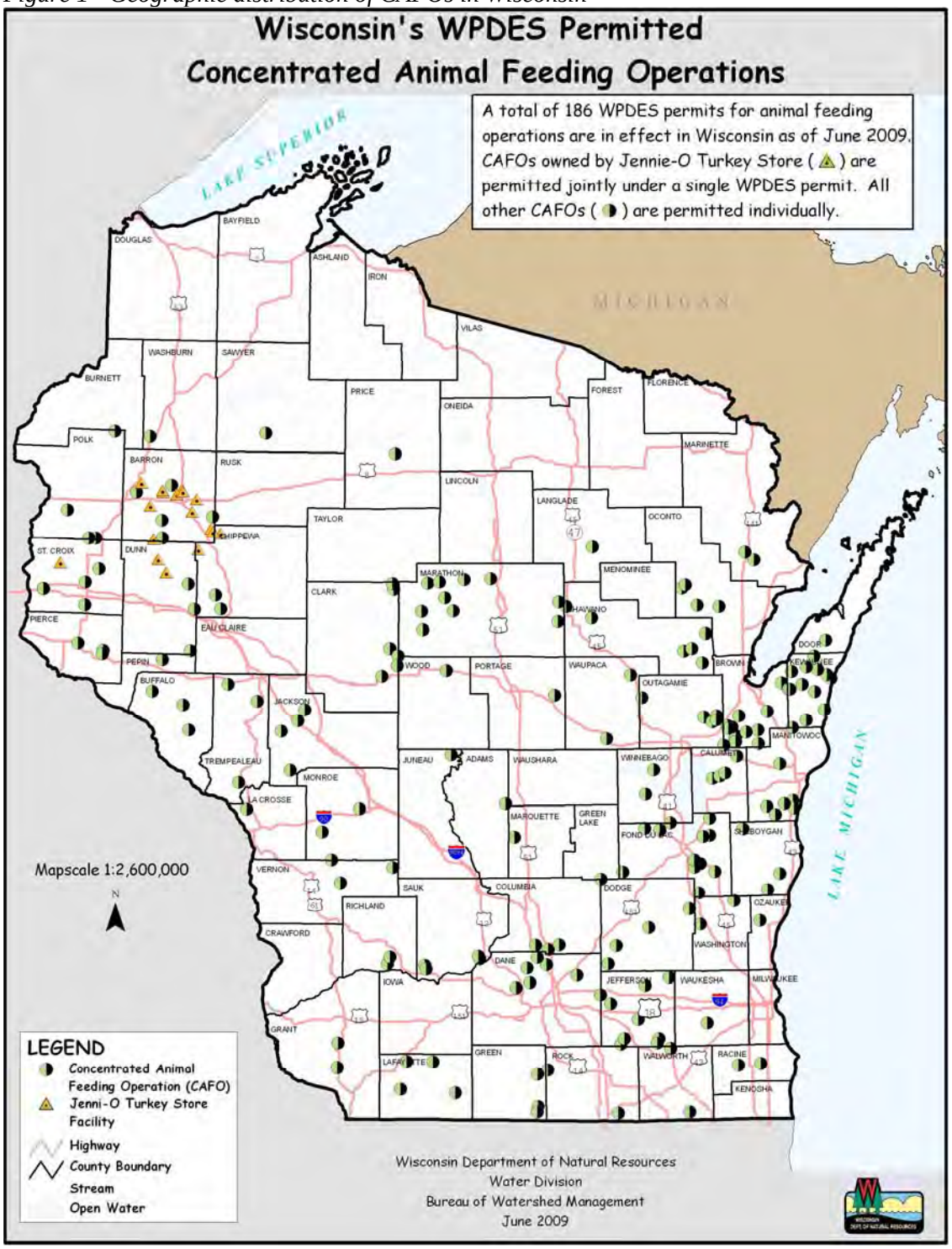
Table 4 - CAFO size distribution

Operation size (AU)	No. of Operations	% of Operations
0-999	2	1
1,000-1,499*	46	29
1,500-1,999*	31	20
2,000-2,499*	26	16
2,500-2,999	15	9
3,000-3,499	14	9
3,500-3,999	6	4
4,000-4,999	8	5
5,000-5,999	6	4
6,000-6,999	1	1
7,000-7,999	1	1
>8,000	2	1
Total	**158**	**100**

Geographic distribution

As identified in the Figure 1, below, CAFOs in Wisconsin are primarily located in the southern two-thirds of the state, with few located in the northern, forested parts of the state and in the urbanized areas of the southeast. In recent years, the most rapid area of increase in CAFO numbers have occurred in the northeastern part of the state.

Figure 1 - Geographic distribution of CAFOs in Wisconsin



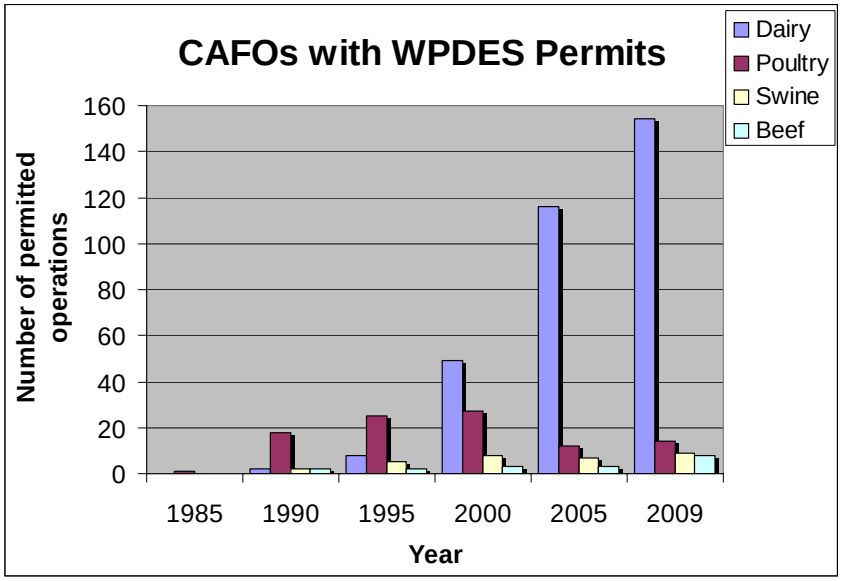
IV.B.2. Trends

The recent trend in Wisconsin has been toward fewer and larger dairy operations. In 2007, Wisconsin had approximately 14,400 dairy cow farms. In 2006 there were 14,900. In 2006, there were 6,300 herds in the most common size category of 50 - 99 head. In 2007 there were only 6,100 herds in this category, although the percentage of herds in this size category (42%) did not change. There were 3,600 farms in the second smallest category of 30 - 40 head in 2007. The

remaining 13% of farms (or 1900 operations) had 1 - 29 head of cattle. Farms with 500 or more head have increased the most. In the past five years farms in this category increased from 13 % of all dairies to 18% in 2007. In the same time period, milk production from those large farms increased from 15% of all state production to 22% (Wis. Data - Dairy Milk Cows by Size Groups: Operations).

This increase in the number of larger operations, particularly for dairies, is reflected in the number of applications for CAFOs over the past 10 years. Beginning in 1985 through the late 1990's, the Department saw slow growth in the number of CAFOs in the state. This began to change in 1999-2000. The Department received 25 and 23 CAFO applications in years 2000 and 2001, respectively. From 2002 to 2006, the Department received on average around 13 applications a year. Beginning in 2007, the Department again began to see a rise in permit applications with 18, 25 and 24 (projected) applications received in 2007, 2008 and 2009, respectively. This trend is shown in Figure 2. See also Appendix C in Section VIII.

Figure 2 - CAFO Permits by type and year



V. Affected environment & environmental effects of large CAFOs

V.A. Physical environment

V.A.1. Topography, geology, soils & groundwater

Geology of Wisconsin

The complex geology of Wisconsin can be simplified by combining thick assemblages of rock layers into four groupings that represent important sources of drinking water and groundwater in the state. Simplifying the geology in this way does not give an adequate idea of the groundwater availability or vulnerability at any specific location within the state but it can provide an overview of groundwater issues associated with a CAFO locating in a given area.

The oldest rocks in Wisconsin are some of the oldest rocks that exist anywhere in the world and were created when the earth began to cool about 4 billion years ago. Between 4 billion and 600 million years, ago crystalline bedrock formed by cooling of magma, erosion, volcanism and metamorphism. The crystalline bedrock that remains today is sometimes referred to as "basement rock" and underlies the entire state. Where the bedrock is close to the surface, fractures in the crystalline rock can be the only source of water. In these areas, drinking water is limited by the number of fractures and how they are connected.

After the basement rocks were formed, layers of sandstone, shale and limestone were laid down as seas advanced and retreated several times until about 425 million years ago. These rocks are an important source of drinking water in the state. Coastal erosion and the existence of broad topographic arches and basins complicate the geology. Eastern Wisconsin borders one of these basins, the Michigan Basin, where a younger, thick sequence of limestone, known as the Niagara Escarpment, was deposited in a warm deep sea. This limestone was altered over time and is referred to as the Silurian dolomite aquifer – an important and sometimes vulnerable source of drinking water in Eastern Wisconsin. The dolomite and underlying Maquoketa shale were deposited between 350 and 425 million years ago.

After about 350 million years ago, there is no geologic record until glaciers advanced and retreated across North America several times starting about 2-3 million years ago. When the climate warmed, about 10,000 years ago, the large ice sheets melted completely, leaving behind complex land forms. It is an oversimplification to say that where glacial sediments occur, groundwater is easy to find or pump because the varying glacial environments resulted in varying permeabilities. The western third of the state, an area referred to as "the Driftless Area" was not glaciated. This area is characterized by ridge tops and steep river valleys which indicate a longer period of erosion.

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Wisconsin's four major aquifers

Wisconsin's groundwater is stored in four principal aquifers: the sand and gravel aquifer, the eastern dolomite aquifer, the sandstone and dolomite aquifer and the crystalline bedrock aquifer (WDNR, 2006). This is a simplification of the hydrostratigraphy of Wisconsin but it will help to set the foundation for a discussion of groundwater susceptibility.

Sand and Gravel: The sand and gravel aquifer is the surface material covering most of the state except for parts of southwest Wisconsin (called the Driftless Area). It is made up mostly of sand and gravel deposited from glacial ice or by rivers in river basins and flood plains. The glacial deposits are loose, so they are often referred to as soil – but they include much more than just a few feet of topsoil. These deposits are more than 300 feet thick in some places in Wisconsin.

The sand and gravel aquifer is the youngest of the state's aquifers having been deposited within the past one million years. Outwash plains composed of sand and gravel deposited by glacial melt water, now form some the best aquifers in Wisconsin. Many of the irrigated agricultural lands in central, southern and northwestern Wisconsin use the glacial outwash aquifer. In areas where large glacial lakes formed, thick deposits of clay formed in the deeper, quiet water. These old lake beds do not transmit much groundwater. Because the top of the sand and gravel aquifer is also the land surface for most of Wisconsin, where permeable, it can be very susceptible to pollution.

Eastern Dolomite: The eastern dolomite aquifer occurs in eastern Wisconsin from Door County to the Wisconsin-Illinois border. It thickens to the east where it borders the broad topographic depression called the Michigan basin. Groundwater travels in this very important aquifer mostly through interconnected cracks and cavities. Where the fractured dolomite occurs at or near the land surface (such as parts of Door, Kewaunee and Manitowoc counties), there is little soil to filter out pollutants from the land surface. Little or no filtration takes place once the water reaches the fractures in the dolomite. This has led to groundwater and well water quality problems including bacterial contamination from human and animal wastes. Because of the vulnerability of this aquifer to bacteria contamination, public wells in Door County have additional sampling requirements. Issues associated with this aquifer may require special consideration when permitting CAFOs.

Under the dolomite is a shale layer (the Maquoketa shale) deposited in a deeper sea. This shale doesn't transmit water easily. It is important as a barrier to pollution between the eastern dolomite aquifer and a lower, older aquifer called the Sandstone and Dolomite aquifer.

Sandstone and Dolomite: The sandstone and dolomite aquifer consists of layers that vary in the amount of water that can be derived from them. In dolomite, groundwater mainly occurs in fractures. In sandstone, groundwater occurs in pore spaces between the sand grains that are loosely cemented together. This aquifer is found everywhere except the north central part of the state.

In eastern Wisconsin, this aquifer lies below the eastern dolomite and Maquoketa shale layers discussed above. In other areas it is directly beneath the sand and gravel aquifer. It is an important source of groundwater for the southern and western parts of the state. In eastern Wisconsin, cities and industries that require a lot of clean water, tap into this aquifer rather than the Eastern dolomite aquifer.

Crystalline Bedrock: The Crystalline bedrock aquifer is composed of a variety of rock types that were formed as the earth cooled between 4 billion and 600 million years ago. During this lengthy period a lot was happening in Wisconsin; rocks were eroded and sediments were deposited in ancient seas; volcanoes were active; mountains were built and destroyed; and molten rocks from the earth's core flowed up through cracks in the upper crust.

The rocks that remain today underlie the entire state and include granites and other igneous rocks. In the north central part of the state they are the only rocks underneath the glacial sand and gravel aquifer. Cracks and fractures in the crystalline bedrock can store and transmit groundwater. Wells must intersect these cracks and fractures to produce water. Some areas contain numerous

fractures while other have very few. The amount of water available is variable and limited. Water for larger municipalities, industries or large dairy herds is not as accessible as in the other three major aquifers. Many wells in the crystalline bedrock aquifer have provided good water. However, most of these wells draw from the upper few feet of the bedrock only. Deeper wells have recovered brackish water that is not drinkable.

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Characteristics that affect potential for groundwater contamination

For the purpose of the LDCAFO GP EA, the primary characteristics used to evaluate threat to groundwater are the following: soil type, surficial deposits, bedrock type, bedrock depth, and depth to water table. Presence of direct conduits to groundwater, topography and the availability of alternative water supplies also affect groundwater quality.

The importance of each characteristic varies for each of the four major aquifers in Wisconsin described in the previous section. Sand and Gravel, Eastern Dolomite, Sandstone and Dolomite and Crystalline Bedrock. Each characteristic should be considered when evaluating a site.

Soil type: Soil is defined here as the unconsolidated material occurring from the land surface up to 5 feet below the land surface. It is the first material through which water and pollutants travel to groundwater. Important soil characteristics are texture (fine clay to sandy), organic matter content (derived from the break down of plant material), permeability (the ease with which water moves through a soil) and water holding capacity (the water available to plants after gravity draining). Finer grained soils with more organic matter provide more groundwater protection. More permeable soils provide less protection. Thick soils are more protective; thin soils over bedrock are less protective.

Surficial deposits: Surficial deposits are geologic materials between the base of the soil and the top of the bedrock. With the exception southwestern Wisconsin, most surficial deposits were left by glaciers. Glaciers advanced and retreated across North America several times starting about 2-3 million years ago. When the climate warmed, about 10,000 years ago, the large ice sheets melted completely, leaving behind complex land forms. It is inaccurate to say that where glacial sediments occur, groundwater is easy to find or pump because the different glacial environments resulted in varying permeabilities.

These materials range from sand grains of the same size that have a high permeability to a mixture of fine to coarse sediments that have a low permeability because the finer particles fill in the voids between the larger gravel-sized grains. They range in thickness from zero to up to 300 feet thick. Surficial deposits with a low permeability protect groundwater while those with a high permeability are less protective. Thick surficial deposits provide more groundwater protection; thin surficial deposits over bedrock are less protective.

The western third of the state, an area referred to as "the Driftless Area" was not glaciated. This area is characterized by ridge tops and steep river valleys which reflect a long period of erosion. Surficial deposits along the river valleys in this area are permeable and can be susceptible to groundwater contamination.

Bedrock Type: Wisconsin's geology consists of many different types of bedrock reflecting a complex geologic history. The oldest rocks in Wisconsin are some of the oldest rocks that exist anywhere in the world and were created when the earth began to cool about 4 billion years ago.

Between 4 billion and 600 million years ago, crystalline bedrock formed by cooling of magma, erosion, volcanism and metamorphism. The crystalline bedrock that remains today is sometimes referred to as "basement rock" and underlies the entire state. Where the bedrock is close to the surface, fractures in the crystalline rock can be the only source of groundwater. In these areas, drinking water is limited by the number of fractures and how connected they are.

On top of the basement rock, layers of sandstone, shale and limestone were laid down as seas advanced and retreated several times until about 425 million years ago. These rocks are an important source of drinking water in the state. Coastal erosion and the existence of broad topographic arches and basins complicate the geology. Eastern Wisconsin borders one of these basins, the Michigan Basin, where a thick sequence of limestone, known as the Niagara Escarpement, was deposited in a warm deep sea. This limestone was chemically altered over time and is referred to as the Silurian dolomite aquifer – an important and sometimes vulnerable source of drinking water in Eastern Wisconsin. The dolomite and underlying Maquoketa shale were deposited between 350 and 425 million years ago.

Where fractured bedrock is present, groundwater susceptibility is very high. Carbonate bedrock has fractures and solution cavities that make it very susceptible to groundwater pollution. Sandstone bedrock is susceptible to groundwater contamination because it is permeable.

Bedrock Depth: The thickness of soil and surficial materials over bedrock varies considerably in Wisconsin. In several parts of Wisconsin, including Door County and the driftless area, bedrock can be exposed at the surface. In other areas, such as southeastern Wisconsin and the far northwestern parts of the state, depth to bedrock is greater than 300 feet. The closer bedrock is to the surface, the more important it is to determine the type of bedrock when evaluating how susceptible the groundwater is to pollution. Where soils or surficial deposits are thin or not present, the groundwater table occurs in the bedrock. If the bedrock is fractured or permeable, pollutants can quickly contaminate groundwater.

Depth to water table: The closer the water table is to the ground surface, the greater the chance that pollutants will move quickly to and travel with groundwater. It is difficult to determine a fixed depth to a water table even at specific locations because it varies seasonally and with rainfall and snowmelt. The best way to determine the variation in depth to groundwater table is to monitor the water level in monitoring wells through all four seasons before a CAFO is constructed. Alternatively, soil scientists look below the surface for evidence of saturation in soils using excavated pits or soil sampling devices. Where depth to groundwater is shallow, it is susceptible to contamination.

Direct Conduits to Groundwater: Direct conduits to groundwater include features that allow surface runoff to enter groundwater directly rather than percolating through soil, surficial deposits or bedrock layers. Where direct conduits are present, it is likely that substances applied to the surface will impact groundwater. Karst features are common in Northeastern Wisconsin and consist of sinkholes, surface fractures, losing streams and other features described on the Karst Feature Reporting Form: http://kickapoovsn.org/pdf/Karst_reportform.pdf . Other direct conduits include mine shafts like those present in Southwestern Wisconsin and unused wells that can be anywhere in the state. Direct conduits to groundwater increase susceptibility to groundwater. It is important to locate these conduits prior to construction of CAFOs to insure that proper separation distances are considered in the site design. In addition, limited information is available on the effects of drain tiles on groundwater quality.

Topography: Where the landscape is internally drained, groundwater is susceptible to pollution because it does not drain to surface water. These areas can be identified by looking at the topography of a region. Areas that are topographic lows with no surface water outlet are generally

internally drained. The sandy areas of the state including Northwestern and Central Wisconsin have areas that are internally drained. A new tool that can be used to identify topographic lows is Lidar (Light Detection and Ranging) which shows contours at two foot intervals for some parts of Wisconsin. For more information on available data go to: http://lidar.cr.usgs.gov/.

Alternative Water Supplies: In Wisconsin, groundwater abundance and quality varies from place to place depending on the aquifer present. For example, cities and towns in the north central and northeastern third of Wisconsin receive the most precipitation but they are underlain by crystalline bedrock, which doesn't yield much water. Groundwater quantity can also be limited either because the aquifer is limited in extent or because contamination makes the water unusable.

CAFOs & Potential Direct and Cumulative Effects on Groundwater

Discharges of pollutants from a given CAFO permitted under the CAFO GP can potentially impact groundwater quality and quantity in a number of ways. Discharges can happen as a result of improper manure and process wastewater handling techniques or equipment malfunction at either the animal production area (where animals are housed and manure/process wastewater is produced and stored) or land application areas. Discharges can also occur that are in compliance with WPDES permit requirements.

Production area discharges of these pollutants in manure and process wastewater can result from either improper design, construction or management. Discharges could occur when a storage facility or runoff control system is not properly designed or constructed for the specific physical characteristics of the site, certain weather conditions or the number of animals at the site. Manure releases can occur from failure of the manure storage structure itself. A properly engineered, constructed, and managed manure storage structure poses little risk to water quality. However, as with any man made structure, there is a remote possibility of failure. A failure of bottom integrity could result in contamination of groundwater that may go undetected for a number of days or weeks. Another even more unlikely situation would be the structural failure of a side wall of a manure storage lagoon. A catastrophic failure of this sort, if not properly contained and cleaned up, could result in a large volume of manure or process wastewater leaching into the soil and reaching groundwater. Management errors or equipment malfunctions can also result in discharges. Valves associated with manure transfer systems may get stuck or mistakenly open or closed, resulting in discharges. Sometimes, machinery at the production area can cause damage to control systems that can result in discharges.

Manure and process wastewater releases associated with land application activities may result from accidents in route to a spreading site, equipment failure at the site, or runoff from misapplication of manure.

One potential way for a discharge to occur is for a truck hauling manure to have an accident, resulting in a manure spill. However, depending on the site characteristics, volume spilled, and timeliness of emergency response, this does not necessarily pose an immediate risk to groundwater. Dependant on the type of soil and depth to groundwater where the a spill occurs and the presence or absence of features such as a sinkholes or karst features, manure can be promptly collected and removed, with very little or no risk groundwater. On the other hand if the spill discharges into an area of a field where shallow groundwater, permeable soils or direct conduits to groundwater exist, it may be difficult to contain and could pose a serious risk to groundwater.

Once at a spreading site, another potential way for a manure spill to occur is from stuck or broken valves or transfer piping, and human error. Again the level of environmental risk from such a spill is determined by the volume of spill, site characteristics, and adequacy of emergency response.

Manure can also reach groundwater as a result of over application or field runoff. Typically manure is either surface applied, tilled into the soil or directly injected into the soil six to eight inches below the surface. While incorporation or injection significantly reduce the potential for it to be picked up by surface runoff and delivered to conduits to groundwater, over application of manure results in a repository of contaminants that can leach to groundwater immediately or over a period of time.

Opportunities for containing discharges from over applied manure are limited since it usually isn't detected until the manure or associated contaminants (*e.g.* nitrate) has already leached to groundwater and contaminated a well.

There have been a number of documented groundwater impacts associated with CAFOs. Discharges of CAFO manure and process wastewaters (and associated contaminants) to groundwater, should they occur, have the potential to cause widespread contamination of aquifers and associated drinking water supplies for communities or individuals. If this contaminated water is consumed by humans, this can result in human health impacts that include sickness (*e.g.* diarrhea) or, possibly, death. The primary pollutants associated with CAFOs, and their impacts to groundwater quality, are described below.

Direct Effects

Assessing the environmental impact on groundwater from dairy CAFOs and non-CAFOs located in Wisconsin requires evaluating the movement and persistence of potential pollutants and the different soil and aquifer materials present in Wisconsin. This section first describes each of the pollutants associated with CAFOs including health effects and presence in Wisconsin groundwater. The groundwater vulnerability and the physical characteristics that control vulnerability are examined. Most potential pollutants are associated with manure storage, land application and crop production. Disposal of animal carcasses was not evaluated as part of this environmental assessment. Most studies on the effect of CAFO related pollutants on groundwater look at how individual contaminants move through the environment. Few studies have examined the effect of multiple contaminants interacting with the environment (Pedley *et.al.* 2006). The impact of substances resulting from the breakdown of these pollutants is also not well documented. Groundwater quality, soil oxygen content and microbes can increase or decrease the detrimental effect animal waste pollutants and agrichemicals can have on groundwater. Studies on the impacts of animal waste and agrichemicals on groundwater have been carried out in Wisconsin, many funded by the Groundwater Coordination Council (GCC) in response to requests from the Watershed and Drinking Water and Groundwater Bureaus. For more information on Wisconsin groundwater research projects funded by the GCC see: **http://wri.wisc.edu/**.

Pathogens, viruses and nitrate are commonly documented pollutants in groundwater attributed to animal waste (Burkholder, *et.al.* 2007). Hormones, and antibiotics related to animal waste, have also been found in groundwater (Guang-Gou, *et.al.* 2002, Karthikeyan, K.G. and J.A. Pedersen, 2006). Heavy metals copper and zinc, both persistent and mobile in groundwater, have been found in dairy manure lagoons (Bradford, *et.al.* 2008). There are drinking water maximum contaminant levels and groundwater standards for both copper and zinc but no studies documenting these metals in groundwater underneath dairy waste lagoons were found. Chomycia, *et.al.* (2008) found that dairy operations have the potential to increase dissolved organic carbon (DOC) levels in groundwater. This is a concern because chlorine, used to treat municipal water, can react with DOC to produce carcinogenic trihalomethanes. Most Wisconsin municipal wells are chlorinated to disinfect drinking water and prevent microbial growth during distribution.

Concentrated Animal Feeding Operations feed mostly corn, soybeans and alfalfa as are many other non-CAFO livestock. These crops are grown on over 7 million acres in Wisconsin. Fertilizers and pesticides are used to increase yields on these fields. Several studies of the occurrence of pesticides and nitrate-nitrogen in groundwater are described in the Wisconsin Groundwater Coordination Council 2009 Report to the Legislature (http://dnr.wi.gov/org/water/dwg/gcc/rtl/2009fullreport.pdf).

A recent survey by the Wisconsin Departments of Agriculture, Trade and Consumer Protection (DATCP), Health Services (DHS); and the United States Department of Agriculture (USDA) documented 32 agrichemical compounds in 398 private drinking water wells. The most commonly detected pesticides were alachlor ESA, metolachlor ESA and atrazine and its metabolites. Nitrate was detected in 9% of wells tested (DATCP, 2007). There are federal and state groundwater standards for nitrate and many of the pesticides associated with grain production.

Pollutants associated with CAFOs as well as non-CAFOs can enter groundwater directly through conduits, such as unused wells or fractures in rock, or by moving through the soils to aquifers. The ease with which pollutants move into groundwater is referred to as groundwater susceptibility (or groundwater vulnerability). Groundwater susceptibility cannot be measured directly so is estimated from information about the subsurface environment. To assess the susceptibility of groundwater to animal waste, the major aquifers in the state and characteristics that can help to protect groundwater are summarized in this document. For each aquifer, the characteristics that make them susceptible are discussed.

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Nitrate

Nitrate is the most common pollutant found in Wisconsin groundwater. Approximately 90 percent of nitrate inputs to groundwater originate from agricultural sources including manure spreading (28%), agricultural fertilizer (23%) and legumes (29%) (Shaw, 1994). Other sources include land application of industrial and municipal waste. Different studies show that between 9% to over 20% of private wells in the State have nitrate levels exceeding the 10 milligrams/liter (mg/L) drinking water maximum contaminant level (MCL) (chapter NR 809, Wis. Adm. code) and groundwater (chapter NR 140 Wis. Adm. code) enforcement standards (ES). The percentage of wells exceeding the MCL and ES varies across the state. Counties with more agricultural land, most located in southern and west central Wisconsin have a higher percentage of nitrate contaminated wells. A 2008 survey completed by the Wisconsin Center for Groundwater Science and Education found 78% of the private wells sampled in the Town of Leeds, Columbia County, exceeded the nitrate drinking water enforcement standard. A 2007 survey in the Town of La Prairie, Rock County found 90% of the sampled private well above the enforcement standard

(Masarik, 2009). A survey completed by the DNR in 2005 documented that over 24 million dollars has been spent on nitrate mitigation by municipalities (Chern, 2009).

It is difficult to broadly estimate the amount of nitrate that leaches to groundwater from CAFOs. Using the Wisconsin Manure Quantity Estimation worksheet, the number of animal units currently permitted for Dairy CAFOs (230,156), and assuming that each animal unit is a 1400 pound lactating cow, an estimated 2.68 billion gallons of manure is produced by animals at permitted CAFOs. Using a minimum credit of nitrogen for manure of 7 pounds per 1000 gallons from the worksheet, about 18.8 million pounds of nitrogen from manure is spread on the land surface each year in Wisconsin. Permit applications for an additional 178,995 (a total of 309,151 AU) animal units of dairy cows have been submitted to the DNR. This would increase the amount of land applied manure to 3.61 billion gallons each year. Using the minimum credit of 7 pounds per 1,000 gallons, at least 25.2 million pounds of nitrogen from CAFOs will be land applied annually.

Under DNR rules, a producer regulated under a WPDES permit under Chapter NR 243, Wis. Adm. Code, must have a nutrient management plan. Nutrient applications can be calculated by hand or using *Snap plus* software (http://www.snapplus.net/) developed by the UW Madison, Soil Science Department. Snap plus software uses the most current UWEX application rate guidelines. The default value in Snap Plus is equal to the recommended rate needed to maximize yield not protect groundwater. Recommended rates are based on UWEX publication A2809 (DATCP, 1998).

While permitted facilities must limit inputs of nitrogen land applied as animal waste, other farms are allowed to over apply different sources of nitrogen. The Northeast Wisconsin Karst Task Force recommended that DNR and DATCP work toward a more uniform set of regulations for land application of municipal, industrial and animal waste (Erb and Stieglitz, 2007). The Task Force found that the same parcel of land may be approved by DNR for whey application but restricted by a county authority for manure application. In cases where land is suitable and approved for multiple waste applications, the Task Force recommended that a single entity should determine nutrient application rates, taking into account all sources. The Task Force also recommended keeping track of sites approved by the various agencies for industrial and municipal waste and providing that to the counties that regulate animal waste sites.

The amount of nitrogen fertilizer applied to crops is recorded by the National Agricultural Statistics Service (NASS). The most recent data shows that in 2003, 380.9 million pounds of fertilizer was applied to 3.8 million acres of corn, 2.5 million pounds of nitrate was applied to about .6 million acres of small grains (barely and oats), and in 2006, 7.4 million pounds were applied to 1.35 million acres of soybeans. The amount of nitrate leaching to groundwater is dependent on precipitation, soil permeability and crop uptake (http://www.nass.usda.gov/index.asp).

Movement of nitrate in soil

Nitrate has a very low ability to bond to organic matter or clay particles and movement is directly proportional to groundwater flow rate. If the manure is surface applied, nitrogen as ammonia can be lost to volatilization. If the manure is effectively incorporated, the different forms of nitrogen are quickly converted to nitrate making it available to plants or subject to leaching through soil or lost to denitrification. Because nitrate is a stable compound, it is persistent in groundwater.

A study by the USGS documented an increase in nitrate in Central Wisconsin groundwater over time with the highest concentrations typically found in younger water (Saad, 2008). Kraft, *et.al.* (2008) showed that nitrate load to groundwater in a thick sandstone bedrock in Dane County has

been increasing over time and will continue to increase until a steady state is reached or until nitrogen leakage from the surface is reduced.

Human health effects of nitrate

Nitrate in drinking water can cause methemoglobenemia or "blue baby syndrome" in infants less than six months old. Cases of blue baby syndrome in Wisconsin were documented by the Department of Health and Family Services in 2000 (Knobeloch, *et.al.*). Once Nitrate converts to nitrite in the human body, it can then convert into N-nitroso compounds (NOCs). These compounds are carcinogens that have been linked to non-Hodgkin's lymphoma (Ward, *et.al.* 1996); gastric cancer (Xu, *et.al.* 1992; Yang, *et.al.* 1998); and bladder and ovarian cancer (Weyer *et.al.* 2001). There is also growing evidence that diabetes in children is linked to nitrate (Parslow *et.al.* 1997; Molchanova *et.al.* 2004). For more information on nitrate health effects, see the Wisconsin Groundwater Coordination Council 2009 Report to the Legislature (http://dnr.wi.gov/org/water/dwg/gcc/rtl/gccreport.htm).

Environmental effects of nitrate

Because nitrate moves with groundwater, it can impact surface water where it discharges in to lakes, streams and wetlands. Studies of streams with elevated nitrate on different species of aquatic species show that effects vary from none, to developmental effects and death depending on species. Certain caddisflies, amphipods, and salmonid fishes seem to be the most sensitive. A recent study in Wisconsin on amphipods to very high concentrations of nitrate showed no effects (Stelzer, personal comm.) however, other studies show lethal effects at nitrate concentrations as low as 8 to 30 mg/L (Carmargo and Alonso, 2006).

Nitrate supplied by groundwater discharge to surface water may cause increases in rooted aquatic plants (Lillie and Barko, 1990, Rodgers, *et.al.* 1995). Data from Wisconsin showed that in 8% of randomly selected lakes, nitrogen was probably the nutrient controlling aquatic weed growth (Lillie and Mason, 1983). Other data from the same study showed that weed growth in up to 16% of Wisconsin lakes might be limited by nitrogen in the water.

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Pesticides

Pesticides applied to grain crops fed to animals at CAFOs and other livestock operations can leach to groundwater. Pesticides represent a wide range of substances including insecticides, herbicides and fungicides. The health effects of pesticides vary by pesticide. For example Atrazine, a common corn herbicide found widely in Wisconsin groundwater, has been linked to weight loss, cardiovascular damage, retinal and some muscle degeneration, and cancer when consumed at levels over the drinking water limit for long periods of time (http://www.epa.gov/safewater/contaminants/basicinformation/atrazine.html). Long-term exposure to alachlor, another common herbicide found in Wisconsin groundwater, is associated with damage to the liver, kidney, spleen and the lining of the nose and eyelids, and cancer (http://www.epa.gov/safewater/pdfs/factsheets/soc/alachlor.pdf). Only about 30 pesticides currently have health-based federal drinking water limits and state groundwater standards. This means that sometimes pesticides are detected in groundwater and drinking water but the harmful levels and health effects are unknown. Also unknown are the health effects of a combination of pesticides in drinking water (2009, GCC Report to the Legislature: http://dnr.wi.gov/org/water/dwg/gcc/rtl/gccreport.htm).

In 2007 DATCP conducted a statewide statistically designed survey of agricultural chemicals in Wisconsin groundwater. The purpose of the survey was to obtain a current picture of agricultural chemicals in groundwater, relate findings to land use, and compare results to previous surveys conducted in 1994, 1996, and 2001. Three hundred and ninety-eight private drinking water wells were sampled as part of this survey. Each well sample was analyzed for 32 compounds including 17 pesticide parent compounds, 14 pesticide metabolites and nitrate-nitrogen. Health standards have been established for 11 of the parent compounds and 4 of the metabolites. Based on a statistical analysis, it was estimated that the proportion of wells in Wisconsin that contained a pesticide or pesticide metabolite was 33.5%. The average number of pesticide or pesticide metabolite detects for wells with detects was 2.3. Areas of the state with a higher intensity of agriculture generally had higher frequencies of detections of pesticides and nitrate. The two most commonly-detected pesticide compounds were the herbicide metabolites metolachlor ESA and alachlor ESA which each had a proportion estimate of 21.6%.

Extensive sampling within the USGS National Water Quality Assessment (NAWQA) program has confirmed the widespread occurrence of pesticides in both surface water resources and groundwater, but generally at concentrations below their respective allowable maximum contaminant levels (Kolpin *et.al.* 2000). Pesticides, especially insecticides, are reaching water resources in urban and suburban areas, including residential sources. The NAWQA study also demonstrated widespread detection of pesticide metabolites, often at concentrations exceeding the parent compound, and for which there may not be adequate toxicity data to establish their health significance (*Rivett, M. et.al. 2006*).

Pesticide movement and attenuation

The mobility and persistence of pesticides in the environment are well understood because the admission of a new pesticide for the market requires a series of standardized laboratory and field experiments. Both the chemical make up of the pesticide and soil characteristics determine the ease with which pesticides move through soil. In general, less permeable soils with moderate to high organic matter and clay content will absorb pesticides onto soil particles, resulting in less movement to groundwater. However, pesticides that have a chemical composition that favors sorption to soils can persist longer in the environment. Persistence of pesticides is also affected by the degradation rate of the specific pesticide. Exposure to sunlight, reaction with soil water or groundwater, and biodegradation by microorganisms cause degradation of pesticides. Table 5 below shows leaching potential of pesticides commonly found in Wisconsin Groundwater (Rivett *et.al.* 2006). The relative leaching potential was determined using the water solubility, biodegradability and sorption potential of the compound (known as the soil organic carbon sorption).

Table 5 - Relative leaching potential for pesticides found in Wisconsin groundwater

Common Name	Groundwater Standard/Maximum Contaminant Level (mg/L)	Relative Leaching Potential
Alachlor	2 (alachlor ESA is 20)	Medium
Atrazine	3 (total chlorinated residues)*	High
Cyanazine	1	Medium
2,4-D	70	Medium
Simazine	4	High
Simazine	4	High

** Total Chlorinated Residues (TCR) is the sum of atrazine and metabolites deethly atrazine, deisopropyl atrazine and diamino atazine.*
Source: modified from USDA Natural Resources Conservation Service and Agricultural Research Service

Health effects of pesticides

Human health effects from acute and chronic exposure to pesticides include liver and kidney damage, major interference with nervous, immune and reproductive system function, birth defects and cancer. Newer pesticides are generally less persistent in the environment and less toxic for mammals (Rivett, M. *et.al.* 2006). Endocrine system disruption is of particular concern for humans, aquatic species and fish-eating wildlife. For more information on the health effects of specific pesticides visit the Department of Health Services website at: http://dhs.wisconsin.gov/eh/ChemFS/index.htm#Aromatic%20Concentrates.

The health effects of multiple pesticides in drinking water are an area of research that is getting a lot of attention. Some studies have found that pesticide mixtures at equal or less than the EPA drinking water standard can produce effects that are not found upon exposure to a single pesticide at the same concentrations. A study funded by the GCC showed that tests of mixtures of the insecticide aldicarb, the herbicide atrazine, and nitrate in rats show endocrine, immune and behavioral effects including decrease in speed of learning, change in aggression intensity and frequency, change and reduction in memory and motor coordination in the brain, change in growth hormone, and reduction in antibodies formation capability (Porter, 1999).

Between 1992 and 2001, the USGS sampled 186 stream sites and over 5,000 wells nationally and analyzed the samples for pesticides (http://pubs.usgs.gov/circ/2005/1291/pdf/circ1291.pdf). The concentrations of pesticides in the sample analytical results were compared to water quality

benchmarks for health effects on humans, aquatic life and fish-eating wildlife. The benchmarks were based on standards and guidelines established by USEPA, toxicity values from USEPA pesticide risk assessments and selected guidelines from other sources. The potential for effects can be assessed by comparing measured pesticide concentrations with water-quality benchmarks, which are based on the concentrations at which effects may occur. The results indicated that while groundwater concentrations were usually too low to cause human health effects, concentrations in streams often exceeded levels at which aquatic species and fish-eating wildlife could be affected. Because groundwater replenishes surface water in most Wisconsin streams, it is important to consider the effect that even low concentrations of pesticides in groundwater can have on surface water.

References:

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Pathogens

Pathogens (defined as bacteria, viruses and parasites that cause disease) have been documented in Wisconsin groundwater. For a summary of recent research conducted in Wisconsin on presence of bacteria and viruses in groundwater, see the Wisconsin Groundwater Coordinating Council, 2009 Report to the Legislature (http://www.dnr.state.wi.us/org/water/dwg/gcc/rtl/gccreport.htm). Pathogens can cause acute and chronic illness if present in drinking water. Acute illness is defined as severe and immediate. Chronic effects are long term. Table 6 shows health effects from pathogens found in animal waste.

Table 6 - Pathogens present in groundwater attributable to animal waste and related symptoms

Organism	Associated human health effects
Viruses	
Hepatitis E	Fever, nausea, jaundice, death
Bacteria	
Escherichia coli	Gastroenteritis, Haemolytic Uraemic Syndrome
Salmonella spp.	Enterocolitis, endocarditis, meningitis, pericarditis, reactive arthritis, pneumonia
Campylobacter jejuni	Gastroenteritis, Gullain-Barre syndrome
Yersinia spp.	Diarrhea, reactive arthritis
Protozoa	
Cryptosporidium parvum	Diarrhea
Giardia lamblia	Chronic diarrhea

Source: adapted from Appleyard and Schmoll, 2006

Movement of pathogens in groundwater

Land application of manure can contaminate groundwater with pathogens where conditions allow them to survive and sometimes thrive. The unsaturated zone (the upper soil and sediment layers that have some water in pore spaces) can play an important role in slowing down pathogens and

must be considered when determining the vulnerability of the aquifer. Changes in soil moisture and temperature; microorganisms that compete for food or that eat the pathogens; and sunlight can slow down or eliminate pathogens before they reach groundwater. Size, shape, and surface charge of the microorganism can control pathogen movement through fine grained material (Bolster *et.al.* 2006). Fracture or macro pore flow (worm burrows for example) increase the likelihood of pathogen contamination.

Pathogens move easily in groundwater when pores and fractures in the rock are full of water (referred to as saturated flow). Many factors, environmental and those specific to each species, control the survival and movement of bacteria and viruses. Table 7 is a simplified summary of the effect of different subsurface factors on survival and movement of viruses and bacteria.

Table 7 - Influence of major factors on the survival and movement of pathogens in the subsurface

Factor	Viruses		Bacteria	
	Influences on survival	**Influences on movement**	**Influences on survival**	**Influences on movement**
Temperature	Survival is longer at low temperatures	Unknown	Survival is longer at low temperatures	Unknown
Microbial activity	Varies: presence of other microorganisms can increase, decrease or have no effect on virus survival	Unknown	Presence of other microorganisms can decrease survival of enteric bacteria though some protozoa may have the opposite effect	Unknown
Moisture content	Most viruses survive longer in moist soils and even longer in saturated conditions; unsaturated conditions can inactivate viruses at the air-water interface.	Virus movement increases under saturated flow	Most bacteria survive longer in moist soils than in dry soils	Bacteria movement increases under saturated flow.
pH	Most enteric viruses are stable over pH range of 3 to 9; however, survival maybe prolonged by near neutral pH values (7).	Low pH can increase virus sorption to soils; high pH causes desorption allowing increased movement	Most enteric bacteria will survive longer at near neutral pH(7).	Low pH encourages adsorption to soils and the aquifer matrix; high pH may increase attachment to aquifer material.
Salt species and concentration	Survival is dependent on the virus type	Increasing the ionic strength of the aquifer matrix increases sorption	Unknown	Increasing ionic strength of the aquifer matrix increases sorption.

Association with soil	Association with soil generally increases survival, although attachment to certain mineral surfaces may decrease survival	Viruses interacting with the soil particles lead to an increase in sorption and decrease in movement.	Adsorption onto solid surfaces increases survival	Bacteria interacting with soil particles are prevented from moving through the soil.
Soil properties	Maybe related to the degree of virus sorption	Greater movement in coarse textured soils, soils with charged surfaces such as clays adsorb viruses	Maybe related to the degree of bacterial sorption	Greater movement in coarse textured soils; soils with charged surfaces such as clays adsorb bacteria
Species	Different virus types vary in survival rates by physical, chemical and biological factors	Sorption to soils is related to surface structure and composition of the virus	Different species of bacteria vary in survival rates by physical, chemical and biological factors	Some species of bacteria bind to surfaces more easily
Organic matter	Organic matter may increase survival by taking up sites on soil particles where viruses could be bound	Soluble organic matter competes with viruses for adsorption sites on soil particles resulting in increased movement.	Organic matter can act as a source of food for bacteria increasing growth and survival	Organic matter may increase adsorption of bacteria decreasing movement.
Hydraulic conditions	Unknown	Virus movement can increase during recharge events including rain, snow melt and irrigations	Unknown	Bacteria movement can increase during recharge.

Source: Pedley et.al. 2006

Special casing areas & well compensation grants

In March of 2006, revision of Subchapter 281.75 Wis. Statutes addressing Well Compensation was signed by Governor Doyle authorizing DNR to allow use of Well Compensation funds for replacement water supplies for wells contaminated with livestock waste. The statute states that compensation can be granted if: 1) fecal bacteria is present, and 2) evidence demonstrates that bacterial contamination is caused by livestock. [s. 281.75 (2)(e) Wis. Stats] Under Subchapter 281.75 Wis. Statutes, chapter NR 123, Wis. Adm. Code was created. To date, 38 well compensation grants totaling over $470,000 have been awarded. Additional costs have been incurred by well owners to cover costs not covered by the grants.

Escherichia coli, known as *E. coli* is a type of fecal coliform bacteria found in the intestines of humans and animals. If well water samples test positive for E. coli it indicates contamination of a well or groundwater by sewage or animal waste. Further testing using Microbial Source Tracking (MST) can determine if the source of *E. coli* is animal or human. Microbial source tracking is a collection of water analyses done at the Wisconsin State Laboratory of Hygiene that includes bacteria, viruses, pharmaceuticals, hormones and various chemicals.

Analyses include:

- Bacteroides, a type of bacteria found in the human intestine, it helps break down food.
- F + coliphage, a virus that infects E. coli and indicates human waste
- Bifidobacteria, bacteria found in the human intestine, it helps with digestion.
- Rhodococcus, bacteria that indicates grazing animal waste.

Chemical testing includes:

- Animal versus human pharmaceuticals, (including antibiotics), and
- Human indicators including triclosan (found in anti-bacterial soaps) and caffeine.
- Hormones such as estrogens that indicate human waste and androgens that indicate animal waste.

Well Compensation awards for replacement wells contaminated by manure have been awarded in the locations in Table 8, below.

Table 8 - Special casing areas & well compensation grant awards for wells contaminated with livestock waste

Location	County	Date Established	New Well Awards
Village of Wayside, Town Morrison	Brown	03/17/06	25
Town of Brothertown	Calumet	10/10/06	1
Town of Lowell	Dodge	07/01/07	0
Town of Byron	Fond du Lac	08/15/07 & 03/25/09	3
Town of Cooperstown	Brown	04/23/08 & 08/12/08	4
Village of Valmy (*Runaway Lodge*)	Door	03/19/09	1
Town of Cato	Manitowoc	04/01/09	3
Town of Lomira	Dodge	04/03/09	1
Town of Easton	Marathon	04/21/09	1
Town of Emerald	St. Croix	05/01/09	2
Total			**41**
Approximate cost: $470,000			

References:

- *Pedley, S., J., M. Yates, J.F. Schijven, J. West, G. Howard and M. Barrett, "Pathogens: Health relevance, transport and attenuation," in: 2006 World Health Organization. Protecting Groundwater for Health: Managing the Quality of Drinking-water Sources. Edited by O. Schmoll, G. Howard, J. Chilton and I. Chorus. IWA Publishing, London, UK. http://www.who.int/water_sanitation_health/publications/PGWsection1.pdf*
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Hormones

Hormones are the chemical messengers that carry instructions to target cells throughout the body and are normally produced by the body's endocrine glands. Two types of hormones are associated with dairy operations: 1) naturally occurring steroids (estrogen, progesterone, and testosterone), and 2) artificial hormones given to cattle to increase milk production. For aquatic organisms, 17 beta estradiol, testosterone and their metabolites, naturally occurring in diary manure, are potent endocrine disruptors at very low concentrations (1 ng/L). Endocrine disruptors are chemicals that may interfere with the body's endocrine system and produce adverse developmental, reproductive, neurological, and immune effects in both humans and wildlife. There is evidence that low levels of endocrine disruptors are linked to breast, prostate and testicular cancers in humans.

Hormones have been documented in surface water and groundwater but the fate and transport of the compounds continues to be researched. A summary of existing research by Dekissa, *et.al.* (2007) showed that hormones associated with animal manure can be degraded under aerobic conditions provided high soil moisture, high organic carbon, and high temperature are present. If temperatures are cold and soils are relatively dry biodegradation is limited. Biodegradation is also limited under anaerobic conditions.

Laboratory-based studies have found that the biological activity of estrogen steroids is greatly reduced or eliminated within several hours to days due to degradation and sorption to soil. On the other hand, field studies have demonstrated that estrogens are mobile and persistent enough to impact surface and groundwater (Hanselman, *et.al.* 2003). Where thin soils overly fractured bedrock, or where there are direct conduits to groundwater contamination by hormones is possible (Peterson *et.al.* 2000). It is possible that hormones bind to very small clay particles (colloids) and are transported to groundwater.

Two studies conducted beneath the same dairy waste lagoon in Israel documented presence of Estrogen, Testosterone and Androstenedione at depths of between 104 feet and 150 feet at greater than the 200 ng/L in groundwater. (Shore *et.al* 2007; Arnon *et.al.* 2008). The lithology under the waste lagoon consisted of 20 feet of clay with high organic matter on top of sand and calcareous sediments with low clay and organic matter. The water table was at a depth of 150 feet. Preliminary results from a study currently being carried out in Wisconsin has shown low concentrations of hormones in tiles below fields where dairy manure was applied (Hemming, 2009).

References:

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Antibiotics

Antibiotics are given to animals to increase their growth; however, the amount of antibiotics used in dairy farming is low compared to pork or poultry production. Antibiotics in the environment are a concern because intestinal bacteria can become resistant to the drugs. The microbes leave the animal in manure and can get into the environment through leaking storage pits or land application. When humans are exposed to the antibiotic resistant microbes, they may be ill longer or need more potent antibiotic treatment.

The United States Food and Drug Administration does not have accurate information about what kinds, how much and where antibiotics are being used across the country. It is estimated that animals raised for food in the US are given 25 million pounds of antibiotics annually to promote growth (Gilchrist *et.al.* 2007). Most animal antibiotics are available over the counter and each farmer decides how they will be used.

Antibiotics can move with water (in dissolved phase) or adsorbed onto colloids or soil particles which can move into groundwater. Antibiotics in groundwater have been documented in Europe and the United States. A groundwater investigation at two pork CAFOs in Illinois showed low concentrations of tetracycline and breakdown substances in groundwater but tetracycline resistant genes were present in groundwater and persistent (Mackie, *et.al.* 2006). A similar study carried out in an unnamed mid-Atlantic state showed that antibiotic-resistant bacteria (enterococci) were detected in groundwater down gradient from pork CAFOs. These studies suggest that livestock manure, especially pork, could contribute to the spread of antibiotic resistance (Sapkota, *et.al.* 2007).

A study conducted at the UW-Madison to determine the fate of common antibiotics in soils indicated that the ability of antibiotics to migrate from the soil surface to groundwater depends on a number of factors including pH and composition of the soil and pore water. Inorganic minerals can adsorb antibiotics. Dissolved humic substances can increase the mobility of antibiotics. Organic matter may also adsorb antibiotics (Karthikeyan, K.G. and J.A. Pedersen, 2006).

References:
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V.A.2. Surface Waters

Description

Wisconsin is a water rich state, with many thousands of streams stretching nearly 84,000 miles in length. Wisconsin has over 40,000 perennial stream miles and an equal number of intermittent miles [based on 1:24,000 scale USGS Topographic Quadrangle Maps (publish date varies), and GIS interpretation of those maps]. There are approximately 15,000 inland lakes and impoundments, spanning over 1.2 million acres. Wisconsin also has over 1,000 miles of Great Lakes shoreline on lakes Michigan and Superior.

In order to understand the description of the water resources associated with the area around a given permitted CAFO, it is important to understand the terminology used to describe the landscape draining to lakes, rivers, and streams. It is equally important to understand how water quality and habitat are impacted by the materials that wash into these water bodies.

The term "watershed" is used to define an area of land draining to a specific body of water. Every waterbody has a watershed that drains water to it. Even the smallest stream has its own watershed. The watershed of a river is composed of multiple smaller sub-watersheds. In Wisconsin we call large watersheds "basins". There are 23 major River Basins in the state. Each river basin can be further broken down into individual watersheds within the river basin (there are 334 watersheds in the state). Each watershed can be further broken down into smaller sub-watersheds. For example, the small sub-watersheds of Parsons Creek and Campground Creek, are part of the Fond du Lac River Watershed. The Fond du Lac River Watershed is one of the 15 watersheds of the Upper Fox River Basin.

Wisconsin has a variety of different stream and lake types across the state. These are categorized according to classification systems that are described below.

Stream types & distribution

Stream classifications

Streams naturally vary depending on a variety of factors, such as size, temperature, and gradient, which influence the types of aquatic life that are likely to inhabit them. Wisconsin's streams are officially classified in the following five categories (listed below) in current administrative code. However, work is underway to redefine the classification system to more accurately reflect each type of stream's fish and aquatic life communities and ecological value. As part of this effort, the categories shown below are subdivided and/or renamed with detailed descriptors of each sub-class. Descriptions of proposed sub-classes from 2004 and 2009 can be found at:

- *Guidelines for Designating Fish & Aquatic Life Uses for Wisconsin Surface Waters* (2004) at http://dnr.wi.gov/org/water/wm/wqs/wbud/UDG_FINAL_2004.pdf, or

- DRAFT *Guidance for the Classification, Assessment, and Monitoring of Wisconsin's Lakes, Rivers, & Streams (DRAFT 2009)*.

The categories currently listed in NR 102, Wis. Admin. Code. are described as follows:

- Cold water communities. This subcategory includes surface waters capable of supporting a community of cold water fish and other aquatic life, or serving as a spawning area for cold water fish species. This subcategory includes, but is not restricted to, surface waters identified as trout water by the department of natural resources in *Wisconsin Trout Streams*, publication 6−3600 (1980).

- Warm water sport fish communities. This subcategory includes surface waters capable of supporting a community of warm water sport fish or serving as a spawning area for warm water sport fish.

- Warm water forage fish communities. This subcategory includes surface waters capable of supporting an abundant diverse community of forage fish and other aquatic life.

- Limited forage fish communities*. This subcategory includes surface waters of limited capacity and naturally poor water quality or habitat. These surface waters are capable of supporting only a limited community of forage fish and other aquatic life.

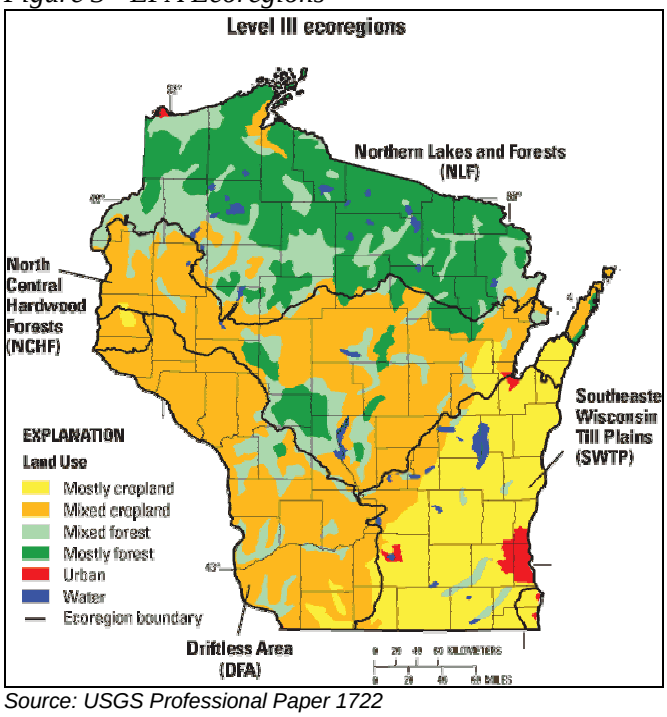
- Limited aquatic life*. This subcategory includes surface waters of severely limited capacity and naturally poor water quality or habitat. These surface waters are capable of supporting only a limited community of aquatic life.

*Note: These types of waters are important ecologically and although they do not support fisheries, they often provide excellent habitat for amphibian and macroinvertebrate species, including species that use these streams seasonally and for spring spawning. The code language above does not fully recognize the importance of these types of streams. Although the water bodies characteristics are different from those that support fisheries, they are not necessarily of lower quality.

Distribution of stream types across Wisconsin

Coldwater trout streams are predominantly found throughout Wisconsin's Driftless Area and Northern Lakes & Forests (see Figure 3, below). These parts of the state tend to have steeper gradients with fast flowing, cold waters. Coldwater streams are also common along the eastern edge of the North Central Hardwood Forests, where the glaciers receded and left deposits of gravel that facilitate infiltration of rainfall and snowmelt that flows into streams as cold, clean groundwater.

Figure 3 - EPA Ecoregions



Source: USGS Professional Paper 1722

Warm water streams are predominant in the Southeastern Wisconsin Till Plains and in much of the North Central Hardwood Forests. These areas, scoured by glacial activity, have lower gradients with slower flowing, warmer streams. In the Southeastern Wisconsin Till Plains, high clay content soils reduce infiltration (*i.e.* increase runoff) and also limit groundwater discharge to streams. The combination of increased surface water runoff and low groundwater inputs results in warmer-water streams.

Lake types & distribution

Lake Classifications

Natural lakes in Wisconsin frequently are classified by the source of water supply. Based on water source and outflows, four categories of lakes have been identified in this publication:

a) Drainage lakes: These lakes have both an inlet and outlet where the main water source is stream drainage. Most major rivers in Wisconsin have drainage lakes along their course. Drainage lakes owing one-half of their maximum depth to a dam are considered to be artificial lakes or impoundments.

b) Seepage lakes: These lakes do not have an inlet or an outlet, and only occasionally overflow. As landlocked water bodies, the principal source of water is precipitation or runoff, supplemented by groundwater from the immediate drainage area. Since seepage lakes commonly reflect groundwater levels and rainfall patterns, water levels may fluctuate seasonally. Seepage lakes are the most common lake type in Wisconsin.

c) Spring lakes: These lakes have no inlet, but do have an outlet. The primary source of water for spring lakes is groundwater flowing into the bottom of the lake from inside and outside the immediate surface drainage area. Spring lakes are the headwaters of many streams and are a fairly common type of lake in northern Wisconsin.

d) Drained lakes: These lakes have no inlet, but like spring lakes, have a continuously flowing outlet. Drained lakes are not groundwater-fed. Their primary source of water is from precipitation and direct drainage from the surrounding land. Frequently, the water levels in drained lakes will fluctuate depending on the supply of water. Under severe conditions, the outlets from drained lakes may become intermittent. Drained lakes are the least common lake type found in Wisconsin.

e) Artificial lakes: Artificial lakes are human-made bodies of water referred to as impoundments. A lake is considered an impoundment if one-half or more of its maximum depth results from a dam or other type of control structure. An impoundment is considered a drainage lake since it has an inlet and outlet with its principal water source coming from stream drainage. Approximately 13 percent of Wisconsin's lakes fit this definition.

Distribution of lake types across Wisconsin

Most lakes are in the northern and eastern parts of the state dotting the path of the glaciers. The unglaciated region, or Driftless Area, of southwestern Wisconsin has very few lakes by comparison.

Seepage lakes are prevalent in the northern third of the state (Northern Lakes & Forests, a.k.a. Northern Highlands), and in the Kettle Moraine. Seepage lakes tend to be found higher within the watershed, closer to watershed divides. Drainage lakes are more common in the southern portion of the state, and are typically connected to river systems.

Waters that have special designations

The federal Clean Water Act requires states to adopt water quality standards to protect waters from pollution. These standards define how much of a pollutant can be in the water and still allow

it to meet designated uses, such as fishing and swimming. The standards are set on a wide range of pollutants such as: phosphorus, sediment, bacteria (*E.coli*), PCBs and mercury.

Though all waters in Wisconsin are required to meet water quality standards, certain waterbodies in Wisconsin have special designations that provide them additional protections from pollutants. For instance, Wisconsin code places legal restrictions on discharges to waterways that are already degraded (Impaired Waters) and those that are pristine (Outstanding or Exceptional Resource Waters). Information about these special designations and restrictions follows.

Outstanding & Exceptional Resource Waters - protecting pristine waters

Wisconsin has designated many of the state's highest quality waters as Outstanding Resource Waters (ORWs) or Exceptional Resource Waters (ERWs). Waters designated as ORW or ERW are surface waters which provide outstanding recreational opportunities, support valuable fisheries and wildlife habitat, have good water quality, and are not significantly impacted by human activities. ORW and ERW status identifies waters that the State of Wisconsin has determined warrant additional protection from the effects of pollution. These designations are intended to meet federal Clean Water Act obligations requiring Wisconsin to adopt an "antidegradation" policy that is designed to prevent any lowering of water quality – especially in those waters having significant ecological or cultural value.

Of Wisconsin's 15,000 lakes and impoundments, 103 are designated as ORW—fewer than 1%. Of Wisconsin's 53,413 streams and rivers, 254 are designated as ORW, and 1,544 are designated as ERW. However, it can be more useful to consider stream statistics in terms of the number of stream miles rather than number of streams, since streams can be of widely varying lengths. Wisconsin has a total of ~42,000 stream/river miles in the state. Based on the current ORW/ERW list, a total of 3,179 stream miles (7.6%) have been designated as ORW, and 4,668 stream miles (11%) have been designated as ERW. Most of Wisconsin's trout waters are also designated as ORW or ERW.

For information about ORWs and ERWs and how to determine whether individual waterbodies are designated as ORW or ERW, visit http://dnr.wi.gov/org/water/wm/wqs/orwerw/.

Impaired Waters - protecting degraded waters

A waterbody is polluted or "impaired" if it fails to meet one or more water quality standards. Wisconsin's Impaired Waters Program is required by Section 303(d) of the Clean Water Act to identify and restore impaired waters by:

- Evaluating and assessing all waters of the state to determine if they meet water quality standards.
- Creating a list of waters, or Impaired Waters List, of those waters that do not meet water quality standards.
- Conducting a Total Maximum Daily Load (TMDL) analysis to set pollutant reduction goals needed to restore waters.

WDNR performs assessment and monitoring activities on Wisconsin water bodies, lists impaired waters and conducts analyses on impaired waters. For information about Impaired Waters and to determine whether individual water bodies are on the Impaired Waters List, visit http://dnr.wi.gov/org/water/wm/wqs/303d/.

CAFO potential direct & cumulative effects on surface waters

Discharges of pollutants from a given CAFO permitted under the LDCAFO GP can potentially impact surface water quality and habitat in a number of ways. Discharges can happen as a result of improper manure and process wastewater handling techniques or equipment malfunction at either the animal production area (where animals are housed and manure/process wastewater is produced and stored) or land application areas. Discharges can also occur that are in compliance with WPDES permit requirements.

Production area discharges of these pollutants in manure and process wastewater can result from either improper design, construction or management. Discharges could occur when a storage facility or runoff control system is not properly designed for the certain weather conditions or the number of animals at the site. Manure releases can occur from failure of the manure storage structure itself. A properly engineered, constructed, and managed manure storage structure poses little risk to water quality. However, as with any man made structure, there is a remote possibility of failure. A failure of bottom integrity could result in contamination of groundwater that may go undetected for a number of days or weeks. Potential impacts of manure on groundwater quality are discussed elsewhere in this document. Another even more unlikely situation would be the structural failure of a side wall of a manure storage lagoon. A catastrophic failure of this sort could result in a large volume of manure reaching the intermittent and perennial stream channels near the facility. Management errors or equipment malfunctions can also result in discharges. Valves associated with manure transfer systems may get stuck or mistakenly open or closed, resulting in discharges. Sometimes, machinery at the production area can cause damage to control systems that can result in discharges.

Manure and process wastewater releases associated with land application activities typically occur in four different ways: accidents in route to a spreading site, equipment failure at the site, or runoff from misapplication of manure.

One potential way for a discharge to occur is for a truck hauling manure to have an accident, resulting in a manure spill. However, depending on the site characteristics, volume spilled, and timeliness of emergency response, this does not necessarily pose an immediate risk to the aquatic environment. If the spill is not near a waterway, wetland, or flowing ditch and the manure is promptly contained and removed, there may be very little or no off-site environmental risk. On the other hand if the spill discharges into a stream, wetland, or flowing ditch, it may be difficult to contain and could pose a serious risk to water quality and aquatic organisms.

Once at a spreading site, another potential way for a manure spill to occur is from stuck or broken valves or transfer piping, and human error. Again the level of environmental risk from such a spill is determined by the volume of spill, site characteristics, and adequacy of emergency response.

Manure can also reach surface waters as a result of field runoff. Typically manure is either surface applied, tilled into the soil or directly injected into the soil six to eight inches below the surface. While incorporation or injection significantly reduce the potential for it to be picked up by surface runoff and delivered to nearby surface waters the soil disturbance associated with these practices increases the potential for longer term nutrient delivery.

Opportunities for containing manure discharged from field runoff are limited since it usually isn’t detected until the manure reaches a stream where its odor, color, and possibly the presences of dead or stressed fish, are observed and reported.

Discharges of CAFO manure and process wastewaters to surface waters, should they occur, have the potential to cause direct, lethal effects on aquatic organisms and both short and long term

shifts in habitat quality and biodiversity, public health threats from pathogens, and water quality impairments. Some of the primary pollutants associated with CAFOs, and their impacts to water quality, are described below.

Pathogens

Pathogens (*e.g.* bacteria, viruses) are pollutants associated with CAFOs that represent a significant short-term human health concern when manure runs off into lakes where people swim or have other direct bodily contact with the water. Individuals may inadvertently come into contact with pathogen contaminated surface water through swimming, wading, hunting, boating or trapping. These individuals may also be at risk for infection. For further information on public health threats from these pathogens please consult your local county health department or the Federal Centers for Disease Control and Prevention at: www.cdc.gov.

Discharge of manure into a waterbody can be a human health threat through consumption of contaminated water. Fecal coliform, a bacteria associated with manure, is generally used as a water quality measure of bacterial contamination. Coliform is a group of bacteria that, while generally harmless, does have strains such as *E. coli (Escherichia coli)* that can be harmful. *Giardia* and *Cryptosporidium* are other organisms associated with manure runoff. If a person or animal swallows water that contains these pathogens either while recreating in a stream or by drinking improperly treated drinking water, it can cause stomach cramps and severe gastrointestinal distress and may be fatal to children, the elderly, and immunocompromised individuals. There are strict regulations for municipal drinking water systems that use surface water as a drinking water source, so municipal drinking water supplies are rarely contaminated from manure.

BOD & Ammonia

The two constituents of greatest concern for direct short-term effect on fish and aquatic life from CAFOs are ammonia and Biochemical Oxygen Demand (BOD). These pollutants are components of manure and process wastewater (*e.g.* milking center wastes, feed storage leachate). BOD, the measure of the level of oxygen demanding materials in water, is affected by the amount of organic matter available for decomposition by bacteria and fungi and by the presence of dissolved chemicals which react with and consume oxygen from the water. It is typically measured by determining the drop in dissolved oxygen in a water sample held in the dark for five days at 20º C, which is 68º F. BOD results in rapid depletion of dissolved oxygen, causing asphyxia of aquatic organisms. The amount of dissolved oxygen the water can hold is strongly controlled by water temperature. Cold water can hold much more oxygen than warm water.

Ammonia is a form of nitrogen that is acutely toxic to aquatic organisms. The level of toxicity is determined by the ammonia concentration in the water, water temperature, and the acidity of the water. Ammonia is more toxic in warm water with low acidity.

Ammonia toxicity and oxygen depletion typically associated with manure spills is lethal to fish, aquatic insects, snails, crayfish, mussels, and certain life stages of amphibians at the discharge site and for some distance downstream.

Acute toxicity for aquatic organisms is the most obvious short term effect resulting from a manure release. Once the toxic components are no longer in the system, aquatic organisms will begin to recolonize the impacted area. In most situations there will be nearby unimpacted areas that serve as a source of organisms for recolonization. The length of time it takes to recolonize will vary depending on the degree of initial impact and proximity of refuge areas. Organisms most tolerant of poor water quality and habitat will be the first to recolonize, while other less

tolerant species will take longer to become reestablished-. It could take from a few months to several years to fully recolonize an area impacted by a manure release.

Water-based recreation will also sustain short term impacts. Since water containing manure will be very unappealing and may pose a health threat, people will likely choose to pursue water based recreation elsewhere.

Longer-term direct impacts are also associated with soil loss from cropped fields. Soil particles carried and deposited by water is commonly called sediment. Heavy sediment loads harm streams by covering the natural stream bottom, eliminating deep holes used by fish for cover and as a refuge during low flow conditions. Sediment can bury high quality habitat such as gravel bars and cobble, which are home to many aquatic insects and serve as spawning areas for fish. Heavy sediment deposits can reduce channel depth forcing the stream to become wider in order to convey the same volume of water. This exposes more of the water to more sunlight which can increase water temperature and decrease dissolved oxygen.

Long term impacts from a single acute spill are unlikely to persist for more than one or two years, depending on the degree initial of impact and the kind of organisms affected. With a single release event, the manure and its resultant impacts will pass through the system or degrade in place to a level that is no longer detrimental to aquatic organism or water quality. As noted in the prior section, aquatic organisms will begin to recolonize the impact zone as soon as water quality begins to improve.

However, the deposition of organic matter from a single manure release can result in long term impact through on-going suppression of dissolved oxygen concentrations and from deposits of soft organic matter on stream beds. As the organic portion of the manure decomposes over time, dissolved oxygen is consumed and phosphorus formerly bound in cellular material is released.

This can then serve as a long term nutrient source for the receiving water bodies. Another kind of long term effect is from continual, low level, chronic discharges of manure or its constituents. The slow, steady, or episodic discharge of ammonia, BOD, and phosphorus has more potential to cause long term impacts than a single manure release.

Phosphorus & erosion/sedimentation

Longer term direct impacts are also associated with direct and indirect discharges of manure and process wastewater pollutants. Phosphorus and soil particles are the two constituents of runoff pollution that pose a significant threat to the State's surface waters. Phosphorus can be directly discharged to surface waters associated with acute runoff events described above. In addition, phosphorus can be deposited in water as result of soil erosion and sedimentation.

Plants need both nitrogen and phosphorus to grow. However, in cool, temperate regions like Wisconsin, it is generally the phosphorus level of a waterbody that determines how much plant and algae growth will occur. An important characteristic of phosphorus that has significant implications for water quality is its tendency to bind to soil particles. Because of this, when phosphorus is applied to fields either as part of manure, process wastewater or commercial fertilizer it stays relatively immobilized. However, when land suffers from erosion, soil is washed into waterways and the phosphorus attached to it is then released into the water. Phosphorus can also be delivered to surface waters dissolved in runoff water or as part of the cell structure of plant material. While improper farming practices can lead to excessive erosion, some amount of soil loss is acceptable. This acceptable amount of soil loss is referred to as tolerable soil loss, or "T". Tolerable soil loss falls within the range of two to five tons per acre per year for most

Wisconsin soils. For the most part, phosphorus associated with this soil that enters surface waters is considered “agricultural storm water” which is not subject to WPDES permit regulation.

Phosphorus that enters surface waters either directly or indirectly, stimulates the growth of algae and other aquatic plants. Some algae are normal and healthy for lakes and streams. When a waterbody becomes overly phosphorus enriched, algae can cloud the water in dense blooms, reducing light penetration so that rooted aquatic plants, which provide good fish habitat, struggle to survive. The dense algae blooms seen on certain Wisconsin Lakes is often the result of excessive nutrient enrichment. Some blooms are harmless green algae blooms but sometimes the excessive nutrients in the lake stimulate a blue-green algae (cyanobacteria) bloom. Blue-green algae can produce a variety of different toxins which can make the water unsafe for humans, pets, and wildlife. More information on blue-green algae can be found at: http://dnr.wi.gov/lakes/bluegreenalgae/.

In streams the algae can from dense blooms or form mats on the stream bottom, making it unsuitable for many organisms. When nuisance algae blooms die and decompose dissolved oxygen depletion can occur. Aquatic organisms depend on oxygen dissolved in the water the same way humans depend on oxygen in the air. Algae and rooted aquatic plants produce oxygen during the day. However, at night they consume oxygen. Waters with abundant algae or rooted plant growth have high concentrations of dissolved oxygen during the day, but at night oxygen levels decrease as the plants respire.

It is common for dissolved oxygen concentrations to severely decline at night, with the lowest concentrations, often approaching zero, just before dawn. When algae and other plants die, bacteria and fungi populations increase to decompose the mass of nutrient-rich cells. The flourishing populations of bacteria and fungi consume oxygen and cause dissolved oxygen depletion. Each organism has its own tolerance for low oxygen. If dissolved oxygen concentrations get too low, aquatic organisms begin to die if they cannot escape the oxygen depleted area.

Certain waters in the vicinity of an operation may already phosphorus enriched. The network of intermittent and perennial stream channels throughout the Wisconsin landscape constitutes a delivery system for dissolved and suspended material washed from the rural landscape. Phosphorus typically slowly works its way into stream channels attached to soil particles, organic matter (manure or other plant material), dissolved in runoff, and through drain tile discharges. Stream flows flush the phosphorus downstream to enrich receiving water bodies. While storm events flush large quantities of phosphorus downstream, phosphorus released from bottom sediments also flows downstream during low flow conditions. This process can result in nutrient enrichment of downstream water bodies. Long term changes in aquatic species can result from chronic discharges of phosphorus, oxygen demanding materials and sediment by changing water quality and habitat that produces conditions that favor pollution tolerant organisms. These organisms can tolerate phosphorus enriched, low dissolved oxygen environments. Good water quality draws more people to recreate on the water than poor water quality. Therefore, water-based recreation typically declines as water quality and the biological communities they support, decline. This can result in long term changes in way people utilize the water resources of an area.

When determining potential impacts associated with a given CAFO, the potential and severity of short and long term changes is dependant on the water bodies themselves in an area. For example, warmwater streams may be more susceptible to problems caused by nutrients in manure runoff than coldwater streams for several reasons:

- Soils in the southeast part of the state tend to have a higher clay content, with the result that these warmwater streams receive less cold groundwater and are more dominated by warmwater runoff.

- Warmer waters have less oxygen-holding capacity than do cold waters.

- Low gradients and slower moving water result in slower flushing rates once pollutants enter streams. This means that there tends to be more pollutant accumulation in these streams.

- Nutrient inputs stimulate bacteria and algae growth, and growth is more rapid at higher water temperatures, which can increase oxygen depletion in these waters.

Coldwater streams may be less susceptible to problems because:

- Coldwater streams are dominated by groundwater, and are therefore less influenced by surface runoff. Groundwater inputs provide some assimilation for runoff received from the watershed.

- Coldwater streams tend to be faster flowing, particularly in the Driftless Area and other regions with relatively steeper gradients. This enables these streams to flush pollutant loads more quickly than lower gradient streams.

- The colder temperatures in these streams keeps bacterial activity at a lower level, and high dissolved oxygen levels may provide some buffer for oxygen dips.

However, trout and other cold-obligate species have a narrower range of conditions in which they can survive.

Stream size may also potentially play a role in a stream’s response to agricultural runoff. Small streams may have lower assimilative capacity than larger ones, though they may also receive less total runoff volume due to their smaller watershed size. The level of impact would likely depend on the scale of the runoff event. Intermittent streams, or dry creeks, may also play an important role as conduits for manure transport during runoff events.

For lakes, the source of a lake's water supply not only determines a lake’s type, but is also very important in determining its susceptibility to potential water quality impacts.

The main sources of water for seepage lakes are precipitation, runoff, and groundwater. If precipitation is the major water source, the lake will be acidic, low in nutrients, and susceptible to acid rain. If groundwater is the major water source, the lake is usually well buffered against acid rain and contains low to moderate amounts of nutrients. Groundwater contamination from manure, local septic systems, or other sources could cause problems. Water exchange in seepage lakes is fairly slow. Because these lakes do not have inflow from streams, they tend to receive lower levels of incoming phosphorus and other pollutants from the landscape than do lakes receiving streams that drain larger watershed areas. However, because they do not have stream outflows to discharge pollutants, seepage lakes accumulate any pollutants that do enter the

waterbody. Therefore, pollutant effects are cumulative in these lakes and are difficult to remedy even after pollutant sources are reduced.

In drainage lakes, stream inflows are the major source of lake water. Nutrient levels are often high and water exchange takes place more rapidly. These lakes have the most variable water quality depending on the amount of runoff and human activity in the watershed. Drainage lakes tend to receive more pollutants but are also able to flush pollutants through the system through the streams that drain them.

Lake depth can also be an important factor related to water quality. Shallow lakes (both seepage and drainage) can be more prone to water quality problems from nutrient loading because they are continually mixed and are subject to other types of disturbance, such as motor boats, carp, or vegetation management. These factors lead to resuspension of sediment and phosphorus in the water column, making nutrients continually available for increased plant growth.

Stormwater

There are a number of potential changes associated with development of a CAFO site that can impact water quality. Development of most CAFO sites includes the conversion of agricultural fields into roadways, buildings, feed storage and manure and process wastewater storage structures. The amount of land converted is dependent on the size of an operation prior to pursuing permit coverage, with brand new operations converting more land than operations that were just below permit size. Some operations that are just below permit size may not need to convert any land to building and other structures and can accommodate increase animal numbers as part of the operations current footprint.

Agricultural fields allow for some infiltration of precipitation. When areas of these fields are developed, those portions will become impervious, prohibiting infiltration. Overall, the amount of precipitation infiltrating into the soil to recharge groundwater across an operation's footpring will be reduced when compared to pre-development conditions but the relative proportion compared to pre-development conditions at a given site is unknown.. Unless this precipitation is directed to detention ponds or other infiltration structures, increasing the amount of storm water delivered to area channels and streams in a short period of time. This can lead to increased scouring of stream banks and decreases in base flow of streams.

It is likely that agricultural fields that occupy CAFO sites prior to development contributed to runoff pollution that entered area flow channels and streams. It is possible that there will be less sediment leaving these areas than there was leaving the site when it was in cropped fields.

Operations may install storm water management system to reduce sedimentation and increase infiltration associated with a given site. However, these practices are not required as part of the storm water WPDES construction site permit or the CAFO WPDES operation permit.

In general, CAFO production sites cover only a small portion of a given watershed. Therefore, the alteration of infiltration and runoff patterns will likely not have a discernable impact on the hydrology or water quality of the nearby intermittent and perennial streams or wetlands.

Secondary or indirect effects

Secondary or indirect effects are those resulting as a consequence of the initial, direct impacts. For example, many of the organisms directly impacted by a manure discharge are food for other organisms. Altering the food chain may produce secondary impacts on a number of other species.

Secondary impacts will be more obvious for terrestrial organisms, such as raccoons, that feed on aquatic organisms like mussels and crayfish. This issue is addressed in more detail in the portion of this document addressing Wildlife.

V.A.3. Wetlands

Description

References:

- *Much of the following information is captured verbatim from the DNR website and the Wisconsin Ecological Landscapes Handbook found at http://dnr.wi.gov/landscapes/pdfs/Wet.pdf*

A wetland is defined in the Wisconsin Statutes as "an area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation and which has soils indicative of wet conditions." Wetland communities have a common characteristic - their soil, or other substrate, is periodically saturated with or covered by water. The spatial arrangement of wetlands is one factor that makes them an important habitat or habitat component for wildlife species. Wetlands form connections between aquatic and upland areas, and can be a linkage among upland communities. Wetlands are found within forests, savannas, barrens, and prairies. They provide water, food and shelter for wildlife and supply unique habitat conditions for many plants. Many bird and mammal species rely on wetlands, especially during migration and breeding. Additional social values associated with wetlands include aesthetics, culture, recreation, education, and scientific study.

Water quality is often dependent upon wetlands because they serve to trap sediment, remove nutrients, protect shorelines, and slow the effects of flood water. They also serve as both discharge and recharge areas for groundwater and provide habitat for many species of plants and animals (Stearns 1978). In part due to these functions, wetlands exhibit higher biological productivity than most other community types, and support rare biota.

Wetlands cover about 16% of Wisconsin's surface area and are noted for their abundance of plant and animal life. Of Wisconsin's 370 species of birds, 39% live in or use wetlands. Many wetlands are forested (wet forests and wet mesic forests, for example) and are part of the continuum of northern or southern forest ecosystems. Wetlands are also interspersed among the former prairie and oak savanna areas of southern and east-central Wisconsin. In the Driftless Area of southwestern Wisconsin, which was not directly affected by glaciation, forested and non-forested wetlands exist primarily along streams and rivers or at spring seeps. Lakes do not occur there except where they have been created by dams. In northern Wisconsin, wetlands occur on vast areas of peat soils occupying former glacial lake beds; as potholes, bogs, and fens; along streams and rivers; on the borders of lakes; as forested swamps and bottomlands; and as coastal wetlands along Lake Michigan and Lake Superior. Some wetlands occur in large continuous patches, while others are isolated within upland communities.

Wisconsin's situation is similar to that of the nation as a whole; 46 percent of its approximately 10 million acres of wetland were lost between 1780 and 1980. These losses were primarily due to drainage for agriculture. At present, Wisconsin has lost 47% of its original ten million acres of wetlands. Many of the remaining 5.3 million acres are in the northern third of the state (Wisconsin DNR 1990). In some southern Wisconsin counties, the amount of wetland loss is well over 75%. A large amount of remaining acreage in Wisconsin exists in a partly altered state, such as with old drainage ditches still functional enough to change the hydrology of the wetland. Much of this remaining wetland acreage was at one time disturbed, either by drainage (followed by restoration) or by being cleared, repeatedly burned, grazed, or periodically plowed (Curtis 1959).

Disturbance and other factors have opened many wetlands to invasion by non-native invasive species that can reduce the ecological value of wetlands.

Several major categories of wetland communities include:

Emergent aquatic communities: sometimes also called marshes, found in shallow water at the edges of lakes and streams.

Wet meadows: including sedge meadows and wet prairies. These communities form on permanently saturated soils and are dominated by grasses or sedges.

Peatlands: are characterized by the accumulation of organic matter which is produced and deposited more rapidly than it is decomposed, leading to peat formation. This process is more likely to occur in cold climates where decomposition is slow. Peatlands include two wetland types that are usually defined separately:

- Bogs: form in closed basins or on slopes where the only water sources are precipitation and surface runoff, and they typically have low nutrient status. The peat is acidic, formed from decomposed *Sphagnum* and other vegetation. Bogs were once thought to be a successional stage between open lake and forest, in which the peat mat would build up and be colonized by shrubs and eventually trees. We now know that bogs can persist in nearly the same condition for thousands of years (Wisconsin. Coastal Management 1995).

- Fens: also form in basins and on slopes, but groundwater inflow is present in addition to water inputs from surface runoff and precipitation. Fens receive greater amounts of oxygen and nutrients because of groundwater contributions and are less acidic. Different types of fens develop under different nutrient conditions. Calcareous fens occur where limestone bedrock contributes high levels of calcium bicarbonate to the groundwater. Fens support grasses, sedges, and a diversity of other herbaceous plants. Peats in fens are less acid than those in bogs and can even be calcareous (Curtis 1959, Verry and Boelter 1978).

Shrub swamps: are wetlands dominated by shrubs. They may occur as a successional stage that follows herbaceous vegetation on sedge meadows, fens or alluvial floodplains.

Forested wetlands: may be dominated by either conifers or hardwoods. They are often associated with alluvial soils in floodplains and with saturated soils in former lakebeds or other low-lying landscape features.

The names of wetland community types reflect their diversity, including wet-mesic prairie, southern hardwood swamp, open bog, calcareous fen, northern sedge meadow, shrub-carr, emergent aquatic, and alder thicket, among others. Most of these community types were described by Curtis in 1959. Since then some revisions have been made and additional types described by the Wisconsin Natural Heritage Inventory (NHI). For detailed descriptions of all of these community types please see the Wetland Communities of Wisconsin chart (Table 9) and associated map of Ecological Landscapes of Wisconsin (Figure 4) below. More information can be obtained at:
http://dnr.wi.gov/org/land/er/communities/index.asp?mode=group&Type=Wetland

Table 9 - Wetland communities of Wisconsin

Wetland occurrences in Wisconsin.s ecological landscapes.

Wetland type occurrences by Ecological Landscape	Northern Wet Forest (S4)	Tamarack Swamp (S3)	Northern Wet-Mesic Forest (S3S4)	Southern Wet Forest	Southern Wet-Mesic Forest	Alder Thicket (S4)	Shrub-Carr (S4)	Northern Sedge Meadow (S3)	Southern Sedge Meadow (S3)	Wet Prairie (SU)	Wet-Mesic Prairie (S2)	Open Bog (S4)	Bog Relict (S3)	Boreal Rich Fen (S2)	Poor Fen (S3)	Shore Fen (S2)	Calcareous Fen (S3)	Inland Beach (S3)	Emergent Aquatic (S4)	Emergent Aquatic - Wild Rice (S3)
Superior Coastal Plain	x	p	p			x	p	x				x			x	x		p	x	
Northwest Lowlands	x						p	p				p								
Northwest Sands	p	p	x			x	p	x				p			p	p			p	
North Central Forest	xx		xx			xx	x	xx				xx		p					xx	
Northern Highland	xx		x			x	p	xx				xx		p	x				x	p
Northeast Hills	xx		xx			x		xx				xx		p			p		x	
Northeast Sands	x		p			p	p	x				p							p	
Forest Transition	xx		p			p	p	x	p	p		x							x	
Northeast Plains	xx		xx			p	p	xx	p			x		p	p				x	
Northern Lake Michigan Coastal	x		xx	p		x	p	x			p	p		x					x	
Western Prairie						p		p											p	
Central Sand Plains	xx	x	x	p		xx	xx	xx	xx			x			xx	p	p		xx	
Western Coulees and Ridges	x		x	x	p	xx	xx	x	xx	p	p	p			p		p		xx	
Central Sand Hills	xx		p			x	xx	x	xx	p	xx	p				p	xx		xx	
Southwest Savanna							p			p	p						p		p	
Southeast Glacial Plains	xx		x	x	x	p	xx	x	xx	x	xx	xx	x				xx		xx	
Southern Lake Michigan Coastal			p		p		p		p	p	x						p		p	

xx= 15 or more EO's. x= 5-14 EO's. p= 4 or fewer EO's.

State Element Ranks assigned by the Wisconsin Natural Heritage Inventory are associated with the wetland types. Rankings are defined as follows (Wisconsin Natural Heritage Inventory Program 2001).

S1= Critically imperiled in Wisconsin because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation from the state.

S2= Imperiled in Wisconsin because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from the state.

S3= Rare or uncommon in Wisconsin (21 to 100 occurrences).

S4= Apparently secure in Wisconsin, with many occurrences.

S5= Demonstrably secure in Wisconsin and essentially ineradicable under present conditions.

SU= Possibly in peril in the state, but their status is uncertain. More information is needed.

Wisconsin Ecological Landscapes Handbook

Figure 4 - Ecological Landscapes of Wisconsin

Source: DNR Land Legacy Places Report

CAFO potential direct & cumulative effects on Wetlands

For a given CAFO project, impacts to wetlands can be adverse. Livestock can impact wetlands through directly or indirectly adding nutrients to wetlands. Even relatively minor concentrations can have devastating affects on some of the more susceptible wetland types. Also, building construction and runoff may decrease groundwater input and/or increase surface water to wetlands which again can adversely impact these wetlands. Crop production may occur in wetlands. Some drainage in wetland soil areas is allowed under current law where wetlands have been previously lost due to cropping and/or drainage. In other cases, wetlands may be actively farmed without modifying the hydrology, so they are still technically wetlands. In either case, most of these wetland's functional values will be significantly affected. In most cases, intact native plant communities will not recover from the impacts of farming. Invasive plant species regularly colonize disturbance, so it is likely that if a farmed and/or drained wetland is allowed to

recover, it will be dominated by non-native species. That is also true with livestock operations where the nutrients favor invasive plants like reed canary grass and cattails.

Wetlands differ in their susceptibility to impacts from livestock operations, and agriculture in general. Highly susceptible wetlands include calcareous fens, sedge meadows, open and coniferous bogs, low prairies, coniferous swamps, lowland hardwood swamps and ephemeral ponds. Less susceptible wetland include cultivated hydric soil areas and wetlands dominated by invasive species such as reed canary grass.

V.A.4. WPDES Permits – addressing potential impacts to surface waters, wetlands & groundwater

The above sections discuss potential water quality impacts associated with LDCAFOs that would be covered under the proposed WPDES LDCAFO GP. The potential of impacts to surface waters, groundwater and wetlands that might occur from an operation would be greatly reduced when covered and operated in compliance with the WPDES LDCAFO GP. The purpose of the WPDES permit program and the proposed LDCAFO GP is to require LDCAFOs to implement BMPs to avoid or minimize potential impacts to water quality. As with CAFOs covered under an individual WPDES permit, this is accomplished through: 1) the review of structures and systems associated with manure and process wastewater storage/handling; 2) the review of an operation's NMP that details how, when, where, and in what amounts manure and process wastewater from the operation will be landspread; 3) coverage of an operation meeting defined eligibility criteria under a WPDES permit that outlines operational requirements for the storage, handling, and land application of manure and process wastewater. These requirements are included in the proposed LDCAFO GP (included as Appendix A); and 4) review and oversight of the CAFO once it is operating, which includes conducting oversight inspections and pursuing enforcement action when needed to obtain permit compliance and address water quality impacts.

In Wisconsin, the WPDES/NPDES permit program has provided the backbone of water quality regulation and protection for CAFOs. Land application practices have been regulated under state water quality protection authority since the inception of the program in 1984. While Wisconsin CAFOs generally have an acceptable level of environmental performance and compliance with WPDES permit requirements, there are instances of noncompliance resulting in water quality impacts (*e.g.*, well contaminations, fish kills) that have required formal DNR enforcement (see Tables 10a and 10b, below). These types of noncompliance and water quality impacts are not specific to large CAFOs. Operations with fewer than 1,000 animal units have also caused water quality impacts. However, there is the concern that with growing numbers of CAFOs, even occasional noncompliance can result in loading of pollutants to groundwater, surface waters or wetlands. This is of particular concern in areas of the state, or in watersheds, where there may be a concentration of CAFOs.

Table 10a - DNR Formal livestock enforcement actions, CAFO

CAFO										
Action	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
NOV	1	2	2	4	4	2	5	2	5	30
Enforcement Conference	2	3	4	5	3	1	5	1	4	14
DOJ	1		5	2	2	2	1	1	2	2
Average settlement	$75,000		$35,000	$24,377	$75,000	$236,250	$58,938	$84,972	$56,250	$45,000

Table 10b - DNR Formal livestock enforcement actions, non-CAFO

Non-CAFO										
Action	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
NOV		2			4	2	3	1	2	2
Enforcement Conference		3			4	1	4	1	2	1
DOJ	1		1			3	1	1	2	
Average settlement	$2,844					$17,290	$36,861	$4,876	$24,976	

On the other hand, WPDES regulatory authority over CAFOs may also make preventing and addressing water quality impacts more effective. CAFOs generally receive greater oversight and are subject to more stringent requirements than smaller-scale, nonpermitted livestock operations. A large factor in the future success of the CAFO permit program will be the ability of the Department to maintain active oversight of growing numbers of CAFOs in the state. The issuance of the LDCAFO GP and the streamlining of the permit process is intended to increase available staff time to conduct more field inspections and other compliance activities.

CAFOs are not allowed to discharge pollutants from the CAFO production area (*e.g.*, manure and process wastewater storage structures, feed storage areas, animal housing areas) to navigable waters, except under certain conditions where additional protection for surface waters is provided. Additional protection is included in the CAFO GP for waterbodies with special designations [ORW, ERW, 303(d) listed waters]. In accordance with antidegradation requirements, any allowed discharge of pollutants from the production area that enter an ORW/ERW may not exceed background pollutant levels. Operations that may impact 303(d) listed waters are prohibited from discharging pollutants that would contribute to the impairment of the 303(d) listed water unless otherwise allowed under a Total Maximum Daily Load.

In order to prevent discharges and protect surface waters, groundwater and wetlands, the means of collecting manure and process wastewater, leachate, and runoff from feed storage areas, along with runoff and stormwater from impervious surfaces, must be designed to meet or exceed applicable regulatory requirements. For any operation covered under the proposed LDCAFO GP, all manure transfer systems and storage facilities must be constructed, at a minimum, in accordance with USDA Natural Resource Conservation Service Standards 313 (Waste Treatment Facility), 634 (Manure Transfer), and 629 (Waste Treatment), plus applicable sections of NR 151, 213, 216, and 243, Wis. Adm. Code. The NRCS standard requires an extensive site assessment to determine area soils and depth to groundwater and bedrock to ensure structures are properly designed and constructed. NRCS Standard 313 specifies concrete thickness, reinforcement and other design requirements for these structures, as well as separation distances between the bottom of the structure and groundwater/bedrock to minimize potential leaching from these structures that could contaminate groundwater.

CAFOs must install permanent markers in each waste storage facility to indicate the margin of safety (MOS - the level which is vertically one foot below the lowest point of the top of the storage structure), and the maximum operating level (MOL – the level measured vertically from the lowest point of the top of the storage structure that is the sum of the MOS and the level necessary to contain the precipitation and runoff resulting from a 25-year, 24-hour rain event). This requirement is intended to help avoid potential overflows and discharges. Design requirements also protect against potential catastrophic failures of these structures. Design and construction in accordance with these requirements should ensure adequate protection of surface waters, groundwater and wetlands.

Additionally, WPDES permits require that all CAFOs develop and adhere to an Operation and Maintenance (O&M) schedule and an emergency response plan. Permit requirements and O&M schedules require operations to monitor and inspect at various frequencies components of the waste storage facilities, manure transfer, leachate collection, runoff controls and stormwater collection systems, record findings, and submit reports to the Department to document proper operation and maintenance of these systems as well as compliance with the NMP requirements. Large CAFOs emergency response plans address potential spills, storage facility overflows, and other unexpected events from both the CAFO production area and land application areas. The advance planning associated with an emergency response plan can help to minimize or altogether avoid environmental impacts associated with unexpected problems.

Nutrient Management Plans for operations covered under the proposed CAFO GP will have been reviewed by the Department and determined to be in compliance with applicable NRCS 590 criteria and NR 243 requirements. NMPs address the application and budgeting of nutrients (*e.g.*, manure and process wastewater) for plant production and soil fertility on a field by field basis. NMPs describe, in specific detail, the crops, tillage, nutrient application rates, locations, and methods implemented in order to protect surface water, ground water, and wetland resources while maintaining the physical, chemical and biological condition of the soil. An operation's NMP accounts for all nutrient sources, including soil reserves, commercial fertilizer, manure, organic byproducts, and crop residues to ensure proper utilization and protect water quality.

Strict adherence to an NMP developed in accordance with the LDCAFO GP will minimize the risk of manure and process wastewater discharges to surface waters and leaching of pollutants to groundwater associated with an operation's land application activities. In addition, allowed discharges of agricultural stormwater from fields receiving CAFO manure and process wastewater are controlled via BMPs required as part of NRCS Standard 590, NR 243 and the operation's WPDES permit. In almost all cases, the agricultural fields that will receive manure and process wastewater from a CAFO covered under the proposed GP will already be receiving manure or other fertilizers as part of crop production on those fields. Under a WPDES permit, nutrients associated with applications of manure and process wastewater will replace applications of nutrients on these fields from other sources. The NMP requirements for CAFOs are as stringent as, and in many cases more stringent than, the requirements for crop producers and non-permitted livestock operations. This will provide a level of management equal to or better than the current level of management on these fields, particularly if the land where CAFO materials are land applied was not previously covered under an NMP.

All of the potential impacts on water quality, habitat, and biological communities will not be increased above current conditions if there are no new acute or chronic releases of manure or process wastewater associated with the activities of a CAFO covered under the LDCAFO GP. If an operation conducts landspreading in accordance with its NMP and WPDES CAFO permit, maintains an adequate land base for landspreading as required by the permit, and properly inspects and maintains manure storage facilities and runoff control systems, the threat to groundwater, wetlands and surface water should be minimal under normal operating and climatic conditions. Ultimately, barring any catastrophic failure of the storage facility or an accidental, unrecoverable spill, there should be no additional degradation of surface water quality or habitat beyond what already exists in the lakes, streams, and wetlands of the region.

There is a trend in the livestock industry toward larger-scale facilities in Wisconsin, and the nation as a whole. In some instances, larger-scale dairy operations have rapidly become an economic necessity due to changing pricing structures and the need to reduce capital inputs while maximizing production. Economies of scale associated with CAFOs have allowed producers to increase production without increasing costs.

There is some question as to whether issuance of an LDCAFO GP will encourage greater numbers of dairy operations to expand to large CAFO size because of potential streamlining of the permit process. The Department does not believe this is an issue for the following reasons:

- While the permit issuance process is streamlined, the application requirements for large CAFOs remains essentially the same.

- It is unlikely that the permitting process has dissuaded operations from becoming a large CAFO. Instead, one potential reason that some operations have not expanded to CAFO size may be compliance concerns associated with the additional water quality requirements. As stated previously, permits for large CAFOs have not been denied, but, an operation may choose not to expand based on compliance issues associated with permit requirements.

- With new federal requirements regarding public noticing of a CAFOs coverage under the LDCAFO GP, and the availability of the operation's nutrient management plan, members of the public still have an opportunity to comment on and request a hearing.

Ultimately, it is the Department's opinion that the market for dairy products and the availability of land for application of manure and process wastewater will likely dictate the rate and number of large Dairy CAFO expansions.

There is also the question of whether large dairy CAFOs are environmentally sustainable and what ultimate impacts a growing number of large CAFOs will cumulatively have on the environment in the State of Wisconsin. There have been numerous reports in many states about growing concerns and impacts associated with large CAFOs. Many of these reports highlight problems in states that do not have a robust NPDES permit program and have instead relied on state programs or non-regulatory programs to address CAFO water quality impacts. In addition, it is only recently that the NPDES permit program has begun to address CAFO land application practices as part of NPDES permit requirements.

If numerous projects of this type are proposed in an area, there is a concern that the land base available for landspreading manure could be overwhelmed and would make a number of such projects nonviable. This is due primarily to costs associated with hauling manure and process wastewater long distances for landspreading. This is an issue that applies to CAFOs whether they are covered under individual or general permit. The application and WPDES permit process for both individual and general permits address this issue, since both permitting processes require that operations demonstrate and maintain adequate land base. It is possible that operations may be limited in size due to land based concerns in certain parts of the state.

V.A.5. Air

All animal agricultural operations generate odors and air pollutants. When localized and insignificant, these odors and air pollutants pose few problems. Often, "ag air" is associated with the positive character of the countryside or in the case of Wisconsin, the "dairyland". Current information indicates, though, that if enough animals are concentrated together in a small area, air emissions may cause health and environmental concerns and could trigger air quality permitting requirements.

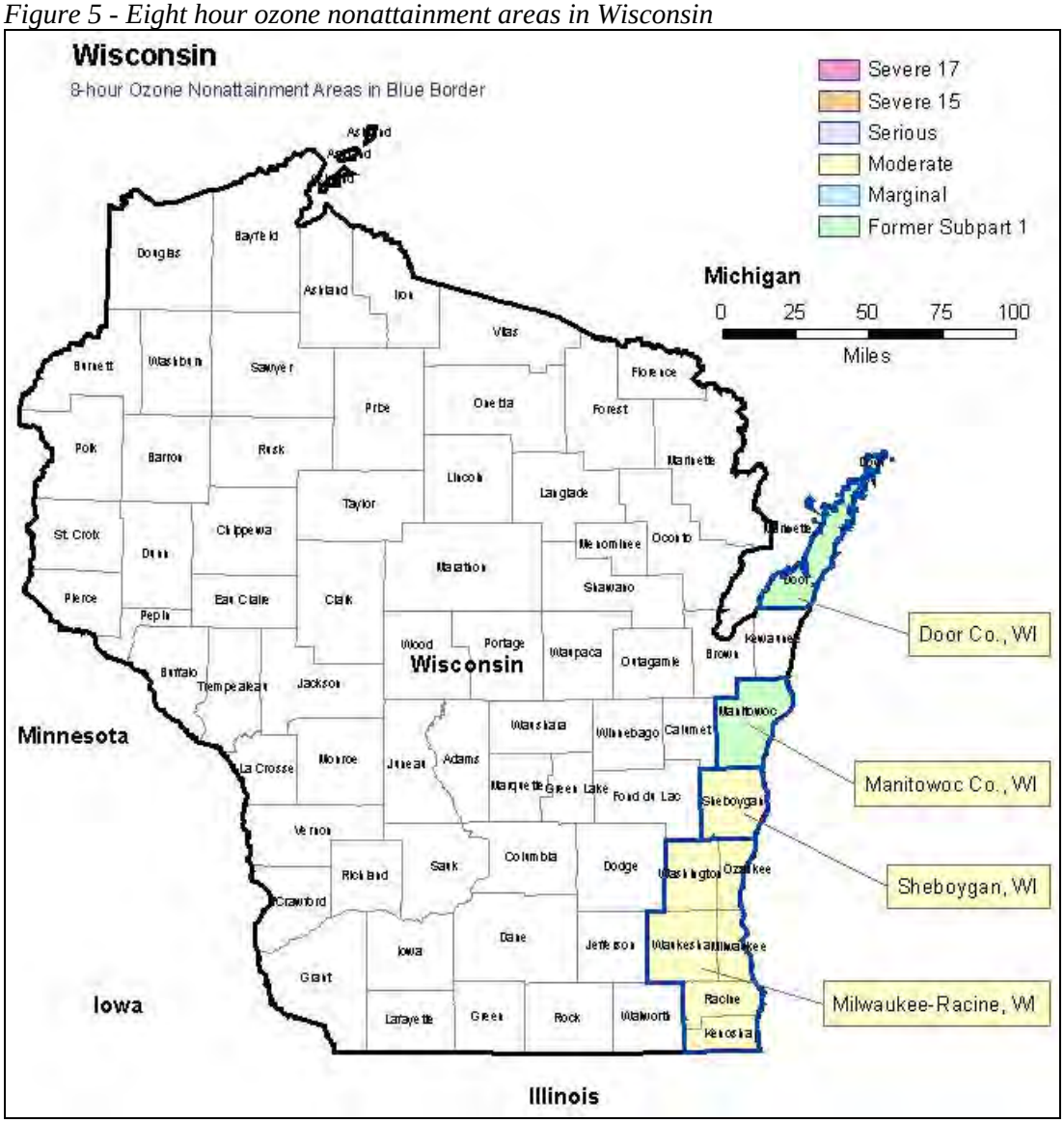
Airborne contaminant emissions emanating from CAFOs, or other types of animal agricultural operations, include gases and particles. Air quality concerns have focused primarily on ammonia (NH_3), hydrogen sulfide (H_2S), odors, particulate matter (PM), volatile organic compounds (VOC), and greenhouse gases (GHG). Diesel exhaust particulate matter emissions from semi-

trucks, manure spreading, and other miscellaneous farm operations are also associated with animal agricultural operations.

Emergency generators, other stationary diesel or biogas engines and other combustion sources, such as dryers, will emit pollutants too. Criteria pollutants [oxides of nitrogen (NOx); carbon monoxide (CO); and sulfur dioxide (SO2)], and incomplete products of combustion are also emitted and formed from the combustion of diesel, biogas or other fuels.

In addition to primary emissions, certain air pollutants are formed through chemical processes in the atmosphere - known as secondary formation processes. The secondary pollutants have deleterious effects. Ammonia reacts with SO2 and NOx to form PM2.5 (particles with an aerodynamic diameter smaller than 2.5 µm). VOC and NOx react to form ozone. Nitrogen containing compounds such as ammonia and NOx result in increased nutrient loading and acidification of soils and waters. The current ozone nonattainment areas are shown in Figure 5, below. The current PM2.5 nonattainment area is shown in Figure 6 later in this section.

Figure 5 - Eight hour ozone nonattainment areas in Wisconsin



Both quantity and quality of air contaminant emissions from animal agricultural operations are difficult to estimate, making off-site air quality impacts difficult to predict. This is due to a

number of variables including: time of year and day (i.e., diurnal and seasonal temperature variation), animal species, number of animals present (which may change over time), type of housing, manure handling system, feed type and chosen management practices.

After contaminants are generated, they can be emitted through animal housing ventilation systems (if used), or volatilized from any number of sources, including: animal housing and production areas, feed preparation and storage, manure management/storage facilities, land application sites, and dispersed by natural weather forces. After these materials are emitted and become airborne, they are transported downwind. Travel distance can vary greatly due to size of particles, weather conditions, and surrounding topography and vegetation. These variations have made it extremely difficult for researchers and regulators to form a clear picture of the expected emissions and emission-related effects from animal agricultural operations.

Without site-specific pollutant dispersion modeling and follow-up site monitoring, it is unclear whether CAFOs covered under this LDCAFO GP will meet ambient air quality standards for hydrogen sulfide and ammonia. Although the total amount of air pollutants emitted from animal agricultural operations will be unaffected with greater setback distances to property boundaries, increased dilution and dispersion will lower the likelihood for ambient air quality standard exceedances for ammonia and hydrogen sulfide at the property boundary.

Ammonia

Ammonia (NH_3) is an atmospheric pollutant of great concern that reacts with NOx and SO_2 to form particulate ammonium sulfates [NH_4HSO_4 and (NH4)2SO4], and ammonium nitrate (NH_4NO_3), which are contributors to ambient PM2.5 and regional haze, as well as to soil and water acidification.

State and national ammonia emission inventories indicate that CAFOs are a major contributor to ammonia emissions. Ammonia is generated from animal waste and is released from barns, lagoons and from land application. Based on a statewide 2005 ammonia emissions inventory, agricultural livestock operations accounted for 84 percent of estimated ammonia emissions.

Ammonia is produced as a by-product of the microbial decomposition of the organic nitrogen compounds in manure, the combination of feces and urine that is excreted. Nitrogen occurs as both unabsorbed nutrients in animal feces and as either urea (mammals) or uric acid (poultry) in urine. The potential for ammonia emissions exists wherever manure is present, and ammonia will be emitted from confinement buildings, open lots, stockpiles, anaerobic lagoons, and land application from both wet and dry manure handling systems.

The volatilization of ammonia from any manure management operation will be highly variable depending on total ammonia concentration, temperature, pH, and storage time. Emissions will depend on how much of the ammonia-nitrogen in solution reacts to form ammonia versus ionized ammonium (NH4 +), which is nonvolatile. High pH and high temperature favor a higher concentration of ammonia and, thus, greater ammonia emissions. The pH of manures handled as solids can be in the range of 7.5 to 8.5, which results in fairly rapid ammonia volatilization. Manure handled as liquids or semi-solids tends to have lower pH. However, there may be little difference in annual ammonia emissions between solid and liquid manure handling systems, if liquid manure is stored over extended periods of time prior to land application. Limited research in Wisconsin (Powell, 2008) found that ammonia emissions from tie-stall barns (the most common housing type on dairy farms with small to medium-sized herds) are usually lower than those from freestall barns.

Ammonia emissions are not constant over the year, but demonstrate seasonal variability. The degree of seasonal variation depends on the geographic region, animal sector, and type of animal production practices used. For example, high temperature increases ammonia volatilization. Precipitation and humidity can either increase or decrease emissions depending on how manure is managed. Higher wind speeds can increase emissions from open manure storage facilities. The population of animals on a farm also varies throughout the year, thereby changing ammonia emissions from housing and manure storage facilities.

The Midwest Regional Planning Organization[1] (MRPO) has been collecting and analyzing data on ambient ammonia concentrations in order to evaluate the potential impacts of ammonia emission reductions on levels of ambient PM2.5 and regional haze. The MRPO found that reducing ammonia emissions would be an effective strategy to reduce PM2.5 concentrations and improve visibility in the Great Lakes region.

Table 11, below lists the candidate control measures for ammonia have been identified and evaluated for their potential effectiveness. These controls were evaluated for a 3-state region (Michigan, Minnesota, and Wisconsin) and a 9-state region (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, North Dakota, South Dakota, and Wisconsin). States have made no commitments yet regarding the implementation of the ammonia control measures. The control measures are sorted in increasing order of cost effectiveness.

Table 11 - Candidate control measures for ammonia

Potential Control Measure	Potential Reduction In Overall NH_3 Inventory (%)
Vegetative buffers for concentrated emission sources	7 – 33
Vegetative buffers at the edge of the farm	9 – 21
Feed adjustments for swine	1 – 3
Feed adjustments for poultry	2 – 3
Incorporation of pig slurry by disc	1 – 3
Incorporation of poultry manure by disc	1 – 2
Incorporation of beef cattle manure	1 – 2
Incorporation of dairy manure by disc	4 – 5
Manure additives	7 – 8
Manure storage pit water cover	1 – 4
Reduce usage of nitrogen fertilizer	15 – 20
Replace urea with lower emission fertilizer	12 – 15

Another secondary effect relating to ammonia is the impact of increased nitrogen deposition from airborne ammonia and ammonium sulfates and ammonium nitrates. This has been documented in studies in the Netherlands, North Carolina, and Idaho. Effects include increased soil acidification, plant nitrogen fortification, and a tendency within the ecosystem towards degraded plant communities.

Research conducted in Wisconsin using an inverse-dispersion analysis technique found ammonia emissions from housing and manure management varied seasonally, with a linear relationship observed with the numbers of animals per farm and the total ammonia emissions. The average per year ammonia emission rate (without adding the ammonia from land application which can add as much as an additional 35%) is approximately 45 pounds of ammonia per cow per year.

[1] *The MRPO includes the states of Illinois, Indiana, Michigan, Ohio, and Wisconsin.*

Ammonia is a state hazardous air pollutant under Ch. NR 445, Wis. Adm. Code and a facility is subject to the rule if more than 0.935 lb/hr or 17,769 lbs/yr[2] of ammonia is emitted from a source. Wisconsin has an ambient air quality standard for ammonia which is 418 ug/m3 (equivalent to a concentration of 601 ppb ammonia) averaged over a 24-hour period. There are exemptions for agricultural waste from the requirements of NR 445 [current language calls for this exemption to expire after July 31, 2011 – see s. NR 445.08(6)(d)] and associated permitting requirements of Chs. 406 and 407, Wis. Adm. Code. Ch. NR 438, Wis. Adm. Code contains reporting requirements when emissions exceed 2,097 lb/yr of ammonia. The Clean Air Act lists ammonia in section 112(r)(3) and both the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Emergency Planning and Community Right-to-Know Act (EPCRA) have reporting requirements that are triggered when 100 pounds per day of ammonia (18.3 tons per year), are "released."

Hydrogen Sulfide

Hydrogen sulfide is a product of the anaerobic decomposition of sulfur-containing organic matter (primarily manure). It is a colorless gas that is heavier than air, highly soluble in water, with odor and health implications. Liquid manure storage pits (inside buildings) or basins (near barns) are the primary sources of hydrogen sulfide in animal production. Significant quantities of hydrogen sulfide can be released during agitation of stored liquid manure. (Jacobson)

Unhealthy levels of hydrogen sulfide beyond the property boundary of large animal agricultural operations have not been documented in Wisconsin and are typically not associated with dairy operations, even those with liquid manure handling systems. Problems with hydrogen sulfide have been documented in 2008 in Minnesota, where air emissions from the Excel Dairy in Thief River Falls were deemed a public health hazard.

Hydrogen sulfide is a state hazardous air pollutant under Ch. NR 445, Wis. Adm. Code and contains a threshold if more than 0.749 lb/hr (3.3 tons/year)[3] of H2S is emitted from a source. Wisconsin has an ambient air quality standard for H2S which is 335 ug/m3 (equivalent to a concentration of 240 ppb H2S) averaged over a 24-hour period. Minnesota has established air quality standards for H2S and are more restrictive than Wisconsin's. Minnesota's ambient air quality standards for H2S are 30 ppb no more than twice over 30-minute periods in 5 days and no more than two periods greater than 50 ppb.

Until July 31, 2011, there are exemptions for agricultural waste from the requirements of NR 445 and associated permitting requirements of Chs. 406 and 407, Wis. Adm. Code. Ch. NR 438, Wis. Adm. Code contains reporting requirements when emissions exceed 3,279 lb/yr of H2S. The Clean Air Act lists H2S in section 112(r)(3), and both the CERCLA, and the EPCRA have reporting requirements that are triggered when 100 pounds per day of H2S (18.3 tons per year), are "released."

Odors

Odors from CAFOs are primarily generated from the breakdown of feed in the gut of animals and in the manure after excretion. Feed, particularly silage under certain conditions, can also be a significant odor source. While there are numerous odorous compounds associated with manure, odors result from a combination of dozens, if not hundreds, of airborne compounds. These

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[2] In 2005, the Department issued guidance on the modeling demonstration method for non-exempt potential emissions from non-vertical or obstructed stacks and non-exempt potential fugitive emissions. In summary, the document suggests that for non-vertical or fugitive emissions, the lowest stack threshold be divided by a factor of 4.
[3] See footnote 2.

compounds can act synergistically to produce an odor that is actually more intense than would be expected from the sum of the individual compounds present. (Ebner, 2008)

Most of the odorous compounds that are emitted from animal production operations are by-products of anaerobic decomposition/transformation of livestock (and poultry) wastes by microorganisms. Animal wastes include manure (feces and urine), spilled feed and water, bedding materials (*i.e.* straw, sunflower hulls, wood shaving), wash water, and other wastes. This highly organic mixture includes carbohydrates, fats, proteins, and other nutrients that are readily degradable by microorganisms under a wide variety of suitable environments. The by-products of microbial transformations depend, in a major part, on whether it is done aerobically (*i.e.* with oxygen) or anaerobically (*i.e.* without oxygen). Microbial transformations done under aerobic conditions generally produce fewer odorous by-products than those done under anaerobic conditions. Compounds such as alcohols and acids may have strong odors too. Moisture content and temperature affect the rate of microbial decomposition.

A large number of volatile compounds have been identified as by-products of animal waste decomposition. The compounds are often listed in groups based on their chemical structure. Some of the principal odorous compounds, individual and as groups, are: ammonia, amines, hydrogen sulfide, volatile fatty acids, indoles, skatoles, phenols, mercaptans, alcohols, and carbonyls. Carbon dioxide and methane are odorless.

Wisconsin Administrative Code requires all sources of air emissions to regulate objectionable odors (s. NR 429.03, Wis. Adm. Code). This rule establishes general limitations on objectionable odor, defines the tests for what constitutes objectionable odor, and sets abatement or control requirements.

Particulate matter and fugitive dust emissions

Wisconsin defines particulate or particulate matter as any airborne finely divided solid or liquid material with an aerodynamic diameter smaller than 100 µm. In general, particles are identified according to their aerodynamic diameter, as either PM10 (particles with an aerodynamic diameter smaller than 10 µm), or PM2.5 (aerodynamic diameter smaller than 2.5 µm). Even low concentrations of air pollutants have been related to a range of adverse health effects. Fine particulate matter (PM2.5) is considered more dangerous since, when inhaled, PM2.5 may reach the peripheral regions of the bronchioles, and interfere with gas exchange inside the lungs (WHO, 2005).

The tiny particles classified as PM2.5 are formed by reactions in the atmosphere, or may be emitted directly to the atmosphere during combustion. Key precursor pollutants include, ammonia (principally from agricultural operations), SO_2 (principally from coal burning), NOx (principally from combustion processes) and organic carbon. The nature and sources of organic carbon are not well understood at this time. Together ammonium nitrate and ammonium sulfate represent about 60% of the mass of PM2.5. On average, organic carbon represents about 30% of the mass of PM2.5. Black carbon and crustal material together are about 10% of the mass of PM2.5.

Some times called coarse particles, the particles in the PM10 size range are generally created by mechanical action such as crushing, grinding or wind-blown dust.

To protect public health and welfare, the EPA issues National Ambient Air Quality Standards (NAAQS) for PM. This includes both PM2.5 and PM10. EPA first issued standards for PM in 1971, and revised the standards in 1987 and 1997. In September 2006, the Agency revised the 1997 standards. The 2006 primary standards tightened the 24-hour PM2.5 NAAQS from 65

$\mu g/m^3$ to 35 $\mu g/m^3$, and retained the current annual PM2.5 standard at 15 $\mu g/m^3$. EPA made the secondary particulate matter standards identical to the primary standards.

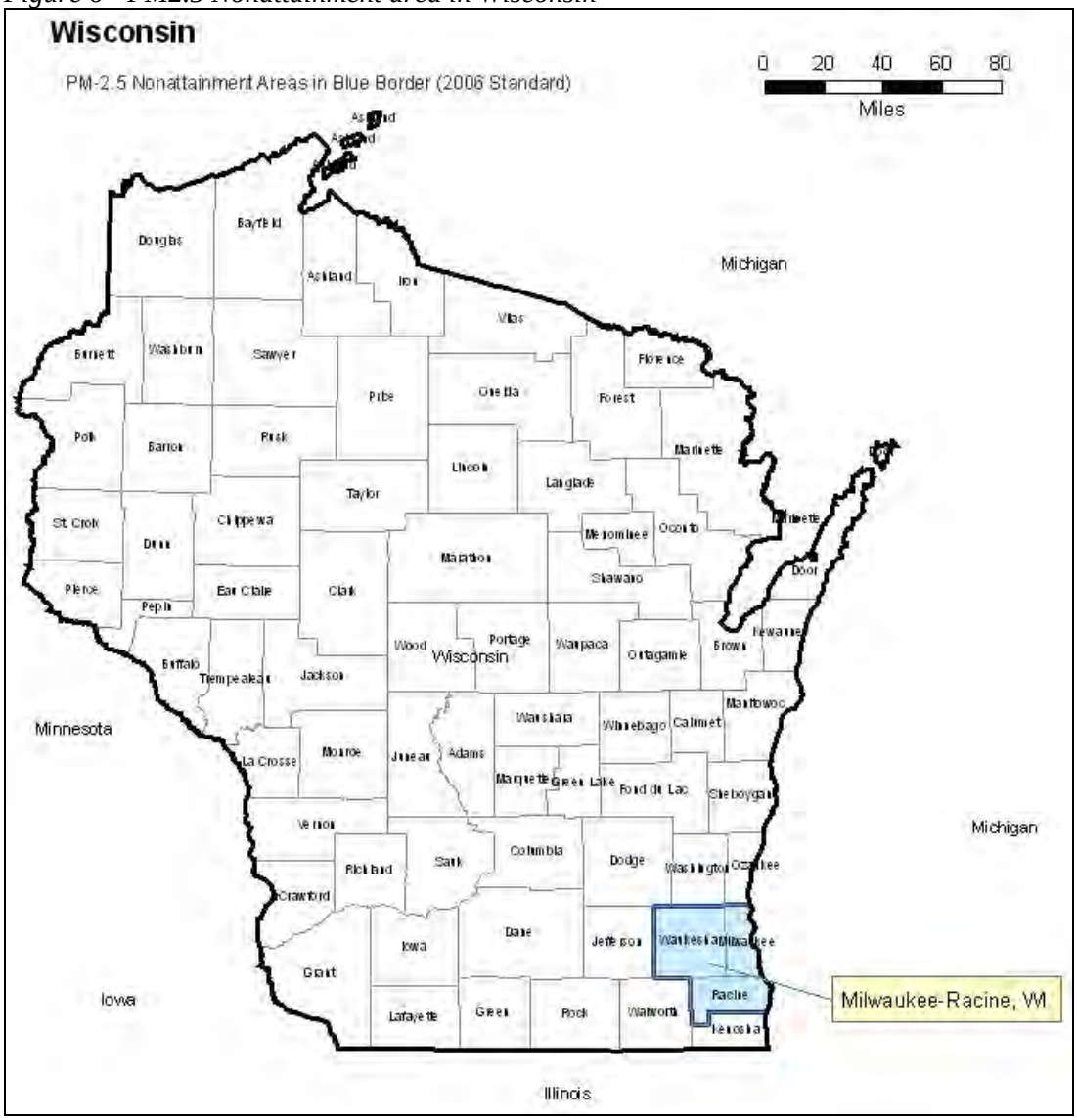
On October 8, 2009, the EPA Administrator signed a final Federal Register notice designating the three county area, Milwaukee, Racine and Waukesha, as nonattainment for the 2006 PM2.5 NAAQS.

In 2006, EPA set two primary standards for PM2.5, an annual standard at 15 micrograms/ m^3, and a 24-hour standard at 35 micrograms/ m^3. The design value for the 24-hour PM2.5 standard is equal to the average over a consecutive three-year period of the 98th percentile concentration in each year. EPA set the secondary PM2.5 standard identical to the primary standards.

In 2006, EPA set 24-hour primary standard for PM at 150 micrograms/m^3. The design value for the 24-hour PM10 standard is equal to the average over a consecutive three-year period of the 99th percentile concentration in each year. EPA set the secondary PM10 standard identical to the primary standards.

Four monitors in the state violate the 24-hour PM2.5 standard. All of the violating monitors are in Milwaukee. Based on these violations, in October 2009, EPA designated a nonattainment area for the 24-hour PM2.5 standard that includes Milwaukee, Racine and Waukesha Counties. Figure 6, below, shows the PM2.5 nonattainment area. Additionally, there are several monitors with design values within 1 microgram/ m^3 of the 24-hour standard including Madison, Green Bay and Potosi. Most other monitors in the state have 24-hour design values between 25 micrograms/ m^3 and 32 micrograms/ m^3. All areas in the state are attaining the annual PM2.5 standard and the 24-hour PM10 standard. However, two monitors in Milwaukee measure annual PM2.5 concentrations above 14 micrograms/ m^3 level.

Figure 6 - PM2.5 Nonattainment area in Wisconsin



The DC Circuit Court of Appeals remanded the particulate matter standards back to EPA. Therefore, EPA is in the process of reassessing the PM standards.

Most animal husbandry practices have low emissions of particles. However, agricultural ammonia emissions contribute to the formation of ammonium nitrate and sulfates, which are considered PM2.5. Agriculture, and particularly farm animals, is by far the largest contributor to ammonia emissions in the U.S.

Bioaerosols are a major component of the particulate matter from CAFOs. Bioaerosols are particles of biological origin that are suspended in air and include bacteria, fungi, fungal and bacterial spores, viruses, mammalian cell debris, products of microorganisms, pollens, and aeroallergens. (Dr. Thorne, U of Iowa).

Fugitive dust is defined in s. NR 415.02 (2), Wis. Adm. Code, as solid airborne particles emitted from any source other than a flue or stack. Fugitive dust can be generated from a number of sources at animal agricultural operations including: animal housing, dry lots/corrals, dry or dusty manure management; mixing of feed and management of bulk materials, traffic on unpaved roadways, and land application.

Dust is difficult to eliminate from animal housing, although a number of practices can minimize dust. It is a combination of manure solids, dander, hair, and feed. It is typically more of a problem in buildings that have solid floors and use bedding as opposed to slatted floors and liquid manure. Dust concentrations inside animal buildings and near outdoor feedlots have been measured, and range from one up to 10 mg/m3 (Curtis 1983). However, it appears that dust emission rates have not been adequately quantified from animal agricultural operations.

Wisconsin's fugitive dust rule, s. NR 415.04, Wis. Adm. Code, establishes general limitations on fugitive dust and sets specific precautions for limiting fugitive dust emissions.

VOCs & Methanol

Volatile organic compounds that contribute to odor and air quality problems have been identified and associated with CAFOs, and research has focused primarily on dairy CAFOs. VOCs are both associated with enteric fermentation and with fresh and stored manure. Rumburg *et.al.* (2005) identified 82 VOCs at a lactating cow open stall and 73 were detected from a slurry lagoon. These compounds include: alcohols, aldehydes, ketones, esters, aromatic hydrocarbons, halogenated hydrocarbons, terpenes, other hydrocarbons, amines, other nitrogen containing compounds, and sulfur-containing compounds.

It appears that the alcohols methanol (MeOH) and ethanol (EtOH) (Shaw *et.al.* 2007; Sun *et.al.* 2008) are the big components of VOCs generated at dairy animal agricultural operations. Both of these alcohols are produced in the rumen (the enteric process) and in the fresh waste primarily by gram-positive bacteria including *Streptococcus bovis* and *Ruminococcus albus* (Shaw *et.al.* 2007). In 2004, California dairy cows and their waste were estimated by air quality agencies to contribute similar amounts of smog-forming VOCs as light/medium duty trucks or light passenger vehicles within the state (SJVAPCD, 2006).

Limited research (Frank Mitlhoener, UC-Davis) suggests that methanol may be emitted from dairy operations at rates as high as 11.12 lb/cow-yr. To our knowledge, no state has made a regulatory decision based on methanol emissions nor has the EPA published or cited information to suggest this pollutant could exceed 10 tons/year (the trigger for developing a MACT (maximum achievable control technology) under s. 112(d), or determining a case-by-case MACT under s. 112(g)(2) of the Clean Air Act).

VOCs are defined in s. NR 400.02(162), Wis. Adm. Code as "any organic compound which participate in atmospheric photochemical reactions" excluding a number of compounds determined to have negligible photochemical reactivity, such as methane. VOC are a criteria pollutant and have permitting thresholds and general control requirements in Chs. NR 405, 406, 407, 408, 419 and 424, Wis. Adm. Code.

Methanol is a federal hazardous air pollutant with emission limitations covered under section 112(b) of the Clean Air Act. Any stationary source which emits or has the potential to emit 10 tons per year of methanol would be a "major source" under the Clean Air Act.

Greenhouse gases

Agriculture in general, and livestock operations in particular, are anthropogenic sources of greenhouse gas emissions. The primary GHGs associated with animal agriculture include methane (CH4) and nitrous oxide (N2O). The July 2008 report of the Wisconsin Governor's Task Force on Global Warming reports that the agriculture sector is responsible for 9% of 2003 state greenhouse gas emissions. A 2006 report by United Nation's Food and Agriculture Organization

states that the production of livestock contributes nearly 18% of worldwide GHG emissions through: the production of commercial fertilizer; the production of grain for feed; land use changes; transportation emissions; and the direct emission of greenhouse gasses by animals, animal waste, and other production processes. The Governor's Task Force report includes several recommended policies for the agriculture sector to reduce GHG emissions. Among the recommendations to reduce emissions are: nutrient and manure management changes (*i.e.* for nitrous oxides and methane); and the production, capture and combustion of animal methane.

While enteric emissions appear to be the majority of GHG emitted by livestock, GHG associated with manure management can be significant. Manure management systems which maintain anaerobic conditions (typically liquid manure systems) generate the largest amounts of GHG. Well-managed grazing systems on perennial forages have a substantial advantage over arable crops in terms of the amount of carbon potentially sequestrated and potentially minimizing the amount of GHG produced because of manure management techniques.

While GHGs are not presently regulated in Wisconsin, the EPA has finalized a rule (40 CFR part 98, subpart JJ) which contains reporting requirements for GHGs (for animal agricultural sources emitting over 25,000 metric tons of carbon dioxide equivalents from manure management activity) from large animal agricultural operations. The maximum number of head covered by the LDCAFO WPDES GP (4,000 head), is not exempt from the requirements of 40 CFR part 98, subpart JJ (exemptions are in the rule for 3,200 head).

Monitoring

Animal agricultural operations covered by this general permit are not required to have plans to do any formal environmental monitoring of odors or air emissions.

The Department lacks the authority to require air quality baseline monitoring at operations covered under the WPDES general permit. However, the Department does recognize the need for agriculture related monitoring information, and as such participated in an air monitoring study with DATCP beginning in 2005. This study assessed odors, as well as hydrogen sulfide and ammonia concentrations related to waste lagoons at six large dairy farms in different parts of the state. This final phase of the study was completed in 2009 and the final report was issued in September 2009.

Over the past several years, in response to complaints about air pollution associated with livestock operations, the Department has conducted a limited amount of ambient air monitoring for hazardous air pollutants near a variety of livestock operations. Measurements in the vicinity of farms within Wisconsin have shown peak hourly concentrations of ammonia downwind from large dairies ranging from 1 $\mu g/m^3$ to 1000 $\mu g/m^3$. However, the monitored concentrations have not exceeded the ammonia daily acceptable ambient concentration standard of 418 $\mu g/m^3$ averaged over a 24-hour period, established in ch. NR 445, Wis. Adm. Code. In addition, hydrogen sulfide has been measured downwind of dairies at levels near 100 $\mu g/m^3$, as compared to the ch. NR 445, Wis. Adm. Code's acceptable ambient concentration standard of 335 $\mu g/m^3$ averaged over a 24-hour period.

The actual off property concentrations associated with the operation of a CAFO will depend on a wide variety of conditions, including: physical layout (*e.g.* distance to the property boundary), temperature, humidity, feeding regime, and a variety of manure management practices. The Department and two Tribes measure ozone and PM.2.5 in many Wisconsin counties. Real-time air quality monitoring is available on the internet at the following link: http://dnrmaps.wisconsin.gov/imf/imf.jsp?site=wisards

Total emissions estimates

Total yearly estimates of air pollutants from animal agricultural operations are difficult to make. Table 12, below, uses Wisconsin-specific emissions estimates (for ammonia and hydrogen sulfide) for a 4000-head (5760 AU) "average" liquid manure dairy operation, including land application. Best estimates are used where Wisconsin data is not available.

Table 12 - Wisconsin ammonia & hydrogen sulfide emission estimates

Pollutant	Dairy Operations Liquid manure systems (4000 Head)
PM_{10}	8.5 tons/year[4]
VOC (volatile organic compounds)	39 tons/year[5]
NH_3 (ammonia)	175 tons/year[6]
CH_2S (hydrogen sulfide)	20 tons/year[7]
CH_4 (methane)	1,100 tons/year (including enteric) [8]
N_2O (nitrous oxide)	6.5 tons/year[9]
MeOH (methanol)	22 tons/year[10]

Health effects

Air emissions including hydrogen sulfide, ammonia and organic dust can have a detrimental effect on the respiratory health of those who work inside the confinement buildings when they are exposed to high levels for long durations. Whether those same symptoms appear in neighbors where emissions may be diluted, is unclear, although the example of Excel Dairy in Minnesota is relevant.

Even when using best management systems and mitigation techniques, some airborne contaminants may be generated. Concentrations of airborne contaminants may build up inside livestock buildings that result in animal and human health concerns. Most concerns are associated with chronic or long-term exposure. However, some human and animal health concerns or safety hazards can result from acute or short-term exposures. Table 13 lists the health effects of various CAFO-related air pollutants.

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[4] *Oregon Technical Support Document (Table 6) to the Oregon Dairy Air Quality Task Force, July 1, 2008*
[5] *San Joaquin Valley Air Pollution Control District, Determination of VOC Emission Factors, Aug. 1, 2005*
[6] *University of Wisconsin Extension average (Erb/Holmes et.al. 2009) and Powell (USDA, USDFRC) land application estimates; Harper et.al. (2008) plus land application 13% lower, but within ranges*
[7] *University of Wisconsin Extension average (Erb/Holmes et.al. 2009)*
[8] *Calculated using Tier 2 IPCC calculator with VS = 11.55 lb/hd-day, Bo=0.24, weighted MCF of 0.37 and IPCC Tier 1 enteric estimates (128 kg CH4/hd-yr)*
[9] *Oregon Technical Support Document (Table 6) to the Oregon Dairy Air Quality Task Force, July 1, 2008*
[10] *Final Report VFAs, Amine, Phenol, and Alcohol Emissions from Dairy Cows and Fresh Waste, Frank Mitloehner, et.al. UC Davis (2006)*

Table 13 - Health effects of CAFO-related air pollutants

Pollutant	Sources	Health Effects
Particulate Matter (3 sizes - Total Suspended Particulate (TSP); Particulate Matter up to 10 micrometers (PM10); and Particulate Matter up to 2.5 micrometers (PM2.5)	Grain & Feed storage and handling; animals; wind blown dust	Larger particles of TSP are mostly associated with physical soiling and considered a nuisance while PM10 and PM2.5 are associated with increased respiratory symptoms such as exacerbation of bronchitis and asthma
Hydrogen Sulfide and other sulfur compounds.	Animal manures	Hydrogen Sulfide may be associated with increased respiratory symptoms. It is also associated with odors at very low concentrations (rotten egg smell). High hydrogen sulfide concentrations can overload the olfactory senses and also cause death.
Ammonia	Animal manures and urine	Ammonia may be associated with increased respiratory symptoms. Ammonia also contributes to PM2.5 concentrations and resulting health effects of fine-particle pollution.
Volatile Organic Compounds	Animals, feeds and waste treatment	This is a general class of chemicals. There are many volatile chemicals given off, many of which have odors and some of which may have effects on the respiratory symptoms, although no one chemical has been strongly associated with symptoms off property as a result of actual exposures. Compounds include volatile fatty acids (butyric and caproic acid), that have a distinct and offensive odor. In addition to health effects of individual compounds, VOCs participate in atmospheric reactions to create ozone, which is a respiratory irritant.

The maximum off-property air concentrations expected from animal agricultural operations will typically occur along the property line, and the magnitude of the impact will decrease with distance from the property line. Due to the fugitive nature of the emissions combined with the short release heights of the barn fans and other sources, the impact of many air emissions from most animal agricultural operations should be indistinguishable from background conditions within 10 kilometers from the site (Department Air Monitoring staff personal communication, 2008).

As noted previously, ammonia emissions can contribute to secondary formation of fine particulates (with regional impact), through complex chemical reactions taking place over several hours. It has been estimated that animal agricultural operations contribution to PM2.5 concentrations in winter in the upper Midwest may be as large as 20% (Hristov, 2009).

There are few studies that have examined animal agricultural operations emissions and direct public health effects. However, national studies using county-level health data have shown that with a large scale increase in livestock farming (a 100,000 animal unit increase in a county) there is also an increase in infant mortality (Sneeringer, 2007).

Mitigating air emissions

There are ways to minimize air quality impacts from animal agricultural operations. Management practices which prevent or minimize the generation of air pollutants in the first place make sense and are often cost effective. Pollution prevention (P2) techniques can include: diet manipulation, selection of a non-liquid manure handling system (not feasible for most large animal agricultural operations covered by this general permit, because the production method often defines manure management from the start), frequent cleaning of animal housing area, selecting bedding types that physically separate feces and urine, and/or installing enclosed solids separation.

Best management practices minimize air quality impacts for any given production method. This is accomplished in three main ways: increasing dilution and dispersion; reducing emissions through capture and treatment; and, as noted above, reducing the actual generation of air emissions in the first place (P2). BMPs have traditionally focused on odor, VOC, hydrogen sulfide and/or ammonia control practices for CAFOs and have been implemented at dairy operations in Wisconsin and elsewhere.

BMPs include, but are not limited to: the use of biofilters (and other air filtration techniques) on building exhaust fans or other controllable emissions; other types of covers for manure lagoons/storage, including the formation of a crust; sequencing-batch reactors, lagoon nitrification/denitrification systems, fixed-media aeration systems; circulated phototrophic systems; forced aeration composting with biofilter; BMPs addressing land application including soil injection or incorporation of manure within a set number of hours.

It has been reported that if a combination of BMPs are used, dairies can reduce ammonia emissions by 65-70%. GHG emissions can be reduced by handling manure dry. If a liquid manure handling system is utilized, GHG emissions can be reduced with the installation and operation of an AD system to capture and combust methane emissions. Other ways to mitigate GHG emissions from animal agricultural operations include: reducing overall farm nitrogen use; avoiding anaerobic conditions for manure storage; reducing energy demand and increase energy efficiency; and regulating diet to reduce N released in the manure and reduce enteric methane.

Biofilter performance range is fairly wide, yet this BMP can reduce ammonia, hydrogen sulfide and odors from animal housing. Biofiltration can reduce both ammonia emissions and odor from animal housing and manure lagoons with impermeable covers by up to 40-50% or more.

Impermeable and permeable covers over manure storage lagoons/basins/ponds can minimize emissions from manure storage facilities. Impermeable covers are physical covers to contain emissions and trap released gases. They are regularly used in conjunction with biofilters and are generally more effective than permeable covers in ammonia mitigation. However, costs for covers vary widely depending on the material used and the method of application. Other important considerations are: 1) the length of the time the covers will be in place; 2) need for biofilters to clean (i.e., scrub) the gases trapped under impermeable covers; 3) excessive ammonia and other gaseous emissions may occur during land application; and 4) removal and clean-up of the material left behind when the useful life of the covers is over.

In some cases, BMPs focused on control practices specific for one air quality parameter may actually contribute to an increase in other air emissions or to environmental problems with other media (for example, soil injection of liquid manure potentially contributing to impacts on groundwater quality, or frequent cleaning of freestall barns to reduce VOCs resulting in an increase in ammonia emissions). Nor will all BMPs be appropriate to any given situation, or economically feasible.

ATCP 51, the Wisconsin livestock facility siting rule, provides information on the effectiveness (percent odor control) of BMPs for odor reduction from a number of animal agricultural operations sources. The odor control practices address odor control practices for prevention, capture and treatment, and dispersion.

Odor reduction measures include cleaning the housing facilities frequently, conserving water, covering feed, removing dead animals from the property within 24 hours, and notifying neighbors before agitating or spreading manure.

Ammonia abatement research in Wisconsin has shown at least three ways to reduce ammonia emissions. The first is to remove excess protein from the cow's diet. This normally saves on feed cost, as well as reducing ammonia nitrogen (and GHG) loss. Secondly, for new construction, floors that divert urine away from feces can reduce ammonia emissions. Slatted floors facilitate this. And finally, select bedding (*e.g.* sand, pine shaving) that separate feces and urine, reduces ammonia losses. These three strategies could potentially reduce in-barn ammonia nitrogen loss by 50 to 60%.

Minimizing time of manure exposure on the ground surface is the most effective strategy for reducing ammonia (and odor) emissions during or after field application of manure. While incorporation of manure may reduce ammonia emissions, the consequences of soil disturbance may lead to increased soil erosion, GHG emissions and water quality concerns.

Table 14, below, lists management practices compiled from a number of published sources and control effectiveness (percent reduction for the category of emission source) for some air pollutants.

Table 14 - Air mitigation measures & effectiveness

Air Mitigation Measures and Effectiveness[11]					
Mitigation Measure vs. Pollutant	**Odor**	**Ammonia**	**Hydrogen sulfide**	**PM**	**P2**
Animal Housing					
Diet manipulation	20% (ATCP) to 25% (Lorimor)	12-50% (Lorimor) 10-15% (Powell)	to 40% (Lorimor)	to 25% (Lorimor)	yes
Bio-filter/filtration	90% (ATCP) 40-50% (Lorimor)	9-99% (Jacobson) 40-50% (Lorimor) 9-100% (LPELP)	40-50% (Lorimor)	40-50% (Lorimor)	
Vegetable oil sprinkling (for swine only)	60% (ATCP) 40-50% (Lorimor) 10-30% (Jacobson)	10-30% (Lorimor)	10-30% (Jacobson)	40-50% (Lorimor) 50-70% (Jacobson)	
Urine-feces segregation		50% (LPELP)		to 80% (Lorimor)	yes

[11] *Jacobson – Larry Jacobson, Biosystems & Agricultural Engr and MN GEIS; Lorimor – Jeffery Lorimor, Iowa State University, and Ch. 10 Emission Control System; Iowa State Extension publication; LPELC – Livestock and Poultry Environmental Learning Center, BMPs in Reducing Loss of Ammonia into the Atmosphere, Washington State University Biological Systems Engr.; ATCP – Ch. 51, ATCP, Wis. Adm. Code; Powell – J. Mark Powell, U.S. Dairy Forage Research Center*

Binding Ammonium (w/zeolite, etc)		reductions in swine and poultry			
Fresh water flush	60% (ATCP)				
pH reduction		reductions	increases		
Treated water flush	30% (ATCP)				
Air dam (for swine only)	10% (ATCP)				
Windbreak (includes man-made berms)	10% (ATCP) 20% (Lorimor)			20% (Lorimor)	
Frequent cleaning of animal areas	10% (ATCP)				
Bedding selection		relative reductions for sand (Powell)			yes
Ozonation		15-50% (Jacobson)			
Wet scrubber/bioscrubber		8-94% (Jacobson) 22-54% (Jacobson)			
ESP				40-60% (Jacobson)	
Non-thermal plasma		to 100% (Jacobson)			
Manure Storage and Treatment					
Anaerobic digestion	80% ? (ATCP) 50-80% (Lorimor)				
Chemical or biological additives	20% (ATCP)				
Compost	80% (ATCP) to 30% (Lorimor)				
Solids separation and reduction	40% (ATCP)				
Mitigation Measure vs. Pollutant	Odor	Ammonia	Hydrogen sulfide	PM	P2
Water Treatment	90% (ATCP)				
Aeration	70% (ATCP)				
Bio-cover (straw and other mat'ls)	60% (ATCP) 60-90% (Jacobson)	40-95% (Jacobson) 17-90% (LPELC)	80-95% (Jacobson)		
Geotextile/permeable cover	50% (ATCP) 50-70% (Lorimor) 10-60% (Jacobson)	10-25% (Jacobson) 44% (LPELC) 90% w/zeolite (LPELC)	10-70% (Jacobson) 50-70% (Lorimor)		
Impermeable cover	60-80% (Lorimor) 90% (ATCP)	80-100% (LPELC)	50-80% (Lorimor)		
Rigid cover		>80% (Jacobson)			
Inflatable cover		to 95% (Jacobson)	to 95% (Jacobson)		

Floating synthetic		45-90% (Jacobson)			
Natural crust	70% (ATCP) 60-85% (Jacobson)	75-90% (Jacobson) 24-32% (LPELC)	N/A (Jacobson)		
Clay balls	60-90% (Jacobson)	N/A (Jacobson)	80-90%(Jacobson)		
Temperature control		to 50% (Jacobson)			
Bottom fill	10% (ATCP)				
Windbreak (includes man-made berms)	10% (ATCP)				
Open lots/corrals					
Frequent Cleaning	60% (ATCP)				
Drag animal lot	50% (ATCP)				
Animal lot moisture control	20% (ATCP)				
Windbreak (includes man-made berms)	10% (ATCP)				
Dust control plan					
Land Application					
Injecting (slot)	50% (Jacobson) 50-60% (Lorimor)	80-92% (LPELC) 50-60% (Lorimor)	50-60% (Lorimor)		
Additives					
Timing					

Alternatives affecting air emissions

Given that the general WPDES permit will cover a number of animal management scenarios, it is important to note that liquid manure systems for large animal populations will create the greatest air quality impacts either on a per farm operation basis or on a per animal basis. USDA reports that odor and ammonia emissions are less in well-managed grazing systems when compared to confinement systems which co-mingle urine and dung in a liquid or slurry manure system. Well-managed grazing systems can also cause improvements to soil quality from organic matter or soil carbon accumulation in contrast with row crops, especially corn silage that return little in the way of root or aboveground biomass to the soil. (USDA NRCS Technical Note No.1, May 2007)

Air management authorities & regulatory approach

Under the federal Clean Air Act, new and existing major stationary sources of federally regulated air pollutant emissions are subject to federal air permit requirements. Included are permit requirements under the federal “Prevention of Significant Deterioration” and “Non-Attainment Area” New Source Review programs, along with the applicable requirements for “Best Available Control Technology”, and “Lowest Achievable Emission Rate” technology and offsets, respectively. Emissions associated with agricultural waste are not categorically exempt from these requirements.

Under the federal Clean Air Act, 188 hazardous air pollutants are regulated through National Emission Standards for Hazardous Air Pollutants (NESHAPs) established by industry sector. No such standards have been established specifically for agricultural waste. Furthermore, ammonia

and hydrogen sulfide, two air pollutants associated with agricultural waste, are not regulated as federal hazardous air pollutants under section 112 (b) of the Clean Air Act. However, section 112 (r) (prevention of accidental releases) does include both ammonia and hydrogen sulfide. In addition, section 112 (b) of the Clean Air Act includes methanol and stationary sources which emit more than 10 tons per year meet the definition of major source under section 112 (a) (1).

Hazardous air pollutants associated with agricultural waste are regulated under the federal Comprehensive Environmental Response, Compensation, and Liability Act, and the federal Emergency Planning and Community Right-to-Know Act. These federal regulations include reporting requirements (100 pounds per day of ammonia or hydrogen sulfide) for releases of hazardous air pollutants to the air.

A federal consent agreement finalized in 2005 sets forth the framework for a federal air monitoring study and establishes a timeline for participating animal feeding operations to achieve compliance with federal air permit, air emission control, and air emission reporting requirements. Over 2,500 animal feeding operations located across the US have signed on to this consent agreement with the US Environmental Protection Agency. The extension of the compliance deadline to July 2011, for compliance with state hazardous air pollutant requirements, aligns with the timeline for compliance established in the 2005 federal consent agreement for animal feeding operations. Assuming timely federal action, the consent decree deadlines would occur in Fall 2010 and Spring 2011.

While there appear to be few directly relevant federal air quality permitting requirements, there are a number of relevant state rules which may apply. In summary, Wisconsin air-related regulations regarding animal agricultural operations include the following:

- Air emission limitations from s. NR 415.04, Wis. Adm. Code, covering fugitive dust sources

- Air emission limitations from ch. NR 445, Wis. Adm. Code, regarding control of hazardous pollutants

- Odor control requirements may be imposed by order of the Department if it determines that a violation of s. NR 429.03 – Malodorous Emissions, Wis. Adm. Code, occurs.

- Potentially applicable permitting thresholds are contained in s. NR 406.04(2)(c), Wis. Adm. Code (construction permits); s. NR 407.02(4), Wis. Adm. Code (operation permits), and s. NR 405.02(22)(a)2, Wis. Adm. Code (prevention of significant deterioration).

- Chs. NR 406, 407, and 445, Wis. Adm. Code, contain provisions that allow a source to exclude emissions of hazardous air contaminants (ammonia and hydrogen sulfide) associated with agricultural waste in determining the need for an air permit until July 31, 2011. These provisions apply to hazardous air contaminants only and do not apply for criteria pollutants such as PM or VOCs or to PSD major source permitting thresholds contained in Ch. NR 405, Wis. Adm. Code.

- Emissions reporting requirements contained in Ch. NR 438, Wis. Adm. Code.

Air permits are required for air pollution sources above permitting thresholds. In Wisconsin, however, such permits have traditionally focused on industrial sources, even though DNR Air Management has issued permits to animal agricultural operations, including manure drying operations, diesel generators, and other emissions sources.

However, air permits have not been issued to animal agricultural operations based solely on emissions from animal waste based on language contained in s. NR 445.08(6) (d), Wis. Adm. Code. Agricultural waste as defined in ch. NR 445, Wis. Adm. Code (Control of Hazardous Pollutants) means "livestock manure, wastewater contaminated with livestock manure, animal waste by-products and litter and bedding material contaminated, derived or mixed with livestock manure."

Emissions of criteria pollutants (PM10, nitrogen oxides, sulfur dioxide, carbon monoxide, total VOCs) from agricultural waste are not covered under ch. NR 445, Wis. Adm. Code. Other emission units at CAFOs may be subject to ch. NR 445, Wis. Adm. Code or a federal New Source Performance Standards or NESHAP (like a spark ignition engine burning biogas) because they do not meet the definition of agricultural waste or are covered by another exemption.

In summary, Chs. 406 and 407, Wis. Adm. Code (State minor source construction and all operation permits) include thresholds of 9 lb/hour for CO and SO2; 5.7 lb/hr for PM, NOx, and VOC; and 3.4 lb/hour for PM10. Ch. NR 405, Wis. Adm. Code (major source permits) contain a threshold of 250 tons per year of any pollutant regulated under the Clean Air Act, which includes ammonia. Stationary sources (excluding agricultural waste sources until July 31, 2011) which emit 100 tons per year or more of any air contaminant (including ammonia), would be a major source as defined in Ch. NR 407, Wis. Adm. Code.

Wisconsin has delayed application of Ch. NR 445, Wis. Adm. Code to agricultural operations until EPA emission factors are released pending the results of a national emissions study on animal agriculture. The EPA-led national CAFO monitoring effort is nearing completion of the two year study designed to measure emissions from a variety of concentrated animal operations around the country, with the intention of developing verifiable emission factors to be applied to the industry. The EPA timeline is to complete data collection in late 2009, evaluate the data, and release a final report and emission factors by July 2011.

Information describing criteria and hazardous air emissions from animal agriculture, including dairy operations, is available in studies done internationally, nationally, and in Wisconsin. There is, however, no final guidance from EPA regarding quantification of emissions from dairy and animal agricultural operations.

Despite the lack of established emissions factors for animal agricultural operations at the federal level, some states have addressed air quality issues at animal agricultural operations. Both California and Idaho have been issuing air quality permits to larger dairy operations and have taken different approaches based on many factors including air quality nonattainment issues for California's major dairy production areas. Both states (and others) have focused efforts on developing and evaluating BMPs to mitigate impacts to air quality. BMPs have addressed odor, ammonia, VOC and/or PM control practices. To our knowledge, emissions from dairy operations have not been regulated nationally under the New Source Review Prevention of Significant Deterioration permitting program. Additionally, we have not fully evaluated either the rationale for these other states decisions or the appropriateness of their permitting thresholds.

The Department has not adopted the methodology or programs of other states with regard to animal agricultural operations and air quality permitting. Instead, the Department has decided to coordinate its work in this area with the outcome of EPA's national concentrated animal feeding operations monitoring effort, which includes two Wisconsin farms.

The Air Management Program is moving forward on this important environmental issue concurrently with the national monitoring study and in coordination with the DATCP. Regulatory

decisions on permitting, applicable standards and ways to mitigate the impact on the environment from animal agriculture emissions will need to consider the type and size of these operations, as well as the results of the national emissions study.

V.A.6. Habitats, flora & fauna

It is the Department's experience that CAFOs typically are located in agriculturally-dominated parts of the state. This also makes intuitive sense for a number of reasons. First, many existing CAFOs are expanded versions of previously smaller farms. Many dairy operations have expanded over 1000 animal unit limit and have required permitting as CAFOs. Secondly, siting new CAFOs in agricultural areas makes economic sense because the feed, bedding and manure spreading lands are readily available in such areas, and because there is little need to remove woody vegetation. Finally, it is easier to site new CAFOs in areas with agricultural zoning, agricultural land use, and an agriculturally-based economy.

Impacts to flora in the vicinity of CAFO production sites are typically minimal since these sites usually are constructed on agricultural land. The flora acclimated to these land use practices, agricultural crops and weedy annual and perennial plants, are capable of tolerating these disturbed conditions. In the short-term, the land use change at CAFO sites will not alter the associated flora significantly in the surrounding area since the primary land use in the area is typically agricultural. Over the long-term, agricultural crops will still tend to be dominant in these areas.

The presence of a CAFO in any given agricultural area will tend to maintain the rural, agricultural character of the area as rural residential development would likely not occur there. Agricultural open lands do support common species of wildlife since many wildlife species have adapted to agricultural land use. These open landscapes are very important to wildlife species such as northern harrier, upland sandpiper and short-eared owl. Loss of agricultural land would have negative consequences to wildlife species such as ring-necked pheasant, white-tailed deer, vesper sparrow, mourning dove, horned lark and killdeer. The primary use of agricultural fields by wildlife is foraging for food, such as insects, weed seeds and waste grains.

The impact of losing a relatively small number of acres of cropland to CAFO production sites typically has little impact on local wildlife species because of the abundance of similar cropland habitat and the more desirable habitats in the agricultural areas in which CAFOs tend to be located.

The primary potential habitat and wildlife impacts are related to water quality associated with the production and handling of manure and process wastewater at proposed operations. Nitrogen, phosphorous, and pathogens associated with manure and process wastewater produced at livestock operations can have detrimental impacts on groundwater, surface waters and wetlands if not properly stored, handled, and land applied. Phosphorus and nitrogen in manure and other sources of nutrients that are applied to cropland to produce feed for livestock can also be a source of detrimental impacts to groundwater, surface waters and wetlands. Nitrogen in the form of ammonia is toxic to fish. Phosphorus in surface waters promotes algae growth through the process of eutrophication, which can result in decreased oxygen levels, and fish kills. Another direct impact is phosphorus enrichment of water bodies. Phosphorus stimulates the growth of algae and other aquatic plants. When a water body becomes overly phosphorus enriched, algae can cloud the water in dense blooms, reducing light penetration so that rooted aquatic plants, which provide good fish habitat, struggle to survive.

The dense algae blooms seen on many Wisconsin lakes are the result of excessive nutrient enrichment. Some blooms are harmless green algae blooms but sometimes the excessive nutrients in lakes stimulates a blue-green algae (cyanobacteria) bloom. Blue-green algae can produce a

variety of different toxins which can make the water unsafe for humans, pets, and wildlife. More information on blue-green algae can be found at: http://dnr.wi.gov/lakes/bluegreenalgae/

In streams, the algae can form dense blooms or mats on the stream bottom, making it unsuitable for many organisms. When nuisance algae blooms die and decompose, dissolved oxygen depletion can occur.

Biochemical oxygen demand associated with manure and process wastewater can consume oxygen in surface waters and contribute to fish kills. Soil erosion associated with crop production can result in sedimentation in roadside ditches and wetlands. Soil erosion can also alter streambed elevations which can increase the probability and severity of floods. Sediment can also destroy or degrade aquatic wildlife habitat and damage commercial and recreational fisheries.

Manure and process wastewater releases associated with land application may result from accidents in route to a spreading site, equipment failure at the site, or runoff from misapplication of manure.

One potential way for a discharge to occur is for a truck hauling manure to have an accident, resulting in a manure spill. However, depending on the site characteristics, volume spilled, and timeliness of emergency response, this does not necessarily pose an immediate risk to the aquatic environment. If the spill is not near a waterway, wetland, or flowing ditch and the manure is promptly contained and removed, there may be very little or no off-site environmental risk. On the other hand if the spill discharges into a stream, wetland, or flowing ditch, it may be difficult to contain and could pose a serious risk to water quality and aquatic organisms.

Once at a spreading site, another potential way for a manure spill to occur is from stuck or broken valves or transfer piping, and human error. Again the level of environmental risk from such a spill is determined by the volume of spill, site characteristics, and adequacy of emergency response.

Manure can also reach surface waters as a result of field runoff. Typically manure is either surface applied and tilled into the soil or directly injected into the soil six to eight inches below the surface. These methods of manure incorporation significantly reduce the potential for it to be picked up by surface runoff and delivered to nearby surface waters. Under some circumstance manure can be safely surface applied without incorporation.

Opportunities for containing manure discharged from field runoff are limited since manure usually isn’t detected until it reaches a stream where its odor, color, and possibly the presences of dead or stressed fish, are observed and reported.

If manure is applied in a manner inconsistent with the nutrient management plan, the risk of discharge to nearby water bodies increases. Land application of manure as part of nutrient management plans is more fully discussed elsewhere in this document.

Finally, while it is a rare situation, manure releases can occur from failure of the manure storage structure itself. A properly engineered, constructed, and managed manure storage structure poses little risk to water quality. However, as with any man made structure, there is a remote possibility of failure. The structural failure of a side wall of a manure storage lagoon could result in a large volume of manure reaching the intermittent and perennial stream channels near a facility.

Regardless of whether manure is released in a spill or from field runoff, spill events have a strong potential for significant, direct, negative impacts to the aquatic environment. The greatest concern is from acute ammonia toxicity and high BOD, which results in rapid depletion of dissolved oxygen, causing asphyxia of aquatic organisms. Ammonia toxicity and oxygen depletion

typically associated with manure spills is lethal to fish, aquatic insects, snails, crayfish, mussels, and certain life stages of amphibians at the discharge site and for some distance downstream.

The over application of manure during land spreading could lead to offsite runoff of nutrients to wetland and drainage systems. Excess algal blooms would be detrimental. This would have negative consequences to wildlife species that utilize these wetland and drainage systems which provide excellent brood-rearing cover and habitat for mallard, wood duck and blue-winged teal, and habitat for aquatic invertebrates which the ducklings utilize for their high protein life requirements.

Manure solids may be trapped within wetlands closest to the discharge site. The liquid portion moving downstream could still contain high levels of ammonia, dissolved phosphorus, pathogens, and BOD. Dilution and degradation of the toxic components of the spill will occur as it moves downstream.

The over application of manure during land spreading could lead to offsite runoff of nutrients to wetlands and drainage systems which could negatively impact wild rice production in wild rice waters. Excess algal blooms would reduce or eliminate germination of wild rice seed.

Another kind of long term effect is from continual, low level, chronic discharges of manure or its constituents. The slow, steady, or episodic discharge of ammonia, BOD, and phosphorus has more potential to cause long term impacts than a single manure release. Long term changes in aquatic species can result from chronic discharges of phosphorus and sediment by producing conditions that favor pollution tolerant organisms. These organisms can tolerate phosphorus enriched, low dissolved oxygen environments. Ultimately, chronic discharges of phosphorus, sediment, and oxygen demanding materials can produce long term impairment of water quality, habitat, and the biological community of water bodies.

Acute toxicity for aquatic organisms is the most obvious short term effect resulting from a manure release. Once the toxic components are no longer in the system, aquatic organisms will begin to recolonize the impacted area. In most situations there will be nearby unimpacted areas that serve as a source of organisms for recolonization. The length of time it takes to recolonize will vary depending on the degree of initial impact and proximity of refuge areas. Organisms most tolerant of poor water quality and habitat will be the first to recolonize, while other less tolerant species will take longer to become reestablished. It could take from a few months to several years to fully recolonize an area impacted by a manure release.

Long term impacts from a single acute spill are unlikely to persist for more than one or two years, depending on the degree initial of impact and the kind of organisms affected. With a single release event, the manure and its resultant impacts will pass through the system or degrade in place to a level that is no longer detrimental to aquatic organism or water quality. As noted in the prior section, aquatic organisms will begin to recolonize the impact zone as soon as water quality begins to improve.

The deposition of organic matter from a single manure release can result in long term impact through on-going suppression of dissolved oxygen concentrations and from deposits of soft organic matter on stream beds. As the organic portion of the manure decomposes over time, dissolved oxygen is consumed and phosphorus formerly bound in cellular material is released. This can then serve as a long term nutrient source for the receiving water bodies.

The basis of the WPDES permit program is to require CAFOs to implement BMPs to avoid or minimize potential impacts to the environment, including surface water quality and quantity. This is accomplished through: 1) the review of structures and systems associated with manure and

process wastewater storage/handling; 2) the review of an operation's NMP that details how, when, where and in what amounts manure and process wastewater from the operation will be landspread; 3) issuance of a WPDES permit that outlines operational requirements for the storage, handling and land application of manure and process wastewater; and 4) review and oversight of the CAFO once it is operating, which includes conducting oversight inspections and pursuing enforcement action when needed to obtain permit compliance and address water quality impacts.

CAFOs are not allowed to discharge pollutants from the CAFO production area (*e.g.* manure and process wastewater storage structures, feed storage areas, animal housing areas) to navigable waters, except under certain conditions where additional protection for surface waters is provided. In order to prevent discharges and protect surface waters, means of collecting manure and process wastewater, leachate, and runoff from feed storage areas along with runoff and stormwater from impervious surfaces must be designed to meet or exceed the applicable regulatory requirements. Strict adherence to nutrient management plans will also tend to minimize the risk of manure discharges to surface waters. All of the potential impacts on water quality, habitat, and biological communities described above will not be increased above current conditions if there are no new acute or chronic releases of manure.

If the nutrient management plans are implemented correctly impacts to local flora should be minimal since the acreages used for land spreading are typically active agricultural land. These areas will likely continue to be cropped in conjunction with land spreading at appropriate times. Changes in vegetation are not expected to be significant as a result of land spreading manure. With the addition of the manure, weedy species that thrive in high nutrient environments may increase but would typically be eliminated through the process of preparing fields for future crops.

Lighting at production sites likely attracts more insects, and consequently, attracting foraging bats to these sites. Primary bat species would include both little brown bat and big brown bat. These sites would also be more attractive to insectivorous passerine bird species such as the common nighthawk.

One of the documented consequences of night lighting is the deaths of migratory birds around tall lighted structures. Since birds migrate at altitudes of several hundred to several thousand feet and CAFO facilities are not typically that tall, lighting at CAFO sites is not expected to have any impact on migratory birds. The effect of artificial night lighting on the behavior and ecology of other species is not as thoroughly studied so it is unknown if there might be any effect on other species from night lighting. Sources of additional information about the biological and ecological effects of night lighting can be found at:
http://www.flap.org/new/Effect%20of%20Light%20Reduction%20on%20Collision%20of%20Migratory%20Birds.pdf or http://www.urbanwildlands.org/nightlightbiblio.html

Wildlife contact with livestock, especially local white-tailed deer population, could lead to possible disease transmission such as bovine tuberculosis. To limit potential disease transmission, facilities could construct perimeter fencing (ideally 10 feet high) for biosecurity reasons, and secure all livestock feed so it is inaccessible to wildlife.

Animals in the vicinity of production sites run the risk of mortality from truck traffic and falling into the manure pits. Mesh fencing about two feet high from ground level would help to prevent wildlife from falling into manure storage pits, especially reptiles and amphibians migrating from their breeding area wetlands to their upland foraging areas.

There should be minimal impacts to listed species that may occur in the vicinity of individual project areas as these lands typically do not support the requisite habitat, or land conversion has

already occurred through decades of farming. Land spreading activities on pasture lands may be intermittently disruptive to grassland bird species. Many grassland bird species are rare in the state. The timing of spreading activities for sites with sensitive species could be adjusted to avoid nesting seasons.

Secondary or indirect effects are those resulting as a consequence of the initial, direct impacts. For example, many of the organisms directly impacted by a manure discharge are food for other organisms. Altering the food chain may produce secondary impacts on a number of other species. Secondary impacts will be more obvious for terrestrial organisms, such as raccoons, that feed on aquatic organisms like mussels and crayfish.

Long term, preservation of local agricultural land though continued agricultural use will tend to slow rural residential development. The mosaic of cropland, grassland, wetland and woodland provides habitat for a rich diversity of wildlife species. It is essential to maintain the quality and quantity of these habitat types. Proper management of habitat types will ensure future generations enjoyment of this wildlife resource. Impact to local wildlife resources may result from the loss and/or degradation of the quality of different habitat types. Should excess nutrient and sediment runoff occur, the quality of local wetlands and wildlife species diversity would also likely decline.

The following summary is from DNR's Land Legacy Report (Pohlman, Bartelt, Hanson, Scott and Thompson (editors), 2006, *Wisconsin Land Legacy Report; An inventory of Places to meet Wisconsin's future conservation and recreation needs*. WDNR, Madison, WI).

Farming practices can adversely impact lands and waters and the habitats that support the state's native plants and animals. Although dramatic improvements have been made in many watersheds, non-point pollution from some farms continues to degrade waterbodies. Pesticides and fertilizers have contaminated groundwater and some drinking water sources. Intensive corn-soybean rotations have replaced fields of small grains and pasture and thus displaced many grassland-dependent species. History has shown that these are solvable problems. What farms provide, even farms that adversely impact some natural resources, are large blocks of undeveloped rural land—a critical component to meet conservation and recreation needs.

Farmers benefit when they have some level of assurance about the future: that an adequate amount of farmland will be available in their area, that an adequate farm base will be maintained to support the local farm service industry, and that their ability to go about day-today farming operations will not be impaired by new residential or commercial (non-agriculture related) developments. The agricultural and conservation communities share many goals, but maybe the most important is the desire to maintain large areas of open space. Future efforts to protect places to meet conservation and recreation needs might prove most effective if they are dovetailed, where appropriate, with efforts to protect areas most important to maintaining an agricultural economy in the state.

Farmland provides many benefits to conservation and recreation lands, but it is not a one-way relationship. Conservation and recreation lands can provide many benefits to farmland, too. Just as farms can buffer and ease the transition from natural areas to developed areas, lands devoted to conservation and recreation uses can help minimize conflicts between developed areas and farmland. As residential development becomes more and more scattered through a farming community, for a variety of reasons, many farms are slowly "squeezed out." One solution may be to target the protection of places to meet conservation or recreation needs in a way that helps buffer important farming areas. (DNR Land Legacy Report).

Forest lands

Figure 7, below shows forest coverage and ownership in Wisconsin.

Figure 7 - Forest coverage and ownership

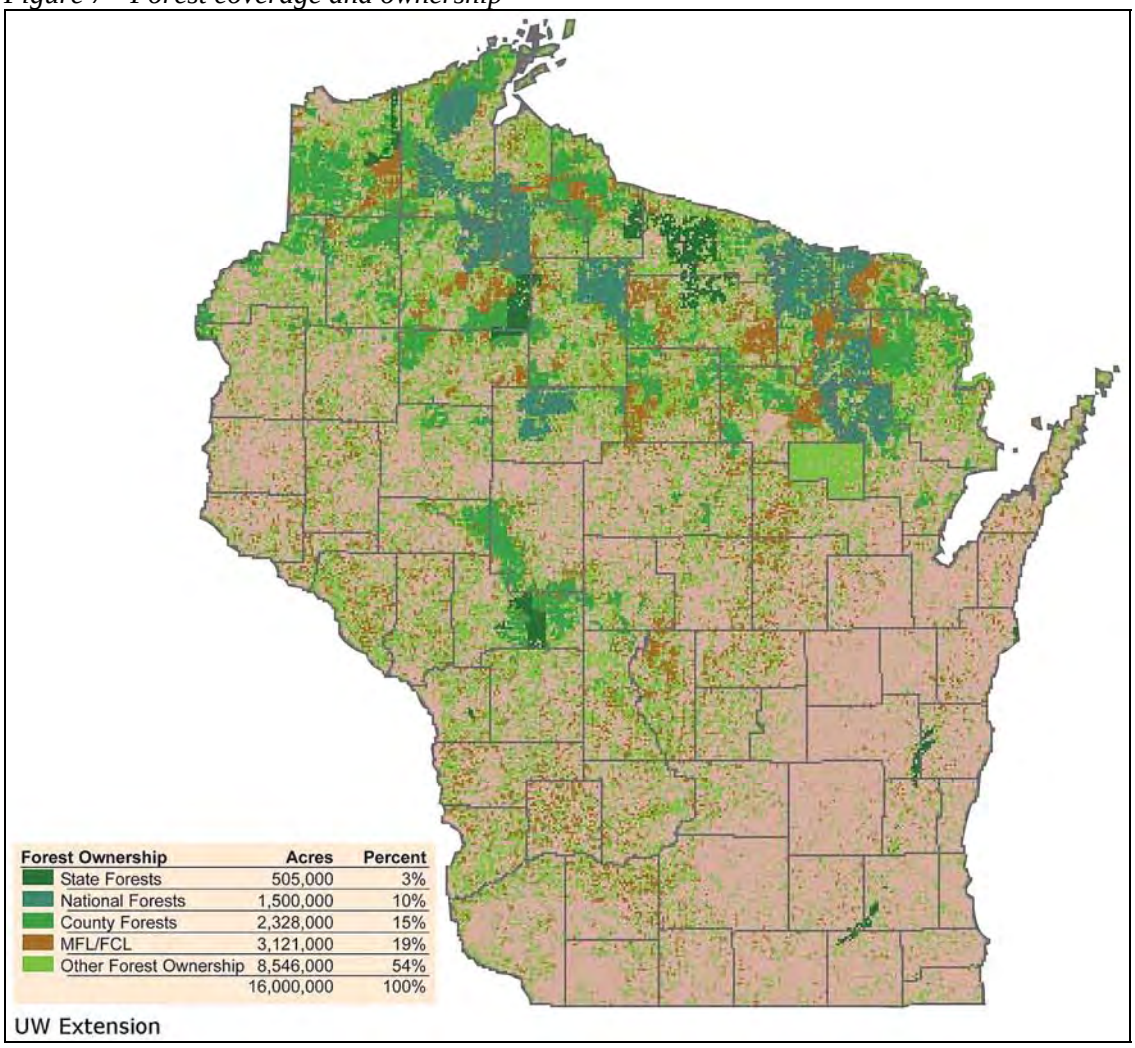
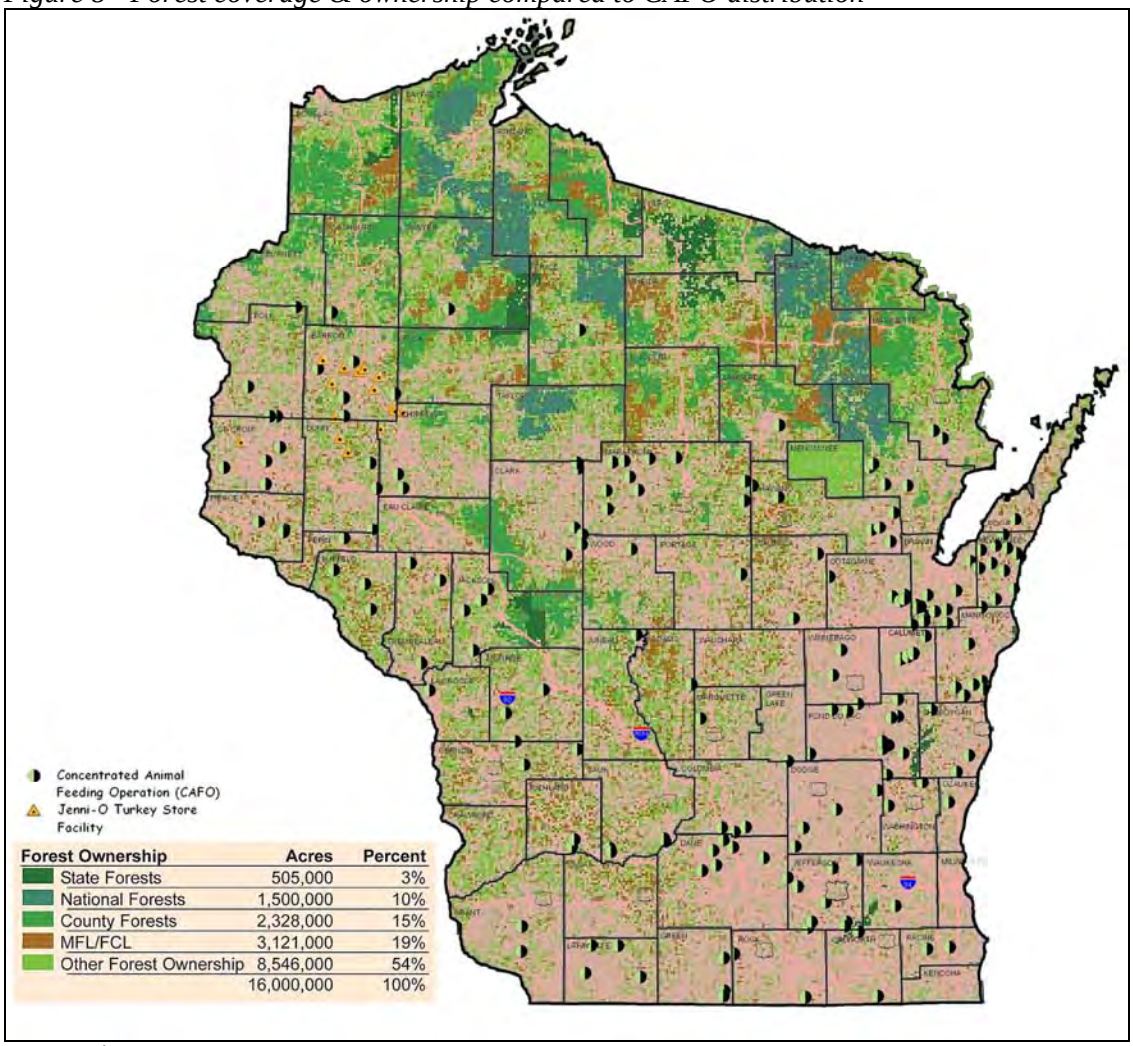


Figure 8, below shows forest coverage and ownership compared to the current distribution of CAFOs (see Figure 1 - Geographic Distribution of CAFOs in Wisconsin in Section IV.B.1). Because this is a statewide map and because of the map symbols used for point locations, apparent proximity of data points cannot be interpreted as the points being at the same location. It is apparent from this figure that CAFOs have tended to have been located in non-forested areas. It is likely, therefore, that CAFOs have little direct impact on forest lands and resources. The Department's experience in CAFO permitting is that CAFOs generally locate on agricultural lands that do not require clearing prior to use.

Figure 8 - Forest coverage & ownership compared to CAFO distribution

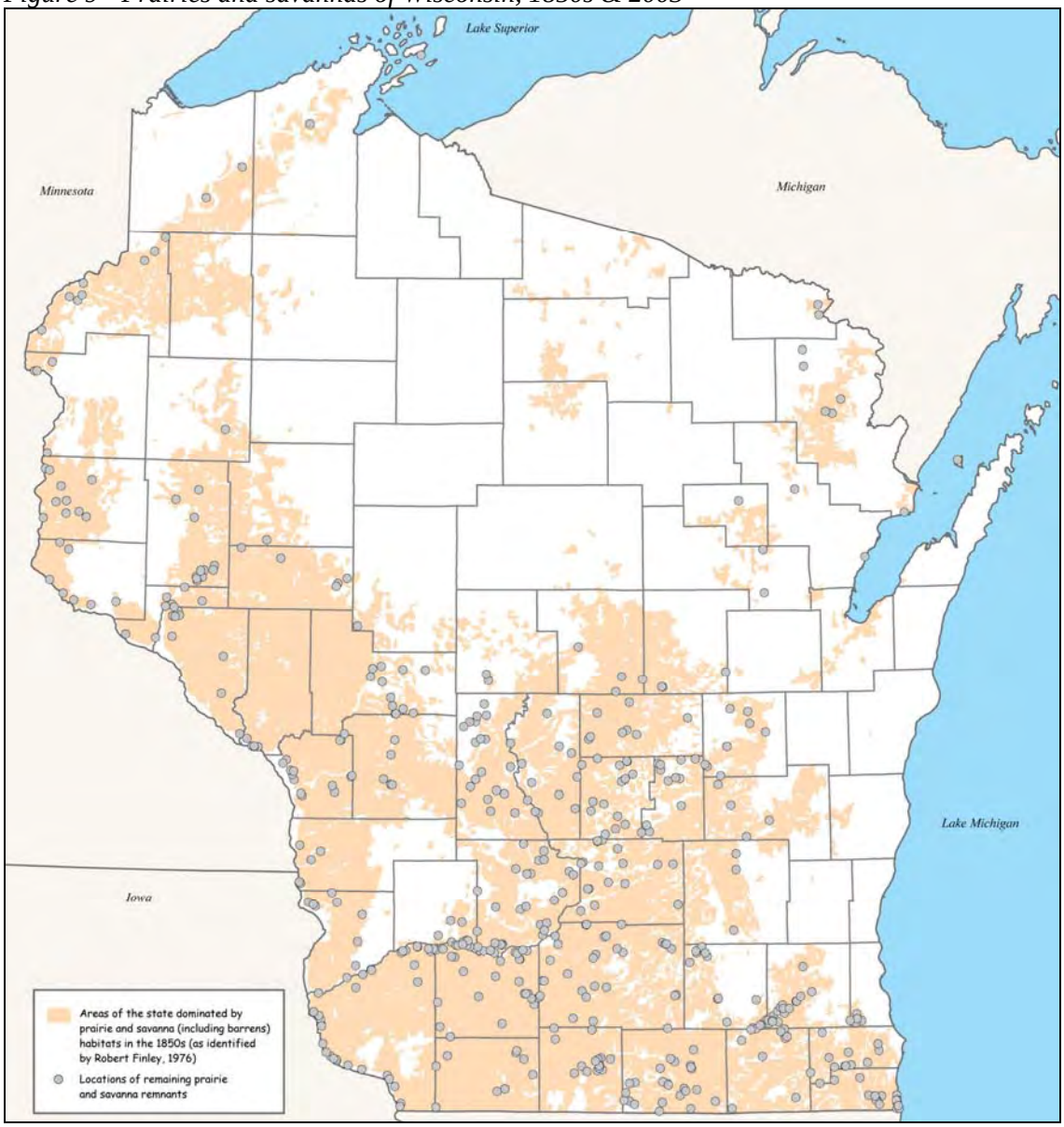


Not to scale

Prairies

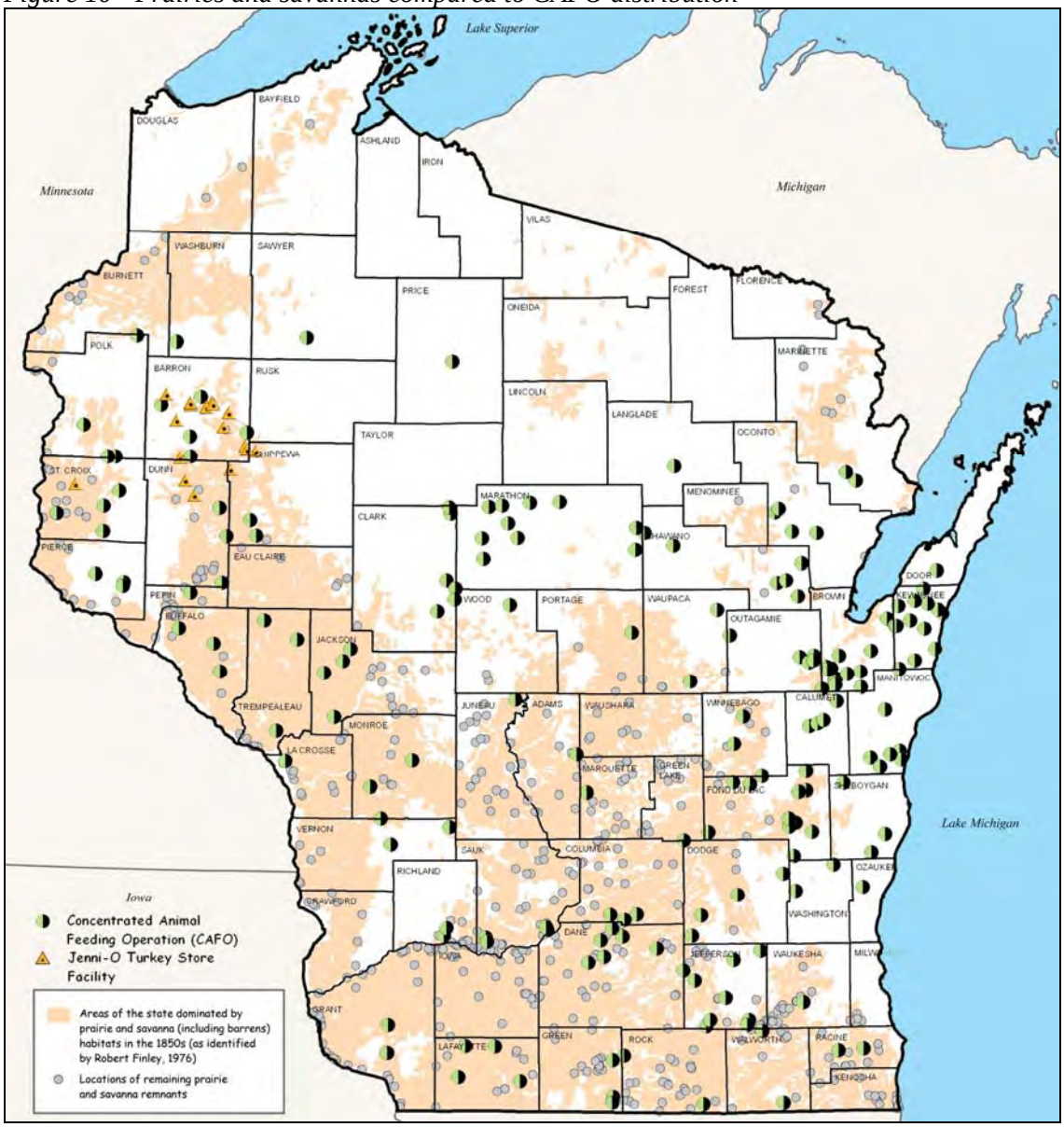
Approximately 2,000 acres of prairie remain in Wisconsin (0.1% of the original acreage) most of which is either quite wet or dry. Of the intermediate type, the "mesic prairie," only about 100 acres of an original one million remain and these are in small (often linear), scattered parcels of a few acres at best. Of the oak savanna communities, an estimated 10,000 acres of oak and pine barrens remain (0.25% of the original) and 500 acres of oak openings (less than 0.01% of the original). Prairies and oak openings are widely regarded as two of North America's most endangered natural communities. Yet, despite this massive land use change, many prairie and savanna animal species adapted to the agricultural-dominated landscape by making use of "surrogate" habitats. Many birds, mammals, and herptiles were able to maintain their populations at relatively stable levels by utilizing these modified habitats (DNR Land Legacy Report) Figure 9 shows the historical and current prairies in the state.

Figure 9 - Prairies and savannas of Wisconsin, 1850s & 2003



The point data (prairie locations) in Figure 9, above, can be compared to the point data in the CAFO distribution (see Figure 1 - Geographic Distribution of CAFOs in Wisconsin in Section IV.B.1). This overlay is shown in Figure 10, below, and shows that CAFOs exist in proximity to some existing prairies. Because this is a statewide map and because of the map symbols used for point locations, apparent proximity of data points cannot be interpreted as the points being at the same location.

Figure 10 - Prairies and savannas compared to CAFO distribution



Not to scale

In the 1950s and 1960s, though, many farms adopted more intensive agricultural practices in response to changing agricultural economics. Pesticides were applied with increasing frequency, small grain and pasture acreage were extensively converted to row crops, and the nature and timing of agricultural disturbances, notably the early and frequent mowing of alfalfa, changed. An unintended consequence of the widespread adoption of more intensive farming practices is what has become decades-long population declines for several prairie and savanna vertebrate species.

Threats to the future survival of our native prairie and savanna flora, fauna, and remnants includes continued loss of remnants (both high quality sites and those moderately degraded by grazing) due to:

- rural home development
- conversion of traditional prairie pastures (unplowed but grazed prairie) to crops, and
- drainage and conversion of wet prairie to farming

These threats may be related to many forms of agricultural operations, including CAFOs.

Surrogate grasslands

Agricultural crop and pasture lands provide habitat for many kinds of wildlife. These lands are referred to as surrogate grasslands in the DNR Wildlife Action Plan (WAP). The following discussion of surrogate grasslands is from the WAP (http://www.dnr.state.wi.us/org/land/er/wwap/).

Of the 2.1 million acres in Wisconsin that were native prairie when Europeans arrived 150 years ago, less than 10,000 acres (<0.5% of the original acreage) of varying quality native prairie remains today. The midcontinental grassland biome has been greatly reduced and degraded throughout its range, generally from farming and grazing and conversion to woody vegetation with the cessation of fires, but also from urban and suburban development. Tallgrass prairie and related oak savanna are now the most diminished and threatened plant communities in the Midwest and among the most altered in the world. As a result, an estimated 15-20% of the state's original grassland flora is now considered rare. Grassland mammals and birds have fared somewhat better, using surrogate grasslands such as hayfields and pastures for their survival needs. However, with conversion from pastures and hayfields to more row crop agriculture, some grassland birds and mammals have also been dramatically declining over the last 30 years. For example, grassland birds as a group are the fastest declining bird group in the state.

Surrogate grasslands now represent the vast majority of grassland habitat in the state. Surrogate grasslands are similar in structure to the former prairies that occurred in Wisconsin. Surrogate grasslands include agricultural habitats such as hayfields, small grains (oats, wheat, and barley), row crops (corn, soybeans, and potatoes), fallow fields, old fields, pastures, and set-aside fields (*e.g.* CRP) planted to non-native cool-season grasses (such as smooth brome, timothy, red-top, orchard-grass, bluegrass, and quack-grass) or native warm-season grasses (such as big bluestem, little bluestem, Indiangrass, switchgrass, and sideoats grama). Examples of other surrogate prairie grasslands include young conifer plantations, orchards, parks, golf courses, airports, roadsides, cut-over or burned-over forests, and mossed bogs (bogs from which sphagnum moss has been removed commercially). Surrogate grasslands also include other idle grasslands, such as those on public or private lands managed for wildlife. Usually, idle grasslands are composed of non-native grasses and forbs, but they also can be plantings of one or several native prairie species, but fall far short of the rich species diversity of the original prairie.

Surrogate grasslands occur in every ecological landscape in Wisconsin; however the highest concentrations of surrogate grasslands are in the Western Prairie, Western Coulee and Ridges, Southwest Savanna, Central Sand Plains, Northwest Sands, and Southeast Glacial Plains Ecological Landscapes. It is estimated that roughly 3 million acres of agricultural land currently provide surrogate grassland habitat.

The following Species of Greatest Conservation Need are listed according to their level of association with the Surrogate Grasslands natural community type, based on the findings in the Wisconsin WAP. The scores in Table 15 are defined as: 3 = "Significantly Associated," 2 = "Moderately Associated", and 1 = "Minimally Associated."

Table 15 - Surrogate grasslands species of greatest conservation need

Common Name	***Scientific Name***	**Score**
Birds		
Barn Owl	*Tyto alba*	3
Bobolink	*Dolichonyx oryzivorus*	3
Dickcissel	*Spiza americana*	3
Eastern Meadowlark	*Sturnella magna*	3
Grasshopper Sparrow	*Ammodramus savannarum*	3
Greater Prairie-Chicken	*Tympanuchus cupido*	3
Henslow's Sparrow	*Ammodramus henslowii*	3
Le Conte's Sparrow	*Ammodramus leconteii*	3
Loggerhead Shrike	*Lanius ludovicianus*	3
Northern Bobwhite	*Colinus virginianus*	3
Northern Harrier	*Circus cyaneus*	3
Short-eared Owl	*Asio flammeus*	3
Upland Sandpiper	*Bartramia longicauda*	3
Western Meadowlark	*Sturnella neglecta*	3
American Golden Plover	*Pluvialis dominica*	2
Bell's Vireo	*Vireo bellii*	2
Blue-winged Teal	*Anas discors*	2
Brown Thrasher	*Toxostoma rufum*	2
Buff-breasted Sandpiper	*Tryngites subruficollis*	2
Field Sparrow	*Spizella pusilla*	2
Marbled Godwit	*Limosa fedoa*	2
Sharp-tailed Grouse	*Tympanuchus phasianellus*	2
Willow Flycatcher	*Empidonax traillii*	2
American Bittern	*Botaurus lentiginosus*	1
American Woodcock	*Scolopax minor*	1
Vesper Sparrow	*Pooecetes gramineus*	1
Fish		
No fish species reported in the Wildlife Action Plan for this community		
Reptiles and Amphibians		
No reptiles and amphibians species reported in the Wildlife Action Plan for this community		
Mammals		
Franklin's Ground Squirrel	*Spermophilus franklinii*	2
Prairie Vole	*Microtus ochrogaster*	2
White-tailed Jackrabbit	*Lepus townsendii*	2

Source: DNR WAP

The following list of threats and priority conservation actions were identified for the Surrogate Grasslands community type in Wisconsin.

- Changing agricultural practices (*e.g.* increased use of pesticides; extensive conversion of small grain and pasture acreage to row crops; elimination of grassy fence rows, field edges, and corners; and changes in the nature and timing of agricultural disturbances, especially early and frequent mowing of alfalfa during the nesting season).

- Changing land use patterns, including urban development and rural home building, which are often focused on the least productive agricultural lands that have the highest portion of set-aside lands. Rural development often results in fragmenting grassland habitat, restricts burning to maintain grasslands, introduces pets that can adversely impact wildlife, and introduces invasive plants. Habitat fragmentation results in patch isolation and the creation of edge effects. This is especially harmful to vertebrate animals, including area sensitive grassland birds.

- Increased fire control and lack of acceptance of the use of prescribed fire to maintain grasslands have resulted in grasslands converting into brush or woodlands.

- Conflicting forest (tree planting) and grassland management practices in former prairie areas of the state have resulted in conversion of grassland to trees, fragmenting grassland habitats.

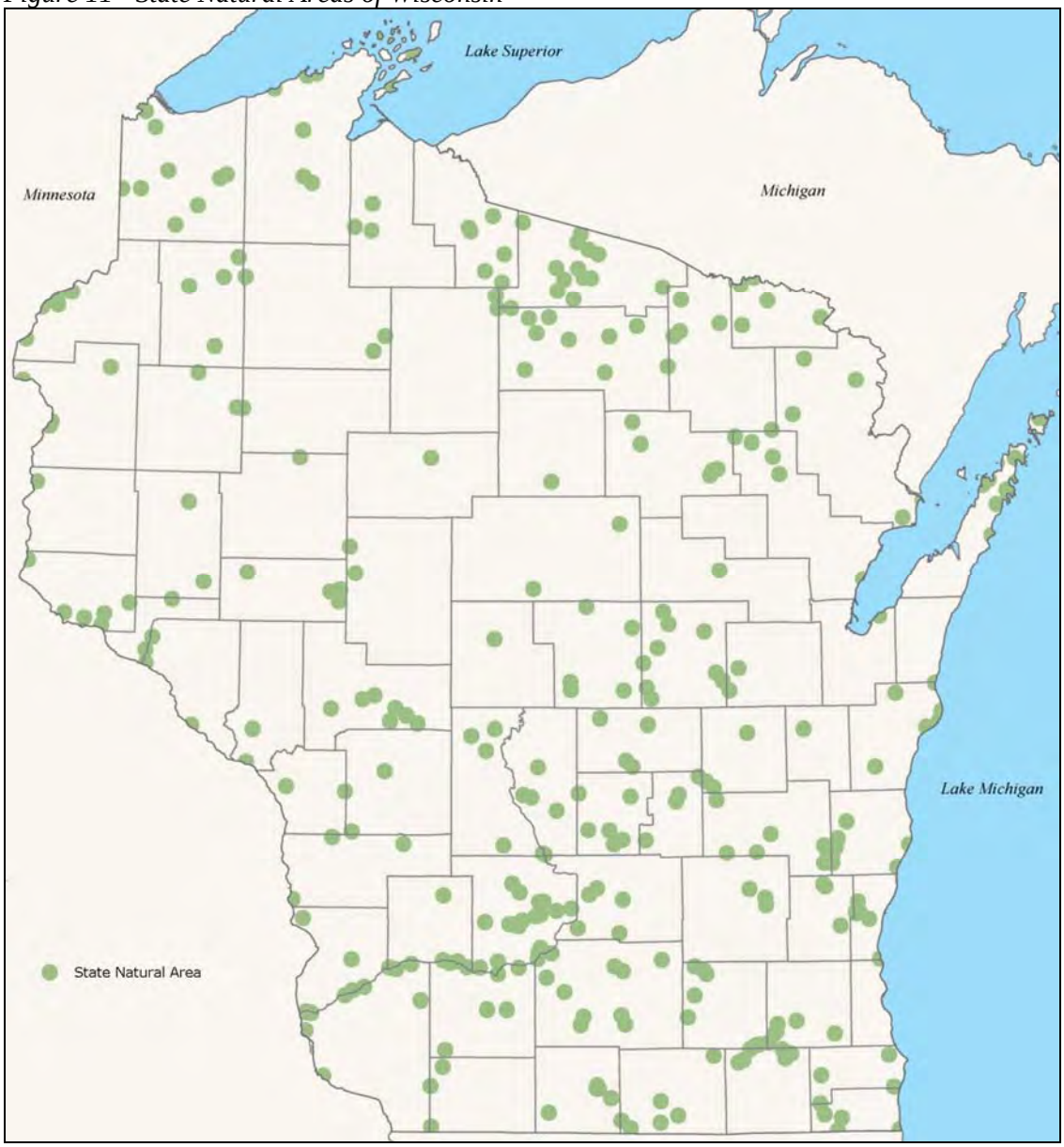
- General lack of attention to or appreciation of grassland communities by the public.

Because CAFOs tend to preserve open agricultural lands, a positive benefit results for species dependent on surrogate grassland habitat. This benefit may be somewhat dampened where CAFO land practices result in agricultural practices such as increased use of pesticides; extensive conversion of small grain and pasture acreage to row crops; elimination of grassy fence rows, field edges, and corners; and changes in the nature and timing of agricultural disturbances, especially early and frequent mowing of alfalfa during the nesting season.

State Natural Areas

Wisconsin harbors a diverse mix of natural biotic communities and native species. Many of the 229 Wisconsin Land Legacy Places collectively contain much of the biological diversity that exists in Wisconsin. However, some species and natural communities have very limited distribution or only occur at small scattered locations around the state. As a result, there will continue to be a need to find and protect these small pockets of critical habitat—both those that support rare species and those that harbor the highest quality examples of natural communities. These natural areas are vital to scientific research because they provide the best remaining examples of natural processes acting over time with limited impacts from human activity. As such, they are valuable benchmarks against which the Department, the academic community, and others can evaluate the affects of humankind’s increasing influence on Wisconsin’s landscape (DNR Land Legacy Report) Figure 11 shows the point locations of Wisconsin's State Natural Areas (SNAs).

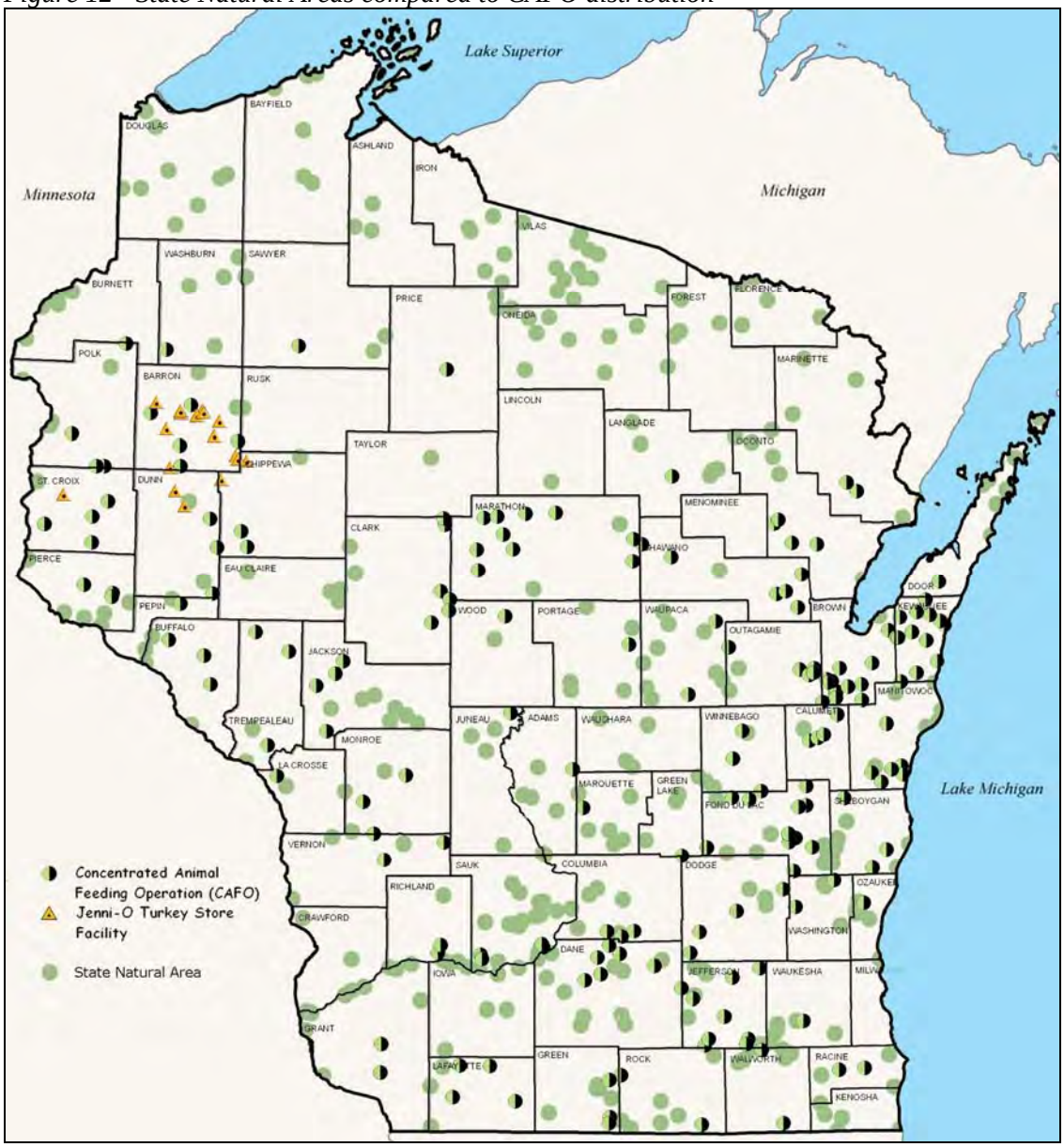
Figure 11 - State Natural Areas of Wisconsin



Source: DNR Land Legacy Report

The point data (Natural Area locations) in Figure 11, above, can be compared to the point data in the CAFO distribution (see Figure 1 - Geographic Distribution of CAFOs in Wisconsin in Section IV.B.1). This overlay is shown in Figure 12, below, and shows that existing CAFOs exist in proximity to some State Natural Areas. Because this is a statewide map and because of the map symbols used for point locations, apparent proximity of data points cannot be interpreted as the points being at the same location.

Figure 12 - State Natural Areas compared to CAFO distribution



Not to scale

CAFOs that occur adjacent to or in close proximity to State Natural Areas may help to protect those SNAs from encroaching development. On the other hand potential CAFO problems, such as polluted runoff and air emissions may serve to degrade nearby SNAs.

Ecological Landscapes

Ecological Landscapes are areas of Wisconsin that differ from each other in ecological attributes and management opportunities. They have unique combinations of physical and biological characteristics that make up the ecosystem, such as climate, geology, soils, water, or vegetation. They differ in levels of biological productivity, habitat suitability for wildlife, presence of rare species and natural communities, and in many other ways that affect land use and management.

The Ecological Landscapes classification system is based on the system developed by the US Forest Service (and many collaborators). This system divides the state into 16 ecologically similar regions, based on soils, existing and pre-settlement vegetation, topography, and types of aquatic

features present. Table 16 lists and briefly describes the 16 Ecological Landscapes shown in Figure 4 in Section V.A.3. For more information, go to: http://www.dnr.state.wi.us/landscapes/

Table 16 - Ecological Landscapes of Wisconsin

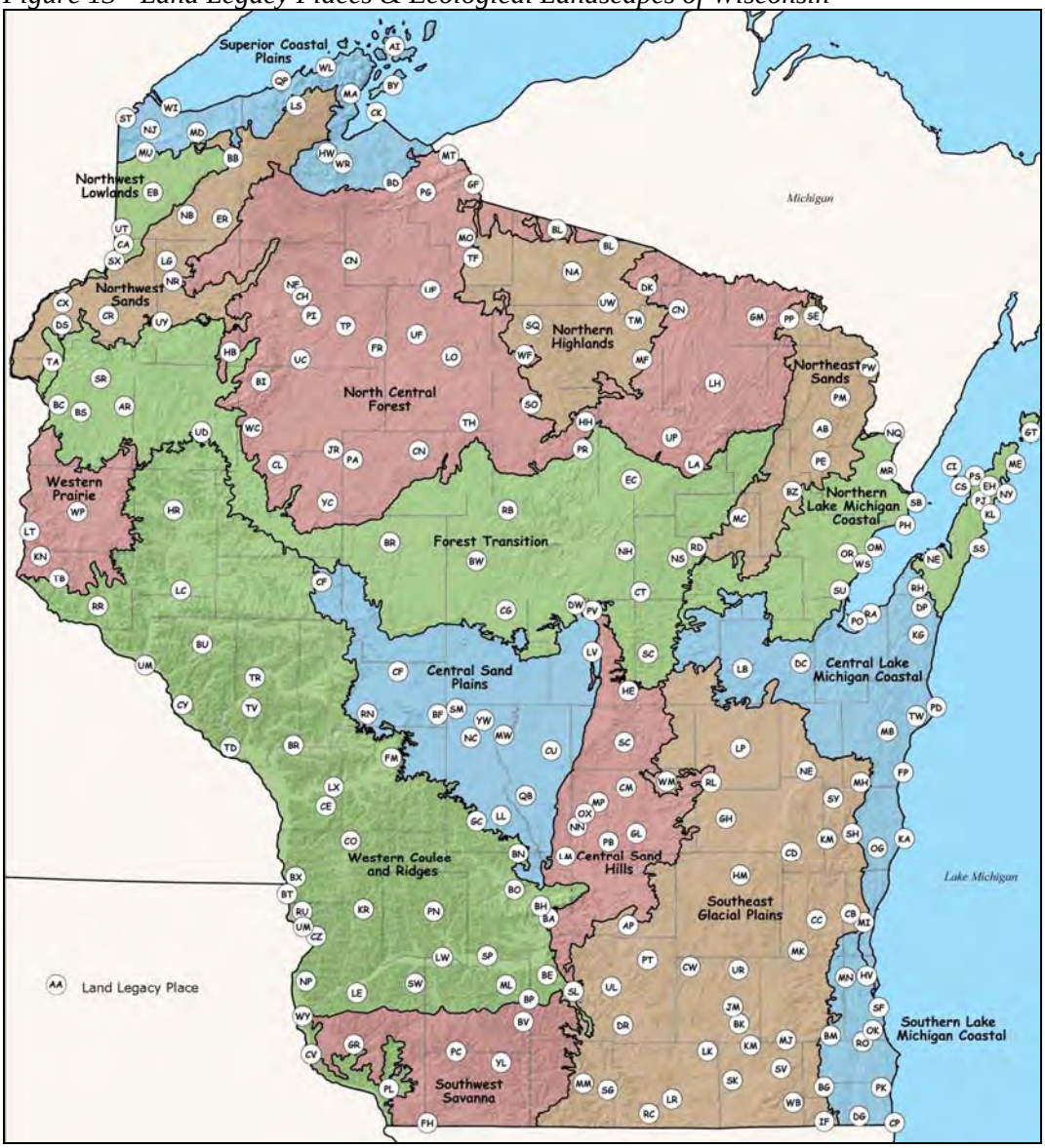
Ecological andscape	Description
Superior Coastal Plain	Lake Superior climate influence; rolling to flat topography with clay soils; primarily agriculture and mixed hardwood and spruce-fir forest, with high gradient streams
Northwest Lowlands	Gently rolling topography with loam and organic soils; primarily mixed hardwood and coniferous upland and wetland forests
Northwest Sands	Gently rolling to flat topography with sandy soils; primarily oak and pine forests
North Central Forest	Gently rolling topography with silt and loam soils; primarily mixed hardwood forests and agriculture
Northern Highland	Gently rolling topography with sandy soil depressions forming many lakes and wetlands; uplands dominated by mixed hardwood and conifer forests
Northeast Hills	Hilling topography with silt loam soils; extensive northern hardwood forests
Northeast Sands	Gently rolling topography with sandy soils; primarily oak and pine forests
Farm-Forest Transition	Gently rolling to flat topography with silt and loam soils; primarily mixed hardwood forests and agriculture
Northeast Plains	Gently rolling to flat topography with sandy soil; a mixture of agriculture, mixed hardwood forests and wetlands
Northern lake Michigan Coastal	Lake Michigan climate influence; gently rolling to flat topography with clay and loam soils; dominated by agriculture in the south and mixed hardwood forest in the north
Western Prairie	Gently rolling to flat topography with many small depressions forming small wetlands, silt and loam soils; uplands primarily agriculture
Central Sand Plains	Flat topography with sandstone buttes and sandy soils; primarily oak and pine forests with wetlands
Western Coulee and Ridges	Ridge and valley topography with shallow soils over sandstone and dolomite bedrock; generally agriculture on hilltops and valleys with some oak and hardwood forested slopes, with high gradient streams
Central Sand Hills	Rolling, hilly topography with sandy soils; a mixture of agriculture, oak and pine forests and wetlands, with many coldwater streams
Southwest Savanna	Ridge and valley topography with shallow soils over sandstone and dolomite bedrock; primarily agriculture with some oak and mixed hardwood forests, with high gradient streams
Southeast Glacial Plains	Rolling topography with silt loam soils; primarily agriculture with small wetlands and mixed hardwood forests
Southern Lake Michigan Coastal	Lake Michigan climate influence; rolling topography with clay and silt loam soils; primarily urban and agriculture

Land Legacy Places

The Wisconsin Land Legacy Report focuses on identifying the places considered most important to meet Wisconsin's conservation and recreation needs over the next 50 years. The report identifies and describes 229 Legacy Places (DNR Land Legacy Report).

Figure 13 shows the point locations of Land Legacy Places as compared to the Ecological Landscapes of Wisconsin (see also Figure 4 in Section V.A.3.).

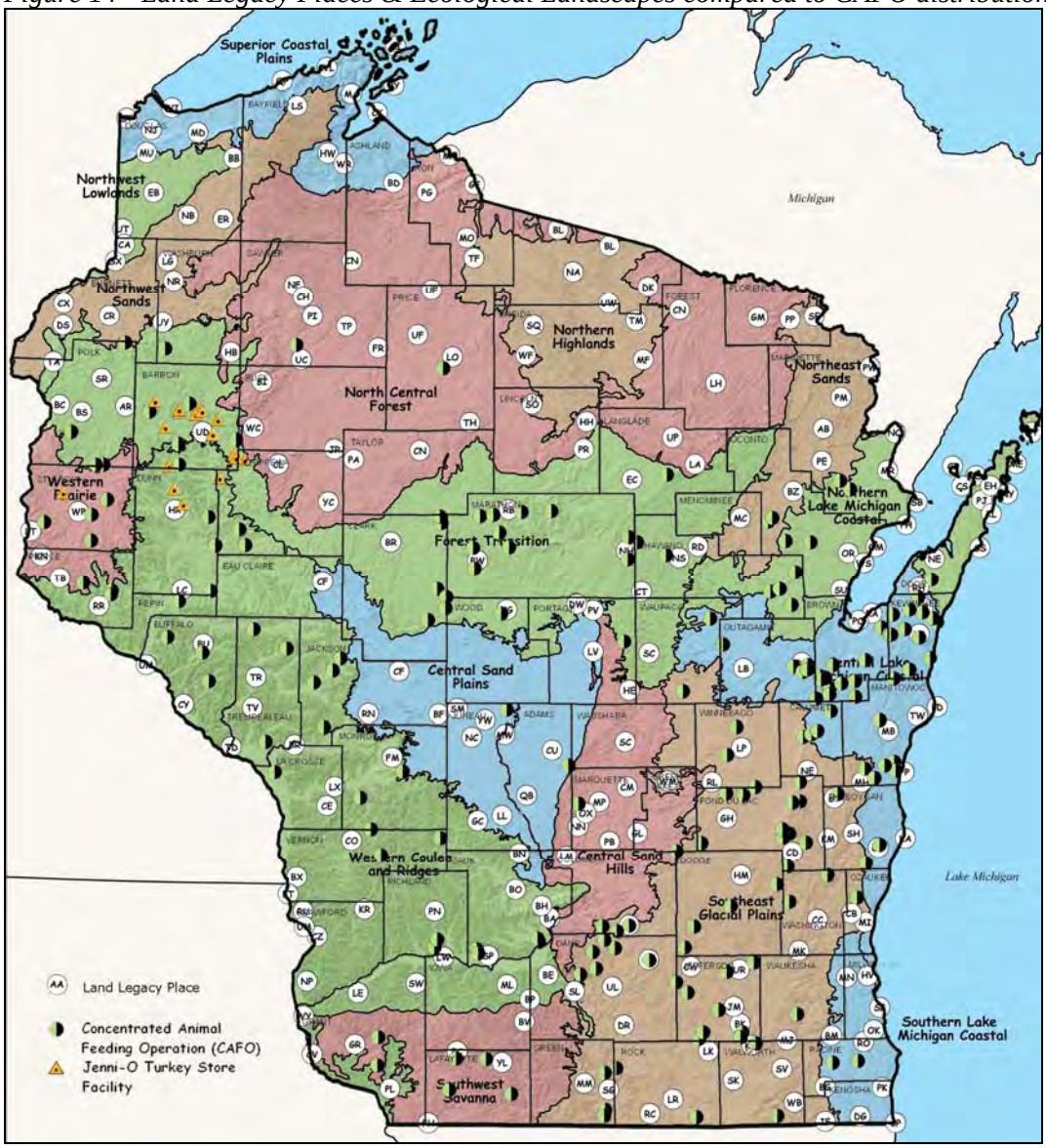
Figure 13 - Land Legacy Places & Ecological Landscapes of Wisconsin



Source: DNR Land Legacy Report

Figure 14 shows this map overlaid with the point data of the current CAFO distribution. This figure indicates that existing CAFOs are scarce in the forested and central sands landscapes. The figure also shows that there are few places where existing CAFOs occur in proximity to DNR-identified Land Legacy Places. Because this is a statewide map and because of the map symbols used for point locations, apparent proximity of data points cannot be interpreted as the points being at the same location.

Figure 14 - Land Legacy Places & Ecological Landscapes compared to CAFO distribution



Not to scale

CAFOs that occur adjacent to or in close proximity to Land Legacy Places may help to protect those places from encroaching development. On the other hand potential CAFO problems, such as polluted runoff and air emissions may serve to degrade nearby Land Legacy Places.

Rare species

The following summary is from the Department's Land Legacy Report.

Most of our lands and waters harbor considerably less complex and diverse groups of species than were present before Euro-American settlement. Cities and farms have replaced most of southern Wisconsin's forests, savannas, grasslands, and wetlands, and as a result many native species now occur in significantly lower numbers than in the past. The northern portion of the state is blanketed with second- and third-growth forests. Although most native species remain, a considerable number have experienced large population reductions, particularly species adapted to older, larger blocks of forest.

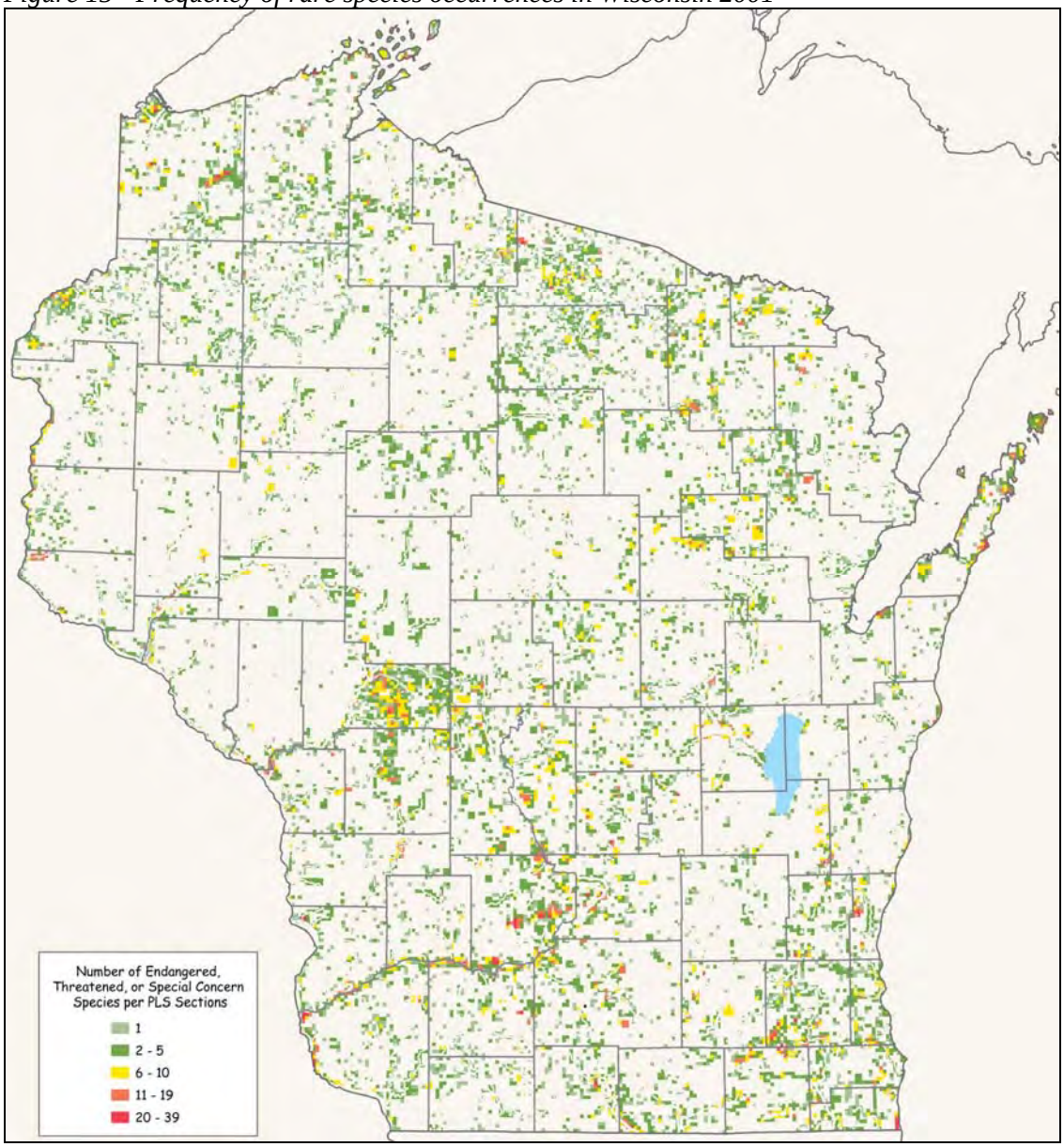
Along with a reduction in the numbers and types of species found in much of the state has been a corresponding decrease in the functional complexity of most remaining natural communities. That is, because the number of species has declined in most of our remaining savannas, barrens, grasslands, wetlands, forests, and other ecosystems, the number of interactions between species, as well as the ecological processes that support them (*e.g.* water, nutrient, energy, and carbon cycles), have been simplified. In less diverse systems, "ecological resiliency" decreases and minor changes in ecological processes can lead to large and chaotic changes to the components of the ecosystem.

Another factor contributing to the loss of habitats and ecological complexity is pollution. Environmental pollution is the human-induced addition of many types of substances to air, land, and water in quantities and/or at rates that harm organisms, habitats, ecosystems, or human health. There are many types of pollution, some with minimal impacts, others appear to have much larger consequences. For many types of pollution, we do not yet adequately understand their impact to the environment or human health. Some examples of pollution include:

- Sediments that wash off bare land and smother gravel riffles in streams,
- Excessive organic waste that flows into lakes or streams and uses up dissolved oxygen as it decays, and
- Chemicals present in industrial and municipal effluent.

Figure 15, below, shows the frequency of rare species occurrences in Wisconsin.

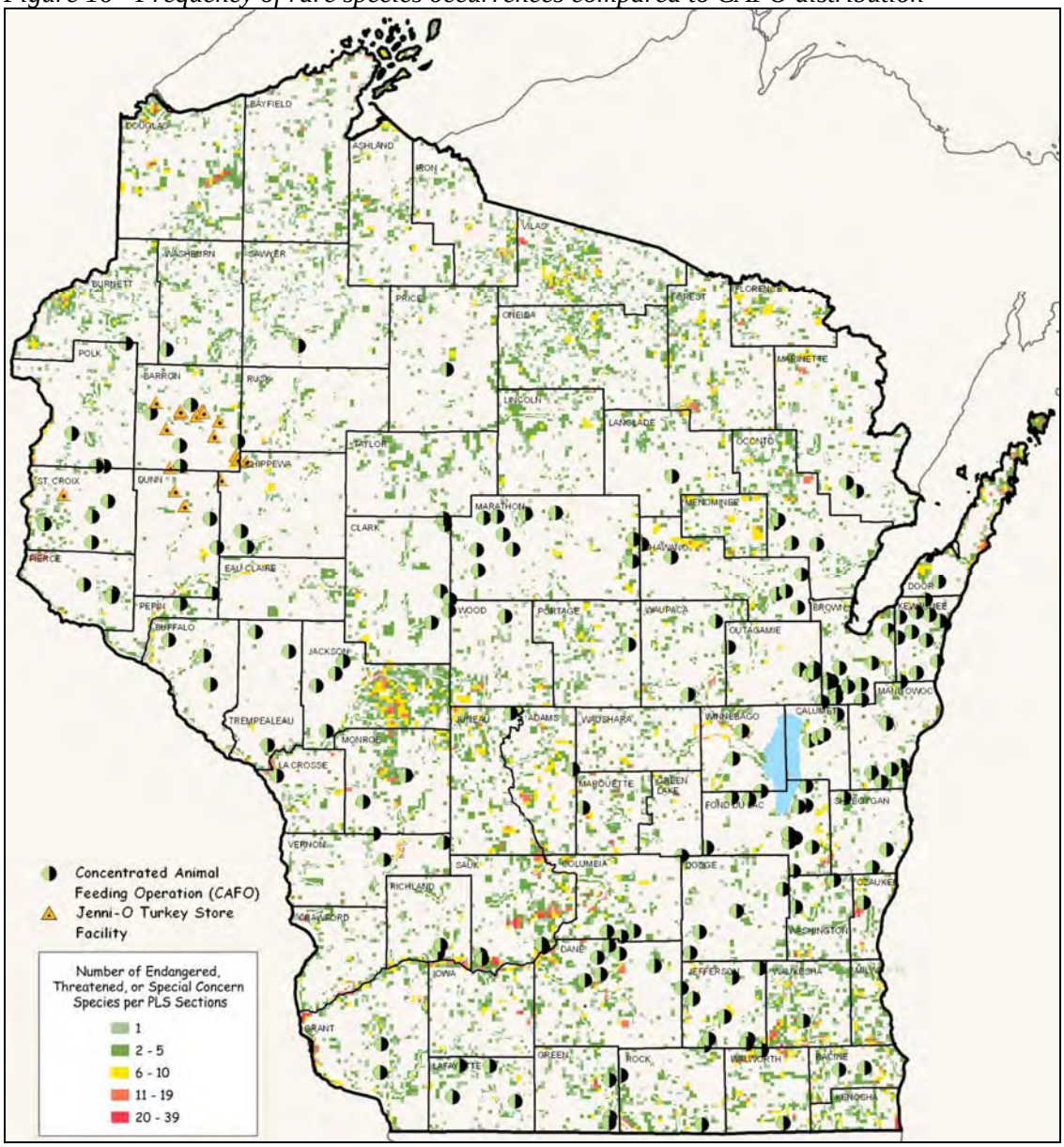
Figure 15 - Frequency of rare species occurrences in Wisconsin 2001



Source: DNR Land Legacy Report

Figure 16, below, shows the current distribution of CAFOs compared to the frequency of occurrences of rare species in the state. Because this is a statewide map and because of the map symbols used for point locations, apparent proximity of data points cannot be interpreted as the points being at the same location. This figure indicates that while CAFOs and rare species may occur in close proximity, for the most part CAFOs tend to occur in areas of relatively infrequent rare species occurrences.

Figure 16 - Frequency of rare species occurrences compared to CAFO distribution



Not to scale

CAFOs may help to protect some rare species that are adapted to agricultural settings, in that CAFOs tend to protect open agricultural areas from encroaching development (see the previous discussion of surrogate grasslands). On the other hand potential CAFO problems, such as polluted runoff and air emissions may serve to limit this benefit.

V.B. Socioeconomic environment

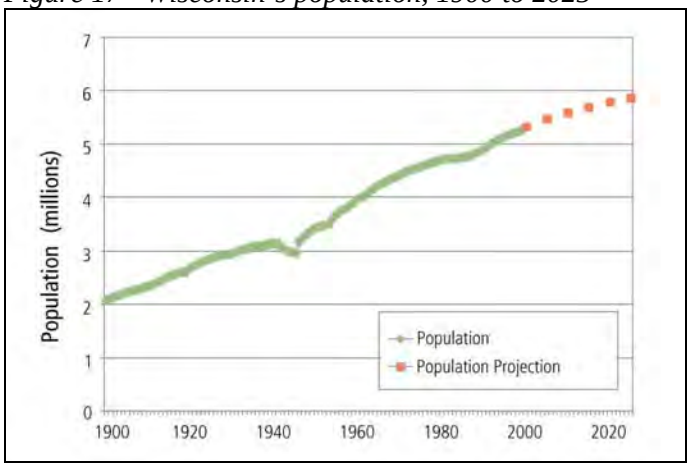
V.B.1. Demographics

The following summary is from the DNR's Land Legacy Report.

Since permanent Euro-American settlement began, the population of Wisconsin has been steadily increasing. Different regions of the state have experienced surges in population as economic conditions and opportunities have changed over time. The population of the southwest corner of

the state surged during the lead mining period; the Lake Michigan coastal cities gained considerable population during the shipping and boat building era; the Fox Valley cities grew with the expansion of the paper-making industry; and the manufacturing industry has long kept the greater Milwaukee area as one of the largest metropolitan centers in the Midwest. The 2000 Census found that 5,363,675 people now live in Wisconsin, a 9.6% increase from 1990 (See Figure 17, below). Our population is slightly older and increasing more slowly than that of the country as a whole (See *http://quickfacts.census.gov/qfd/states/55000.html*.).

Figure 17 - Wisconsin's population, 1900 to 2025



Sources: Chart: DNR Land Legacy Report, Data: U.S. Census Bureau. See http://eire.census.gov/popest/archives/state/st_stts.php and http://www.census.gov/population/projections/state/stpjpop.txt

One trend that has remained consistent over the past 150 years is the growing urbanization of our population. At the beginning of the 1900s, Wisconsin had a predominantly rural, farm-based population; now, more than half of the state's residents live in municipalities with over 10,000 people (U.S. Census Bureau. In 2000, See *http://www.census.gov/population/censusdata/places/55wi.txt*). Some villages and rural towns, particularly those that played important roles in the timber and mining industries in the north as well as some in the southern and western part of the state away from major highways, have fewer residents now than 50 or even 100 years ago. Eighteen of Wisconsin's 72 counties lost population from 1940 to 1990 (U.S. Census Bureau. See *http://www.census.gov/population/cencounts/wi190090.txt.* See also Ostergren, Robert C. "The Euro-American Settlement of Wisconsin, 1830–1920," Chapter 8 within *Wisconsin Land and Life*, ed. Ostergren and Vale, University of Wisconsin Press, 1997). The nine most populous counties, all of which lie between Green Bay, Madison, and Kenosha, now comprise over 50% of the entire state population. The fastest growing population centers in the state are all south of State Highway 29 and are typically small to mid-sized cities at the fringe of large cities.

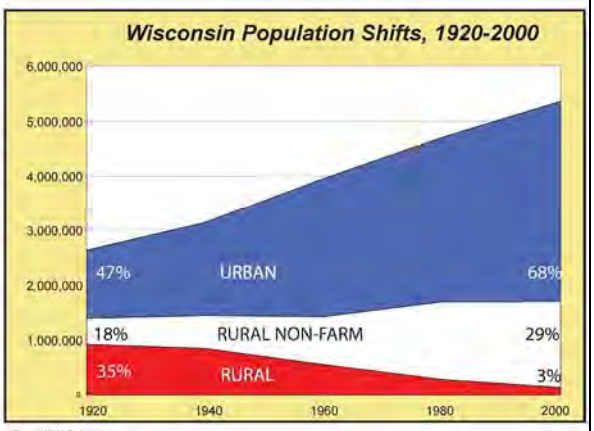
Figure 18, below, provides insight into the historical shifts in population distribution in Wisconsin.

Figure 18 - Population shifts in Wisconsin

Population Shifts

During the early part of the 20th century, the majority of Wisconsin's population was rural and lived an agrarian lifestyle.[1] Drawn by the amenities of city life, Wisconsin's urban population expanded from roughly 800,000 in 1900 to 3.7 million in 2000. During the same time period, Wisconsin's rural population grew from 1.3 million to 1.7 million. In the era following the Great Depression, there was a sharp decline in the number of rural residents living on farms and a subsequent trend toward suburbanization of urban and rural areas. By 2000, only 3% of Wisconsin' population resided on farms, compared with 29% in rural non-farm areas, and 68% in rural areas.

(Rural is defined as a census designated place of less than 2,500 persons.)



From: UW Extension

The majority of Wisconsin's population is concentrated in a small number of metropolitan areas, areas which also have the highest levels of income, education, and property values. While its population may live predominantly in a select few areas, the majority of the state's land remains mostly rural and sparsely populated. In general, the southern and eastern parts of the state, especially the lower Lake Michigan coastal region, are highly urbanized and have relatively high levels of income, education, and property values. Other regions (except for the northwest and the north woods which remain rural without large population centers) have at least one highly populated, and urban county surrounded by more rural counties. The northern part of the state can be characterized as being heavily impacted by seasonal housing and tourism and as having a rapidly aging resident population. Seasonal housing and tourism are also important considerations in many rural areas of the state where full-time residents may represent a small portion of overall recreation demand. This is especially true in the north woods, northwest, and upper Lake Michigan coastal regions. Population growth and housing development have occurred relatively quickly in several areas of the state, particularly suburban counties and non-metro recreation counties. This growth is expected to continue as population growth and housing development continue to occur rapidly (DNR SCORP, p. 1-14, http://dnr.wi.gov/planning/scorp/plan/WIS_2005-10_SCORP_CHAPTER_1.pdf).

Consistent with national trends, the average age of Wisconsin's population is aging and is influenced by the large "baby boom" generation. As today's 40 to 60 year-olds enter retirement, they are likely to spend increasing amounts of time and money pursuing a variety of outdoor recreation activities. Also consistent with national trends, the average age of Wisconsin farmers (52 years) is older than that of the average worker in the state (39 years) (U.S. Department of Agriculture, National Agricultural Statistics Service. 1997 Census of Agriculture. See *http://www.nass.usda.gov/census/census97/volume1/wi-49/wi1_01.pdf.* U.S. Department of Labor, Bureau of Labor Statistics, 2000 Geographic Profile. See *http://146.142.4.22/lau/table12full00.pdf*). In addition to the social changes this aging farm population will bring to our rural communities, it is also likely to affect the pace and pattern of land ownership changes over the next fifty years (DNR Land Legacy Report).

Figure 19, below, shows the current census population by county.

Figure 19 - Population by county

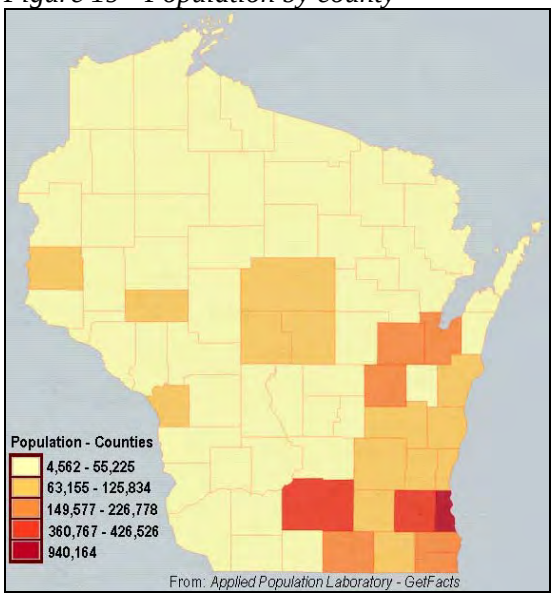
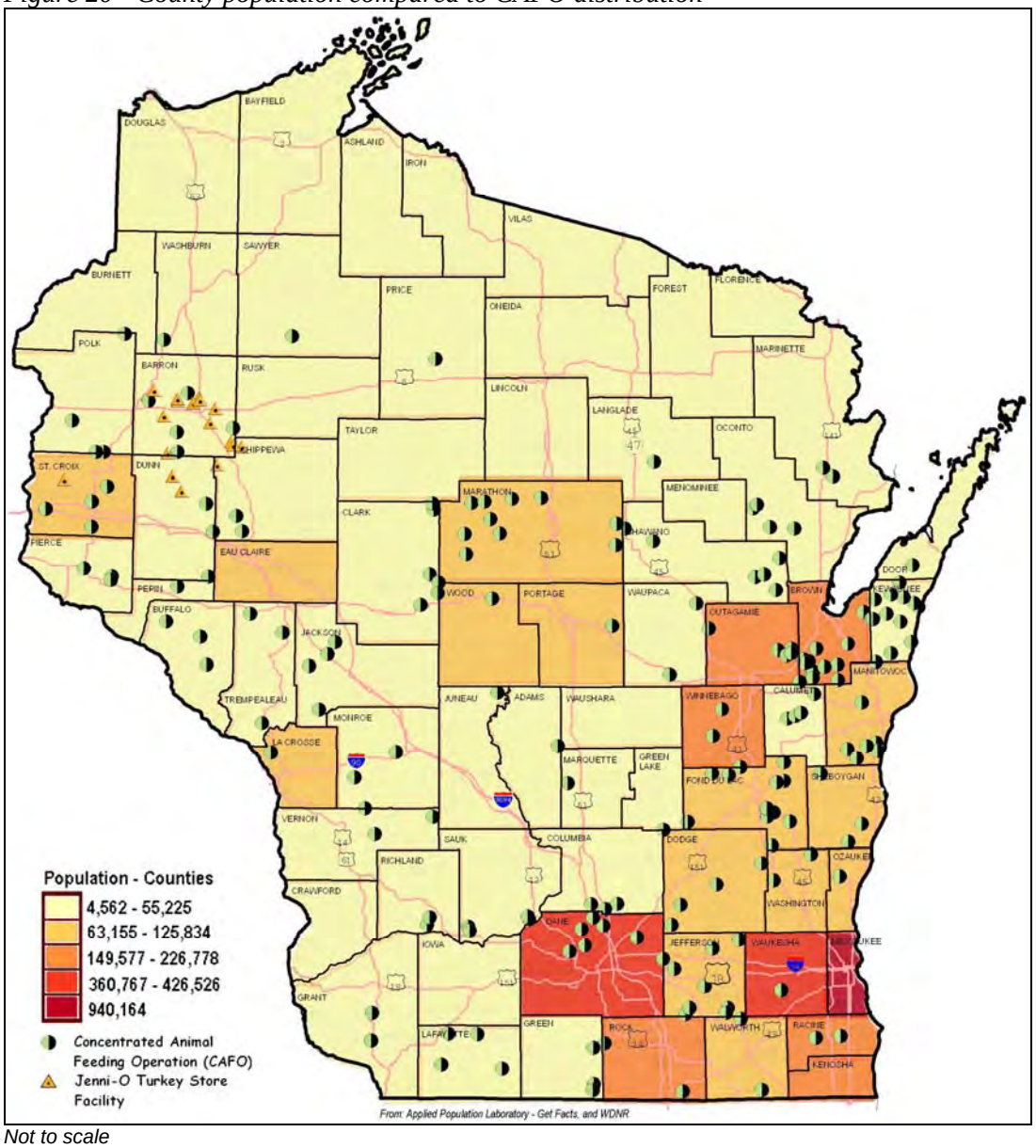


Figure 20, below, compares the distribution of existing CAFOs (see Figure 1 - Geographic Distribution of CAFOs in Wisconsin in Section IV.B.1) with current population by county. The figure shows little correlation between county population and CAFO location. CAFOs occur in both populous and un-populous counties. Even relatively populous counties, such as Dane, show a strong presence of CAFOs.

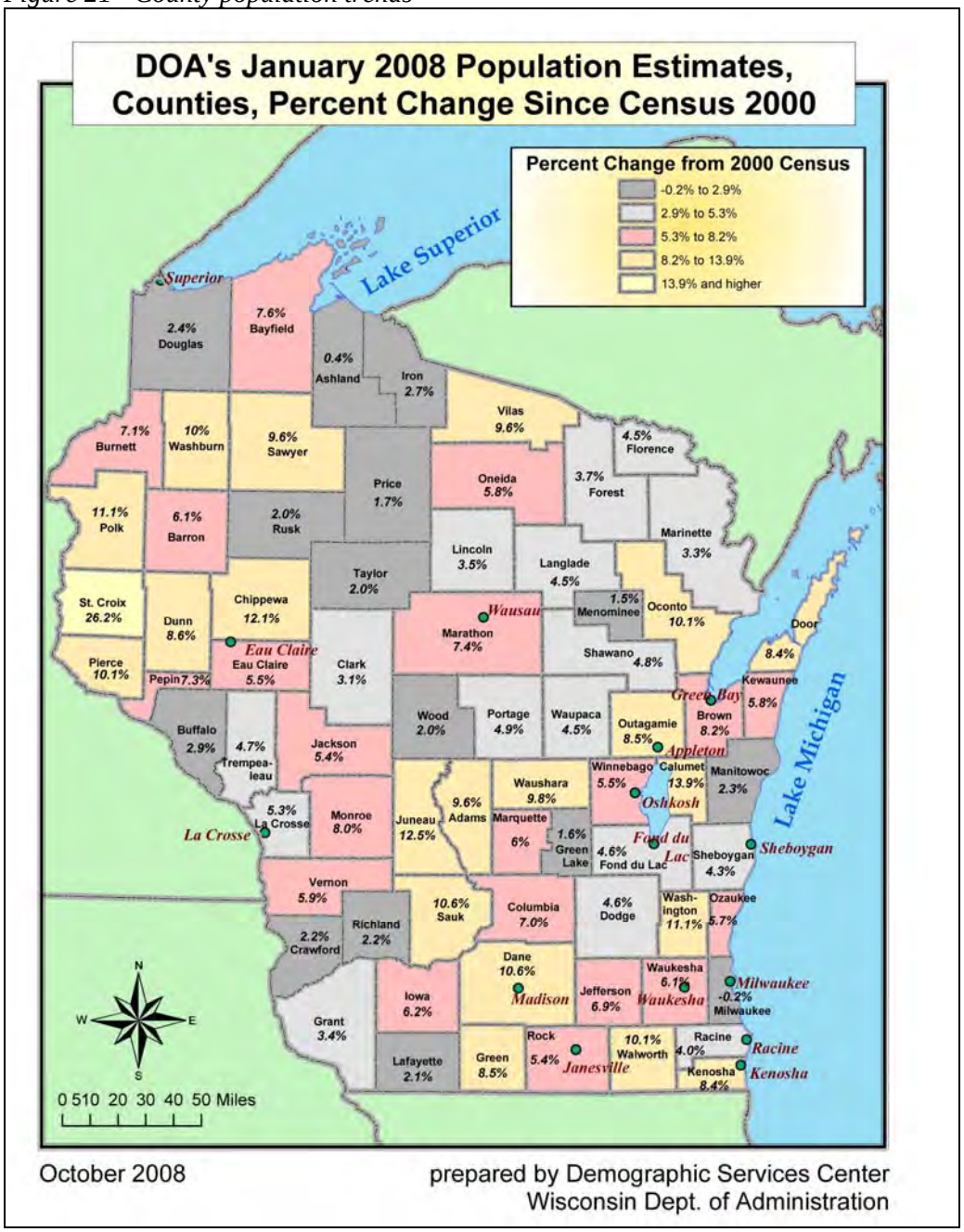
Figure 20 - County population compared to CAFO distribution



Not to scale

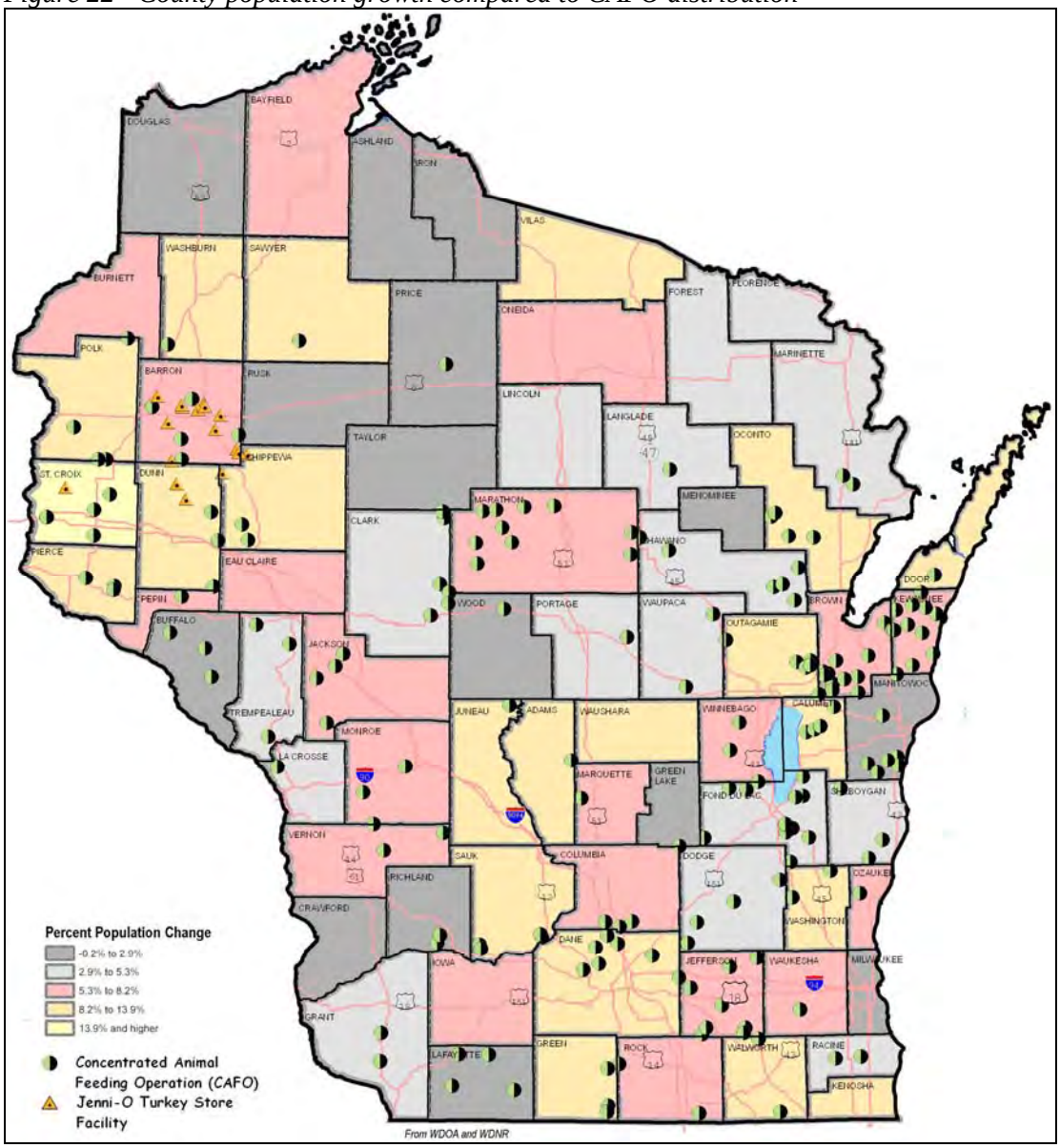
Figure 21 shows the county population trends in the state.

Figure 21 - County population trends



Overlaying the distribution of CAFOs (see Figure 1 - Geographic Distribution of CAFOs in Wisconsin in Section IV.B.1) on this figure gives us Figure 22, below. While we cannot conclude that a cause and effect relationship exists, it appears that CAFOs and population growth are positively correlated. It would appear to be a safe assumption that the existence of CAFOs within a county do not necessarily retard population growth.

Figure 22 - County population growth compared to CAFO distribution



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Ethnicity

Although more homogenous than the country as a whole, Wisconsin's racial composition continues to diversify. Approximately 5.7% of the state's population is African American, 3.6% Hispanic American, 1.7% Asian American, and 1.0% Native American. All of these minority groups are expected to increase in population faster than the state's Caucasian population (U.S. Census Bureau. See *http://quickfacts.census.gov/qfd/states/55000.html* and *http://www.census.gov/population/projections/state/stpjrace.txt*, as reported in DNR's Land Legacy Report).

Figure 23, below shows the percentage of population of whites by county.

Figure 23 - Percent white population by county

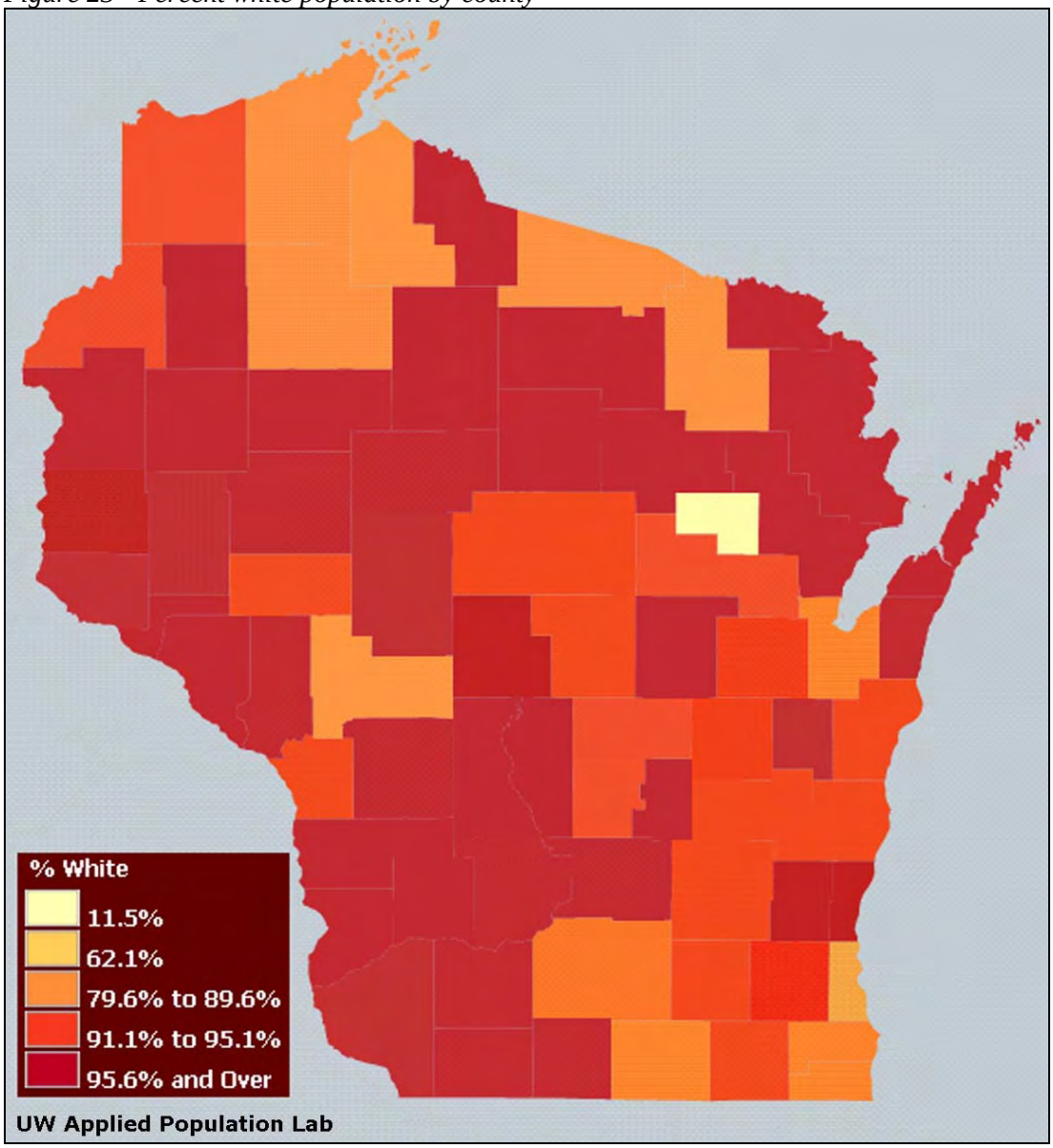
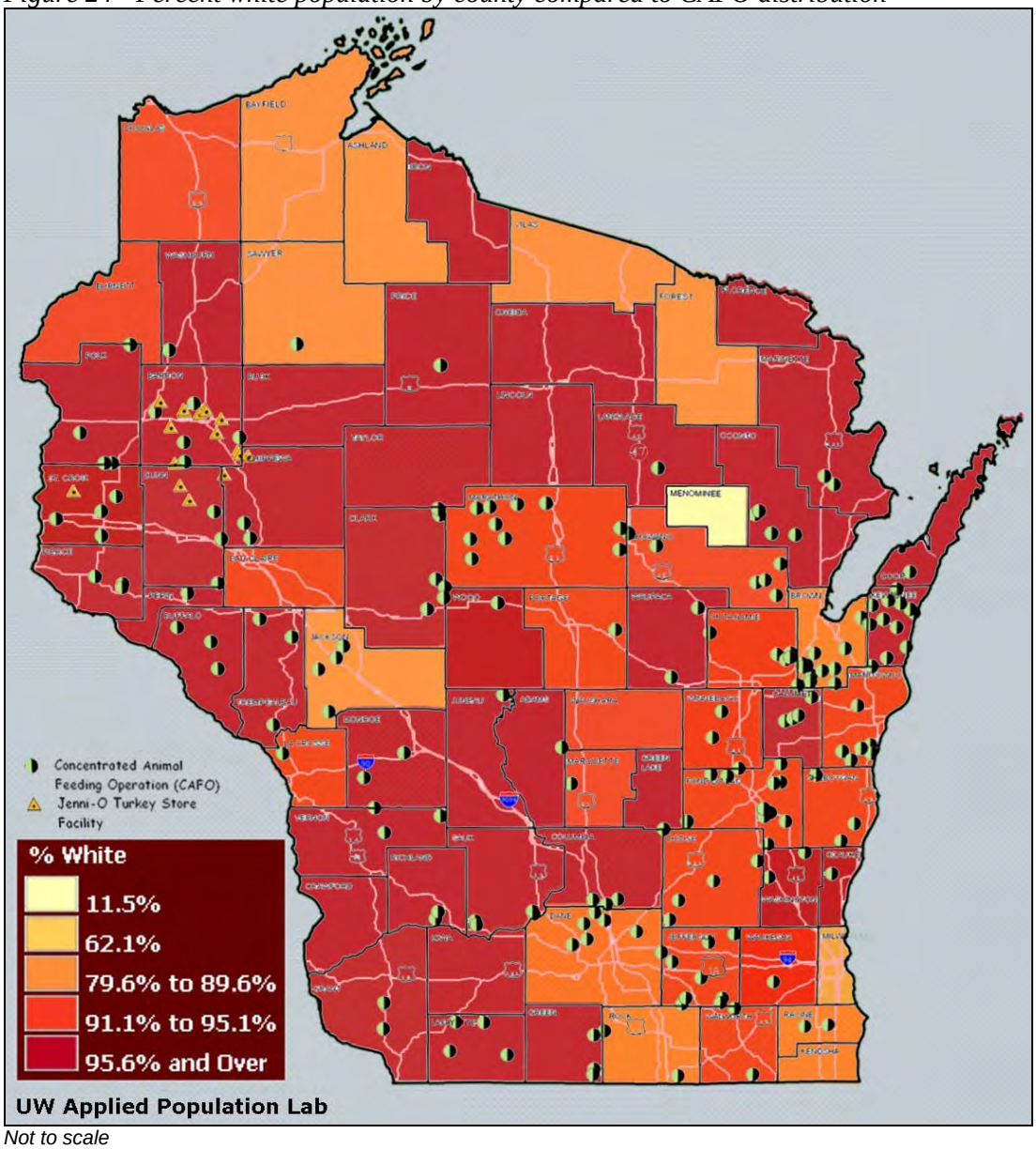


Figure 24, below shows the white population data as compared to the distribution of CAFOs (see Figure 1 - Geographic Distribution of CAFOs in Wisconsin in Section IV.B.1). At this scale, the map does not appear to indicate a correlation between CAFO distribution and race. Two notable counties that do not currently have any CAFOs are Menominee and Milwaukee. Both of these counties have relatively high minority populations. Menominee County has a large Menominee Tribal population. Milwaukee County is highly urbanized and has a higher than average (in Wisconsin) minority population.

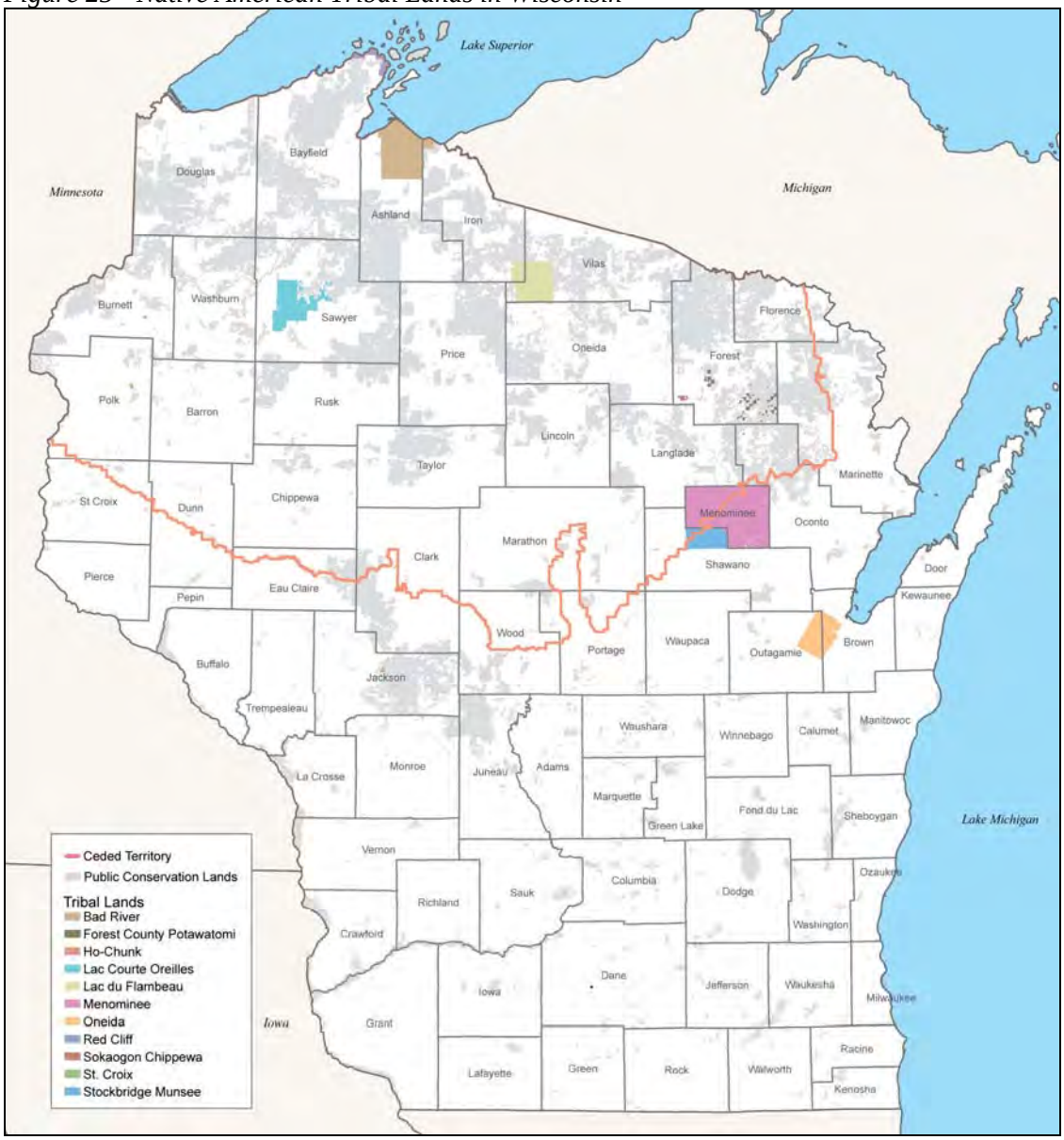
Figure 24 - Percent white population by county compared to CAFO distribution



Not to scale

By the time of the first treaties between the U.S. government and the tribes in this area, there were at least 8 tribes that had claims in the region. Directly involved in the 1825 Prairie du Chien Treaty were the Ho-Chunk (Winnebago), Menominee, Ojibwe (Chippewa), Sioux, Sac, Fox, Ioway, and Potawatomi. Later, bands of the Oneida and Stockbridge-Munsee Tribes moved from the east and eventually settled here as well. Today, the federal government recognizes eleven Tribes in Wisconsin (six Ojibwe, and the Menominee, Ho-Chunk, Potawatomi, Oneida, and Stockbridge-Munsee) and has established reservations for each (See Figure 25, below). The six Ojibwe Tribes are the Bad River, Lac Courte Oreilles, Lac du Flambeau, Red Cliff, Sokaogon (Mole Lake) and St. Croix.

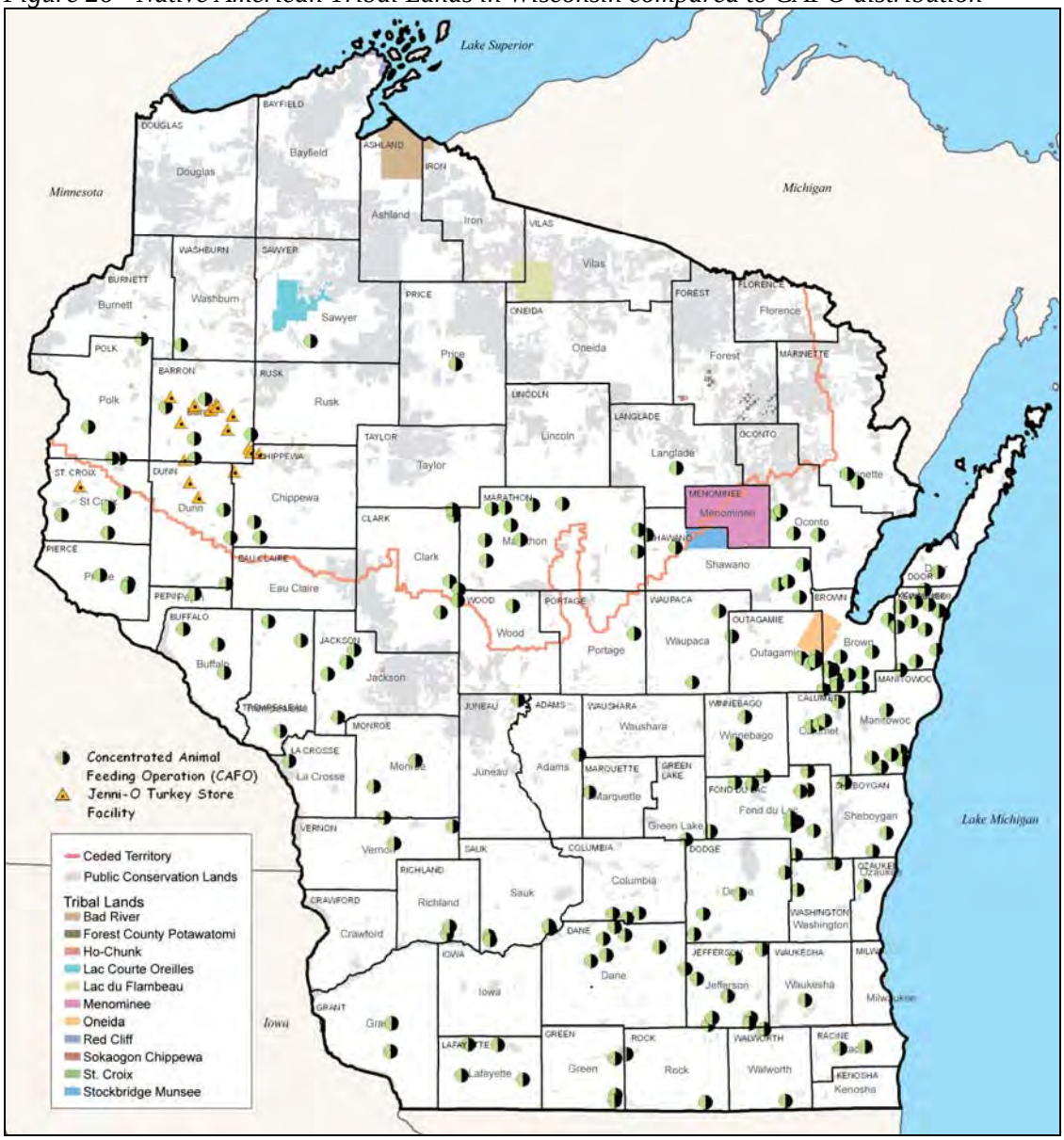
Figure 25 - Native American Tribal Lands in Wisconsin



Source: DNR Land Legacy Report

Figure 26, below shows the Native American tribal lands compared to the current distribution of CAFOs (see Figure 1 - Geographic Distribution of CAFOs in Wisconsin in Section IV.B.1), and shows that CAFOs do not occur on tribal lands, although some do occur within the ceded territory.

Figure 26 - Native American Tribal Lands in Wisconsin compared to CAFO distribution

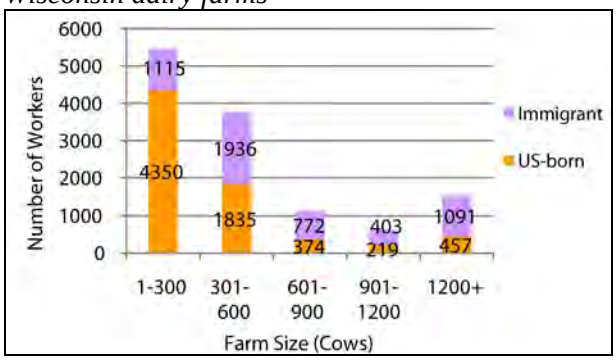


Not to scale

Minority employment

A 2009 study estimated that over 40% of Wisconsin hired dairy employees are immigrants. That is at least 5,316 individuals. The study also found that the proportion of immigrant workers increases with the size of the farm. Immigrants working in the Wisconsin dairy industry come from many countries around the world, but nearly 90% are Mexican. Most of the rest come from Central and South America [Harrison, Lloyd and O'Kane, February 2009, *Overview of Immigrant Workers on Wisconsin Dairy Farms. Program on Agricultural Technology Studies (PATS), Room 202 Taylor Hall, University of Wisconsin-Madison*. See: http://www.pats.wisc.edu/projects/2] This information (shown in Figure 27) is also from this study.

Figure 27 - Estimated number of hired workers on Wisconsin dairy farms



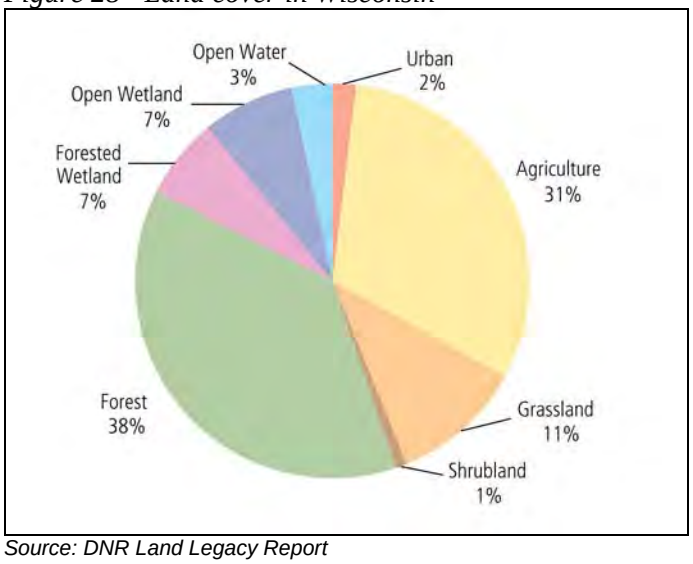
A recent article in the Madison Capital Times claimed that about half of all immigrant crop workers are illegal immigrants (Kushner, 11/11/09, *Immigrants change face of Wisconsin dairy industry*. The Capital Times, Madison. See: http://host.madison.com/ct/news/local/article_a083838a-e0d2-5338-9479-0c95ae382710.html).

V.B.2. Land use & transportation

Existing land use summary (from DNR Land Legacy Report)

Figure 28 shows the various kinds of land cover in Wisconsin, and the percentages of each.

Figure 28 - Land cover in Wisconsin



Source: DNR Land Legacy Report

Although the major impacts to, and conversion of, native habitats mostly occurred before 1950, Wisconsin's landscape continues to be significantly altered. The changes occurring now, albeit not as dramatic as the felling of forests or the plowing of prairies, also have great and long-lasting effect. The most pervasive and potentially damaging changes occurring now are the continuing fragmentation of habitats (now more a result of rural and suburban development than farming and forestry use), the accelerating fragmentation of ownership parcels into smaller and smaller tracts, and sprawling growth. These changes have debilitating impacts to many of our native species and the natural systems that support them.

At their root, these changes are a function of how we choose to use land and how many of us there are. As described earlier, the state's population is climbing at a relatively consistent rate. More importantly though, Wisconsinites use significantly more developed land per person now than fifty years ago. Housing has become more affordable in recent decades to a growing percentage of the population and about 70% of Wisconsinites now own their homes (U.S. Census Bureau. See *http://quickfacts.census.gov/qfd/states/55000.html*). Yet, houses today are typically bigger and sit on larger lots than 50 years ago. In addition, new commercial and retail establishments tend to be larger, more spread out, and devote more space to parking than those in older neighborhoods. This reduction in the density of development, combined with our growing population, has led to a significant expansion of the amount of land devoted to our cities and suburban areas. Lower density developments that are spread out can also result in significant costs to local communities to provide police and fire protection, schools, water and sewer, and other services.

Not only are our cities growing, their "fringes" are becoming increasingly wide. A growing number of people are drawn to housing that is within commuting distance of their work but where they can "get away" from urban life. As more and more of these scattered residential developments occur in an area, the rural setting that attracted people to the area in the first place is slowly degraded, which leads some to move farther and farther into the countryside. Since most Wisconsin cities are surrounded by farms, much of this growth consumes agricultural land and is a primary reason the state has lost almost 4,000,000 acres of farmland in the last 30 years (Wisconsin Agricultural Statistics Service. See *http://www.nass.usda.gov/wi/misc/nofmhist.htm*).

Concurrent with the increase in housing, commercial, and industrial development is the growth in our "developed infrastructure" (*e.g.*, roads, schools, wastewater treatment plants, landfills, and utility lines). This infrastructure is an integral part of our strong economy and quality of life. Exact figures for how much land is devoted to our developed infrastructure do not exist, but almost 1,000,000 acres are estimated within our road network alone.

Reflecting its scenic beauty and abundant recreation opportunities, Wisconsin is also experiencing considerable growth in second home development. Although occurring throughout the state, growth in the number of homes for seasonal and retirement use is highly concentrated in northern Wisconsin, particularly along lakes. As the number of available and affordable lake lots has dwindled, significant development pressure has shifted to places that, 25 years ago, few people would have considered desirable for a second home: rivers, streams, very small lakes, "farmettes," woodlots, ridges, and hilltops. With expansions of our road network and the apparent willingness of some people to travel further distances to "get away," even once remote areas are now under considerable land use pressures. Often, people are drawn to the quietest, most scenic and pristine sites they can find—typically places that are of high ecological value, sensitive to development impacts, and increasingly rare.

Along with the growth in second homes has been a dramatic rise in the demand for recreational land for personal use. As a result, many former farms and large wooded tracts have been divided into 80, 40, and 20-acre parcels. As rural land is fragmented and increasingly owned by non-residents, land uses often change. In some cases, agricultural fields are taken out of production, forest and game management goals shift, and lands once open for public recreation are posted with "No Trespassing" signs. These changes can have dramatic impacts on local economies and the cultural identities of our rural communities.

Agricultural land

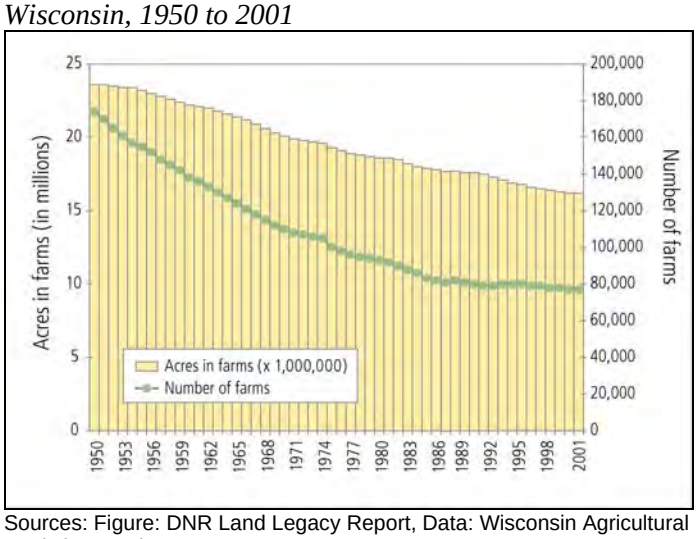
The following summary is from the DNR's Land Legacy Report

Wisconsin farms substantially contribute to local and state economies. It is estimated that over 500,000 people in the state rely directly on agriculture for their jobs. Wisconsin farmers produced and marketed milk, crops and livestock valued at $5.9 billion in 2001. [See *http://www.nass.usda.gov/wi/annbull/page5.pdf* and also *http://www.wfbf.com/Facts.htm#impact*] Although the farming lifestyle is often romanticized in popular culture, in reality farming is a business subject to a variety of economic, social, and environmental forces that shape and influence decisions. Just as other business owners do, farmers and their families make choices about how to most effectively and efficiently manage their talents and capital investment—their land, machinery, buildings, and livestock. Because farming uses large tracts of land that remain primarily undeveloped, unlike many other businesses, it can also help meet some important conservation and recreation needs.

Most farms in Wisconsin are a mix of agricultural fields, pasture, scattered woodlots, and occasional creeks and wetlands. Together, these environments provide habitat for many game and non-game species. Farmland also provides valuable "open space," allowing species to move from one area to another. And when situated adjacent to conservation lands, farms provide a buffer that eases the transition—ecologically, recreationally, and aesthetically—between our parks, forests, and wildlife, fishing, and natural areas and nearby residential, commercial, and industrial areas. Issues that affect the agricultural economy have a large impact on how land in Wisconsin is used, and will ultimately be used, and how successful efforts to meet conservation and recreation needs will likely be. This is particularly true in the southern and eastern parts of the state, where farming is the dominant land use.

The farming community has experienced dramatic changes over the past fifty years. The amount of land in farms has dropped from 23.6 million acres in 1950 to 16.2 million acres in 2001 (an average loss of 145,000 acres a year). Similarly, during those 51 years, the number of farms has fallen from approximately 174,000 to 77,000 (Figure 29). The size of the average farm steadily increased from 135 acres in 1950 to 221 acres in 1991 (it has been hovering around 210 acres for the last several years). Yet, due to a variety of economic factors, farm size has undergone a dichotomous change.

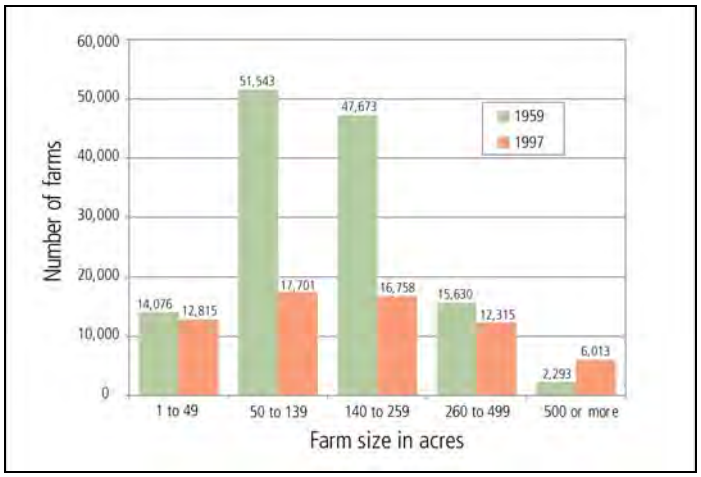
Figure 29 - Number of farms and total acres in farms in Wisconsin, 1950 to 2001



Sources: Figure: DNR Land Legacy Report, Data: Wisconsin Agricultural Statistics Service
See http://www.nass.usda.gov/wi/misc/nofmhist.htm

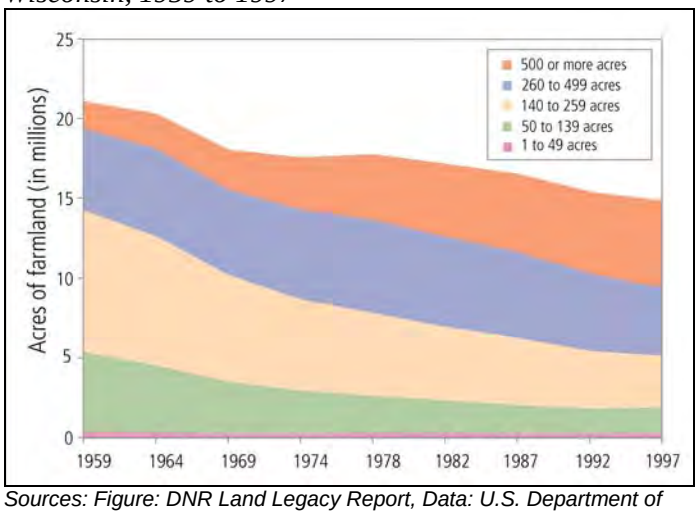
From 1959 to 1997,34 the number of “medium” sized farms—those between 50 and 259 acres—fell dramatically from 99,000 to 34,000 (Figure 30a). The number of smaller farms remained relatively constant and the number of farms over 500 acres more than doubled. This change in the number of small, medium, and large farms has led to a dramatic shift in who owns and manages remaining farmland. As Figure 30b shows, in 1959, two-thirds of Wisconsin’s farmland was held in farms less than 260 acres. By 1997, the situation had flip-flopped; two-thirds of farmland was held in farms with 260 or more acres (and more than one-third of remaining farmland was in farms with 500 or more acres).

Figure 30a - Number of farms in Wisconsin by size, 1959 and 1997



Sources: Figure: DNR Land Legacy Report, Data: U.S. Department of Agriculture, Census of Agriculture. For most recent data, See *http://www.nass.usda.gov/census/census97/volume1/wi-49/toc97.htm.*

Figure 30b - Total acres held by different size farms in Wisconsin, 1959 to 1997



Sources: Figure: DNR Land Legacy Report, Data: U.S. Department of Agriculture, Census of Agriculture.
See http://www.nass.usda.gov/census/census97/volume1/wi-49/wi1_08.pdf

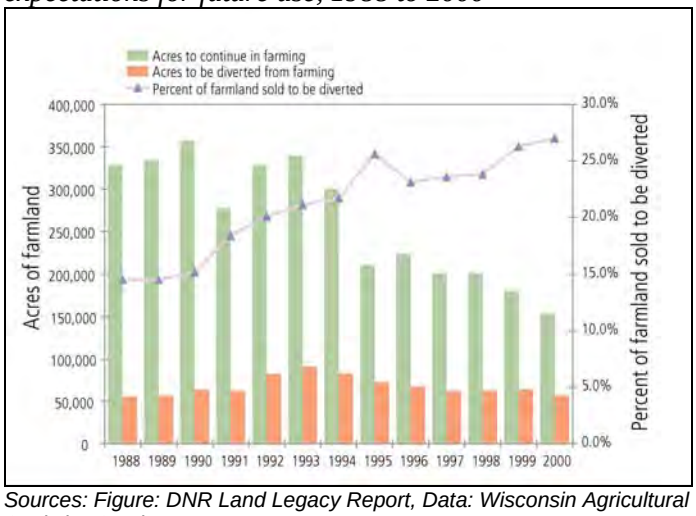
The distribution of small and large ownership parcels is not uniform across the agricultural part of the state. A quick look at nearly any plat book in the southern part of the state shows that the closer one is to cities, the more likely it is that ownership holdings are smaller. Rural areas within commuting distance of cities are typically a mix of mid-sized parcels (40 to 260 acres, many of which contain some active farm fields), smaller parcels (5 to 20 acres, many of which have homes

on them), and scattered subdivisions. Larger ownerships (over 260 acres) tend to be distant from urban centers.

When residential developments begin to spread into an agricultural area, changes occur that are often self-perpetuating. Some new non-farming residents are not prepared for the practices that accompany most farm operations. Manure spreading, loud machinery, chemical application, and other day-to-day activities sometimes lead to conflicts between new residents and farmers. Some new non-farming landowners, particularly those that do not rely on farmland as a source of yearly income, decide not to rent out their farm fields to nearby farmers. If landowners elect not to rent out their pasture or cropland, nearby farmers are forced to travel farther, pay higher rents, or both, to find additional lands to farm. Between 25 and 30% of farmland in Wisconsin is rented, and many farmers need to rent cropland and pastures in order to keep their operations economically viable. (U.S. Department of Agriculture, Census of Agriculture. See *http://www.nass.usda.gov/census/census97/aelos/tbl05.pdf*). Hauling machinery long distances on roads presents serious safety and traffic flow problems.

Owners of newly acquired farmland are surveyed to determine how they anticipate using the land in the future. As Figure 31 indicates, when asked what their expectations are for their newly acquired farmland, owners of 27% of the farmland sold in 2000 already had decided to divert the land to other uses. As new developments occur in areas once dominated by agriculture, the value of land typically climbs. If the price of farmland far exceeds its "farming value," farmers cannot purchase or rent an adequate land base for their operations.

Figure 31 - Acres of farmland sold and new owners' expectations for future use, 1988 to 2000



Sources: Figure: DNR Land Legacy Report, Data: Wisconsin Agricultural Statistics Service
For most recent data, see *http://www.nass.usda.gov/wi/landsales/total01.pdf*

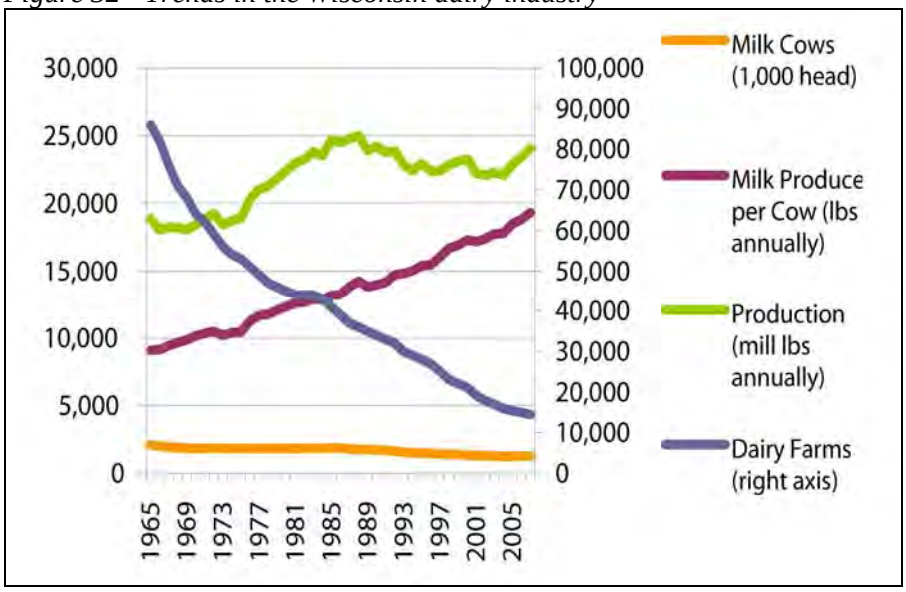
Together, these social and economic pressures can often lead farmers to sell their land, sometimes cleaving off pieces over time or, in other cases, selling their entire business operation and their land base. In either case, as the number of farms and the amount of land in farms declines, the area's service industry that supports the agriculture economy—seed, chemical, and implement dealers, mechanics, veterinarians, farm credit organizations, and others—also declines, thus exacerbating the difficult conditions for remaining farmers.

Combined with the aging population of our farmers, this economic situation is likely to result in rapid changes to our rural countryside. In a 1999 study, when asked to estimate how long they would be able to continue farming given their financial situation and age, one-third of Wisconsin's farmers did not expect to be farming in five years (Jackson-Smith, Douglas, Sunung

Moon, Marcia Ostrom, and Bradford Barham. *Farming in Wisconsin at the End of the Century: Results of the 1999 Wisconsin farm poll.* Program on Agricultural Technology Studies, Wisconsin Farm Research Summary No. 4, University of Wisconsin–Madison, 2000)

The dairy farming industry in Wisconsin has shown a similar pattern. Dairy farms are declining in number, increasing in size, and increasing in productivity (http://www.nass.usda.gov/Statistics_by_State/Wisconsin/index.asp). Wisconsin dairy operations are also relying more heavily on hired labor (Harrison, Lloyd and O'Kane, February 2009, *Overview of Immigrant Workers on Wisconsin Dairy Farms. Program on Agricultural Technology Studies (PATS), Room 202 Taylor Hall, University of Wisconsin-Madison*. See: http://www.pats.wisc.edu/projects/2). This information is shown in Figure 32, and is also from this study.

Figure 32 - Trends in the Wisconsin dairy industry



Developed land

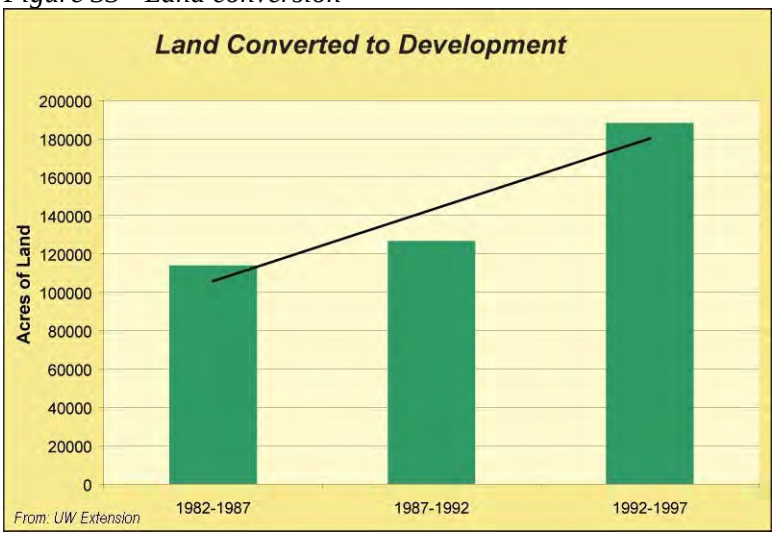
Urban sprawl - low density development near urban areas - has been a common development pattern in Wisconsin since the 1940's. In more recent decades, rural sprawl has become more common. Rural sprawl is the movement of people from urban and suburban areas to rural areas due to the open space amenities offered by rural areas. This migration is largely enabled by the weak land-use regulations and relatively low land prices in many rural areas. Such rural sprawl often has the effect of natural habitat alteration, fragmentation, and destruction. (Housing Megatrends, UW Extension)

The ownership fragmentation, or “parcelization,” of our countryside has significant implications for how the Department and others interested in conservation and recreation issues approach land protection efforts. it is our experience that ownership fragmentation often leads to habitat fragmentation, primarily through construction of new residences and the installation of associated infrastructure, such as roads and transmission lines. With new residences come demands for more gas stations, convenience stores, restaurants, and other establishments. this conversion of land use can make efforts to implement protection strategies more difficult and expensive (DNR Land Legacy Report).

The conversion of land from undeveloped to developed has been steady trend in Wisconsin. Figure 33, below, shows the amount of land converted between 1982 and 1997. A total of 670

square miles of undeveloped land was converted to developed during this 15 year span. This is an area roughly the size of Eau Claire County. The pace of land conversion may be increasing so that in the 15 year span from 1997 to 2012, another 882 square miles would be converted. (Housing Megatrends, UW Extension)

Figure 33 - Land conversion



As discussed previously, CAFOs, to the extent they are economically viable, tend to maintain open agricultural lands and inhibit conversion to other uses.

Figure 34, below, is from UW Extension, and provides insight into regional housing growth patterns in Wisconsin.

Figure 34 - Regional housing growth

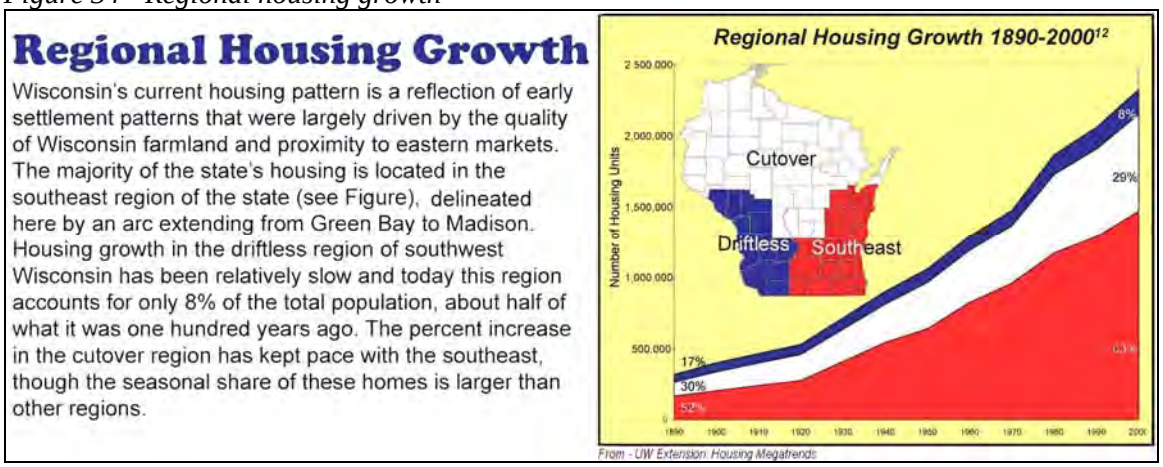
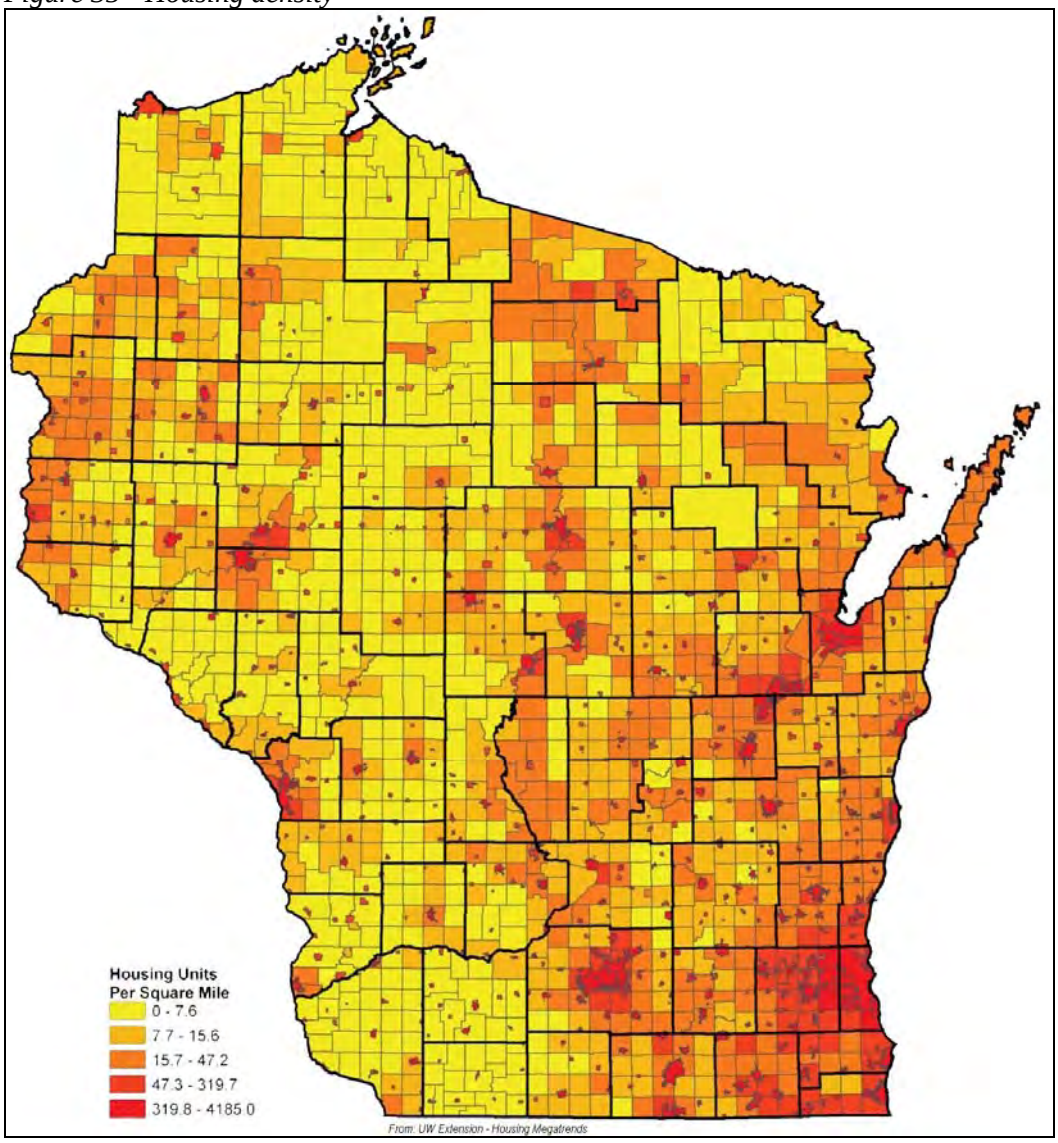


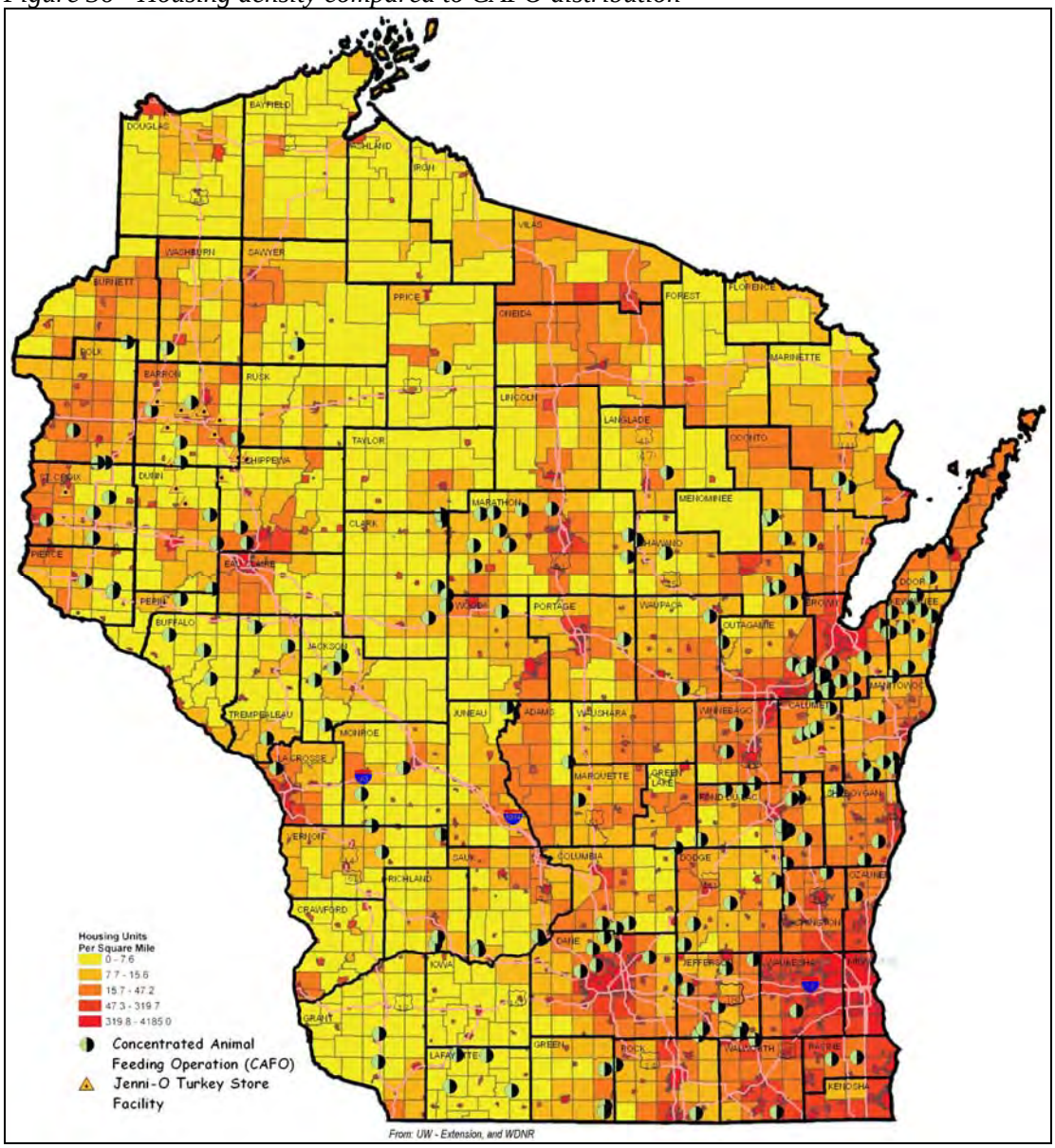
Figure 35, below, shows current housing density levels per square mile. For this figure, a "housing unit" is defined as a house, an apartment, a mobile home, a group of rooms, or a single room that is occupied or intended for occupancy as separate living quarters. Areas with higher housing densities include southeast Wisconsin, the Fox River Valley, western Wisconsin near the Twin Cities, and areas with amenities, such as Adams, Juneau, Oneida and Vilas Counties.

Figure 35 - Housing density



The distribution of CAFOs (see Figure 1 - Geographic Distribution of CAFOs in Wisconsin in Section IV.B.1) is overlaid on the housing density figure in Figure 36, below. This figure shows that CAFOs may be near, but do not tend to be within areas with high housing densities. Moderate housing densities and CAFOs do not appear to be mutually exclusive. CAFOs and higher density housing areas do not tend to occur in the same areas, however.

Figure 36 - Housing density compared to CAFO distribution



Not to scale

Wisconsin commuters that live in non-metropolitan areas tend to commute longer distances to work than those in metropolitan areas. Figure 37, below, illustrates this point. Areas tending to have the longest commute distances are Iron, Burnett, Adams and Crawford counties. Commuting constitutes 28% of miles traveled in Wisconsin. Most workers (89%) drive to work. Transportation constitutes 25% of state energy use, and vehicle miles have doubled since 1970 in Wisconsin.

Figure 37 - Commuters driving >50 miles to work each way

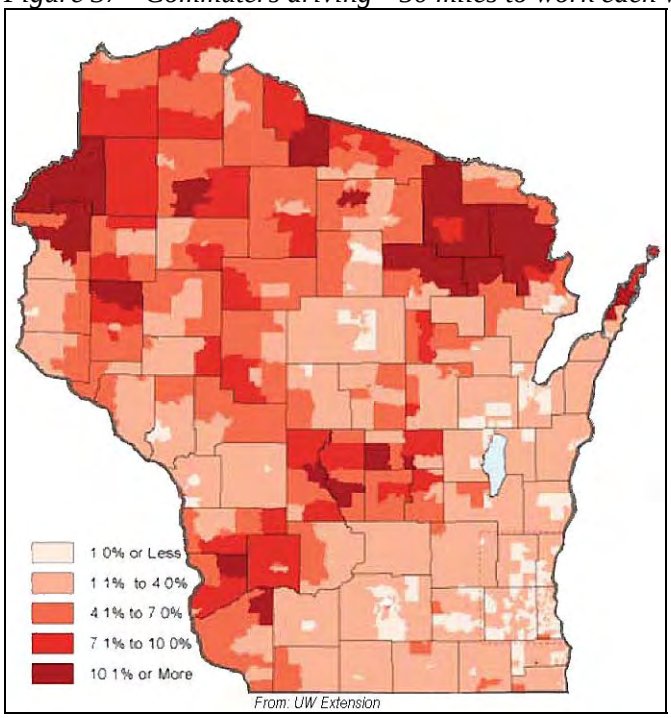
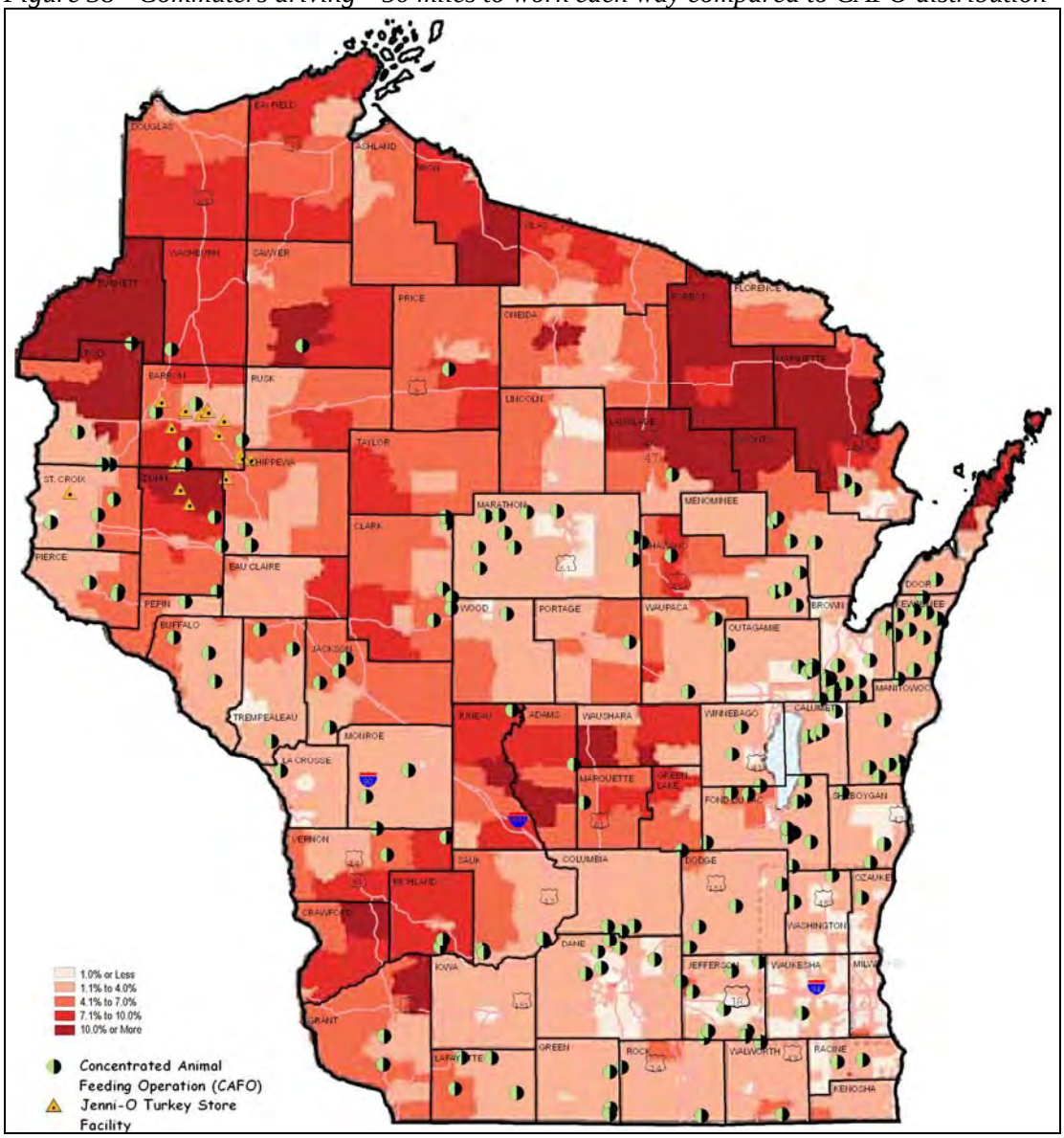


Figure 38, below, compares commuting distance and the current distribution of CAFOs (see Figure 1 - Geographic Distribution of CAFOs in Wisconsin in Section IV.B.1) in Wisconsin. The map shows that current CAFO locations do not appear to be strongly associated with areas in which workers are making unusually long commutes to work.

Figure 38 - Commuters driving >50 miles to work each way compared to CAFO distribution



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Land Use Planning

The development of large scale dairy operations, or other CAFOs, often can result in a variety of real or perceived land use conflicts. Significant issues include (U of MN Generic EIS on Animal Agriculture, 1999):

- Environmental concerns (odor, air and water pollution, manure handling and storage),
- human health concerns,
- nuisances (ag. use versus non-ag-use, large versus small),
- differing rural aesthetics,
- threat to traditional rural culture,

- use of land for agriculture versus use for tourism/recreation,
- fear of property value reduction,
- fear of rural “brownfields” (contaminated sites that cannot be reused for other purposes without significant cleanup).

Some of these issues may be addressed by developing or updating a land use plan and zoning ordinance to head off land use conflicts in the future. Environmental and human health issues can be avoided or minimized by adherence to appropriate permit conditions.

CAFOs typically will not have much impact on existing zoning. CAFO owners typically select sites because of existing Ag 1 zoning and the likelihood it would remain the same. In the long term the presence of CAFOs may result in fewer parcels being rezoned or given conditional use permits to allow other uses.

Crops will continue to be grown to provide feed for animals at CAFOs. These animals generate a large volume of manure. Disposal of this manure typically provides an alternative to purchasing commercial fertilizers to enhance the soil and grow crops in local areas. Nutrient Management Plans require certain conditions be met for land application of that manure. Nutrient Management Plan requirements include separation distances from water resources and other land features to ensure increased protection of water resources. Since not all farms have NMPs, this may result in more protection of water quality conditions.

Figure 39, below, shows the townships and counties that have submitted final, adopted comprehensive land use plans to the Wisconsin Department of Administration (WDOA) as of January 2009.

Figure 39 - Land use plans received by WDOA

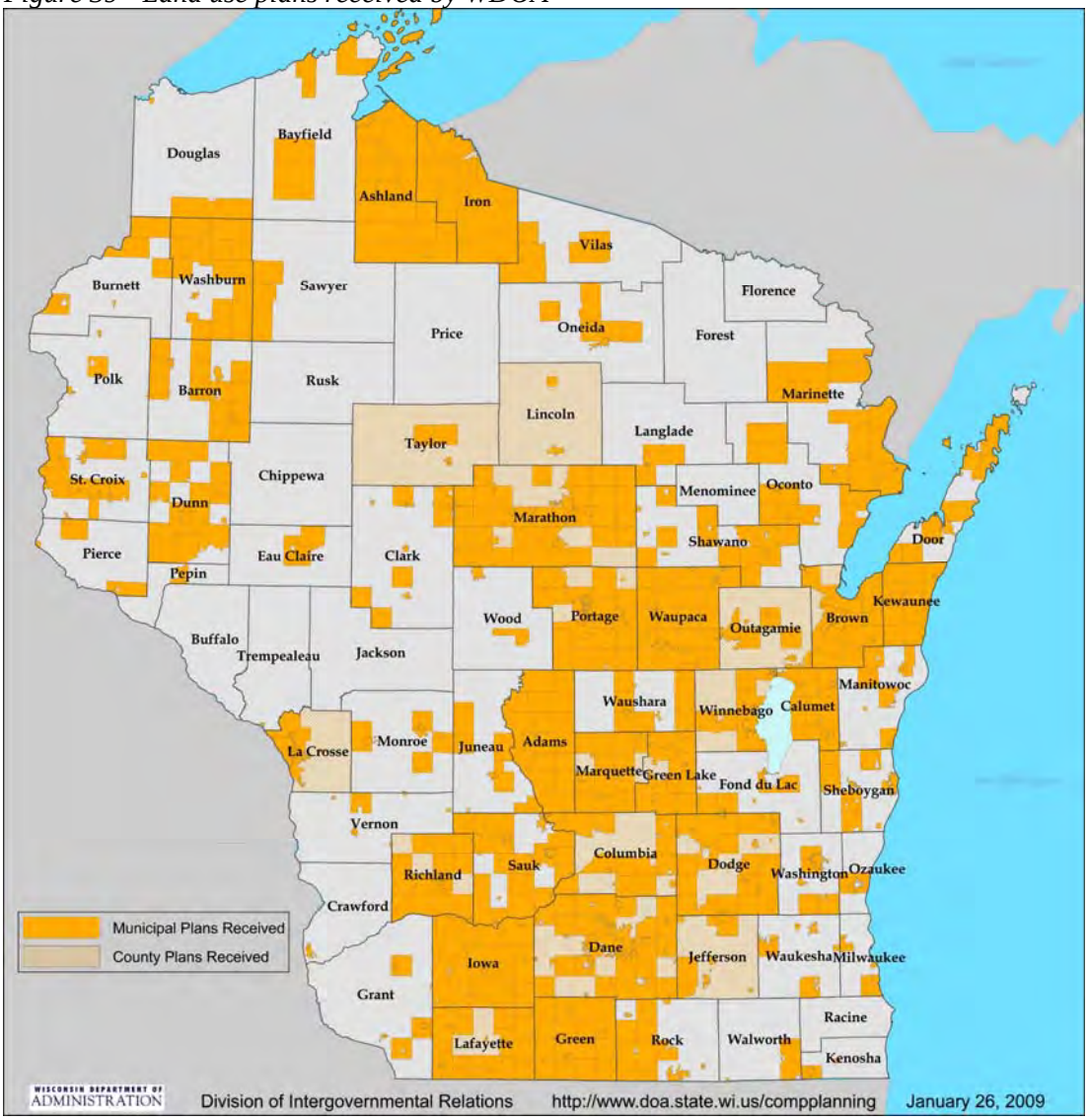
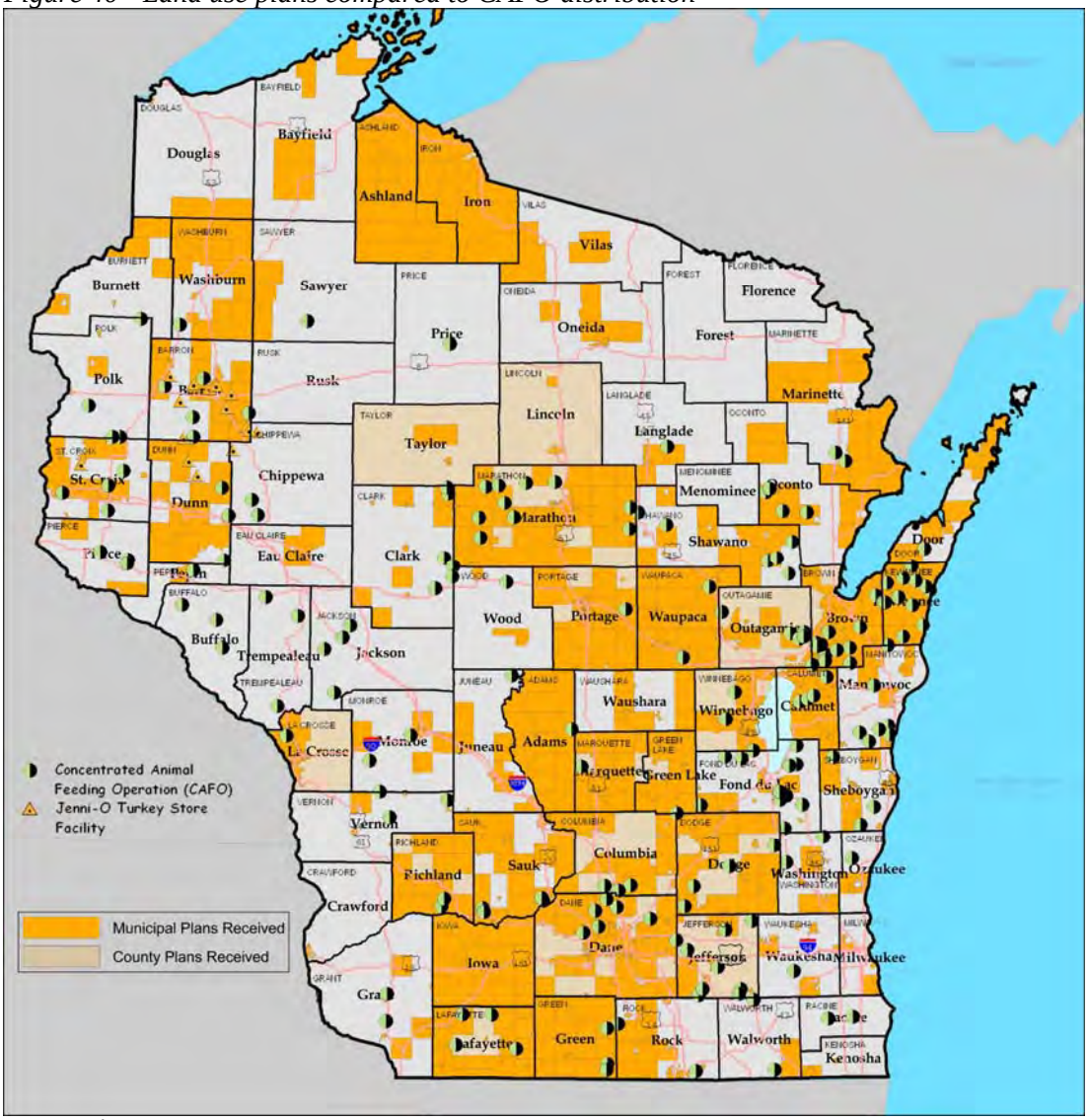


Figure 40, below, is the result of overlaying the distribution of CAFOs (see Figure 1 - Geographic Distribution of CAFOs in Wisconsin in Section IV.B.1) on the land use plans map. The map indicates that many CAFOs occur in areas with land use plans.

Figure 40 - Land use plans compared to CAFO distribution



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Recreation

DNR's Statewide Comprehensive Outdoor Recreation Plan (SCORP) reports that Wisconsinites are active participants in most forms of outdoor recreation. Recreation participation rates within Wisconsin are higher than most other regions of the country. This may be attributed to the combination of Wisconsin's abundant recreation resources as well as the state's four season climate, a resource that allows for recreating in every season (DNR SCORP, p. 2-2, http://dnr.wi.gov/planning/scorp/plan/WIS_2005-10_SCORP_CHAPTER_1.pdf).

Table 17 lists all Wisconsin resident outdoor recreation activities surveyed in the SCORP.

Table 17 - Wisconsin outdoor recreation participants by activity (Age 16+)

Activity	Percent Participating	Number of Participants (1,000s)
Walk for pleasure	85.8	3,567
Family gathering	78.9	3,280
View/photograph natural scenery	67.5	2,806
Gardening or landscaping for pleasure	65.3	2,715
Visit nature centers, etc.	65.3	2,715
Driving for pleasure	60.3	2,507
View/photograph other wildlife	57.0	2,369
Attend outdoor sports events	56.9	2,365
Picnicking	56.6	2,353
Sightseeing	55.3	2,299
View/photograph wildflowers, trees, etc.	50.0	2,079
Bicycling	49.3	2,049
Visit a beach	47.3	1,966
Swimming in lakes, streams, etc.	45.8	1,904
Visit historic sites	45.2	1,879
Yard games, e.g., horseshoes	44.8	1,862
View/photograph birds	40.9	1,700
Fishing – freshwater	40.7	1,692
Gather mushrooms, berries, etc.	39.5	1,642
Attend outdoor concerts, plays, etc.	38.5	1,600
Visit a wilderness or primitive area	38.3	1,592
Swimming in an outdoor pool	38.3	1,592
Visit outdoor theme/water park	37.6	1,563
Fishing – warmwater	37.0	1,538
Motorboating	36.4	1,513
Day hiking	35.0	1,455
Camping – developed	32.3	1,343
Visit a farm or agricultural setting	31.8	1,322
Running or jogging	29.4	1,222
Sledding	29.3	1,218
View/photograph fish	28.1	1,168
Visit other waterside (besides beach)	26.4	1,097
Golf	25.9	1,077
Off-road driving with an ATV	23.4	973
Canoeing	20.5	852
Mountain biking (off-road)	20.4	848
Target shooting	20.2	840
Inline skating	20.0	831
Visit prehistoric/archeological sites	19.4	806
Hunting – big game	19.2	798
Trail running	18.6	773
Snowmobiling	18.3	761
Mountain biking (single track)	18.0	748
Off-road 4-wheel driving (SUV)	17.7	736
Ice skating outdoors	16.6	690
Nature-based educational programs	16.3	678
Camping – primitive	16.0	665
Volleyball outdoors	14.8	615
Hunting – small game	14.5	603
Rafting	14.4	599
Fishing – coldwater	13.9	578
Visit a dog park to walk a pet	12.4	515
Tennis outdoors	12.3	511
Waterskiing	12.2	507
Basketball outdoors	11.6	482
Boat tours or excursions	11.5	478
Skiing – cross-country	11.4	474
Fishing – ice	11.4	474
Fishing – Great Lakes	11.0	457
Hunting – upland birds	10.5	436
Rowing	10.1	420
Softball	10.1	420
Horseback riding (any type)	9.8	407
Soccer outdoors	9.8	407
Use personal watercraft	9.7	403
Skiing – downhill	9.7	403
Disc golf	8.8	366
Horseback riding on trails	8.1	337
Snowshoeing	8.0	333
Snorkeling	7.7	320
Baseball	7.0	291
Football	7.0	291
Backpacking	6.9	287
Paintball games	6.6	274
Rock climbing	5.9	245
Off-road motorcycling	5.9	245
Hunting – migratory bird	5.0	208
Handball or racquetball outdoors	5.0	208
Sailing	4.9	204
Fishing – fly	4.8	199
Snowboarding	4.7	195
Ice hockey outdoors	4.0	166
Mountain climbing	3.4	141
Orienteering	2.7	112
Skateboarding	2.6	108
Kayaking – recreation/sit-on-top	2.4	99
Skiing – telemark	2.4	99
Geocaching	2.0	83
Kayaking – whitewater	1.8	75
Caving	1.6	67
Scuba diving	1.3	54
Dog sledding	1.1	46
Windsurfing	0.7	29
Surfing	0.3	12
Kayaking – touring/sea	0.2	8

Source: DNR SCORP

As part of the SCORP, approximately 1,300 residents were surveyed and asked which barriers caused them to not recreate as often as they would have liked. This question was open ended, allowing respondents to provide up to three different barriers. Responses gathered were then divided into two categories: personal and environmental barriers. The most commonly listed of

these barriers are provided in Table 18 below (DNR SCORP, p. 2-17, http://dnr.wi.gov/planning/scorp/plan/WIS_2005-10_SCORP_CHAPTER_1.pdf).

Table 18 - Most common personal & environmental barriers to outdoor recreation in Wisconsin

Personal Barriers	Environmental Barriers
1. Lack of time	1. Distance/travel time
2. Family commitments	2. Lack of access to public lands
3. Job/work	3. Lack of information about where to go
4. Crowding	4. Not enough campsites/electric sites
5. Conflicts with motorized uses	5. Noise from ATVs and other motorized uses
6. Cost	6. Lack of bike trails
7. Age	7. Lack of public transportation
8. Fuel prices	8. Lack of snow

Source: DNR SCORP

It is important to note that conflicts with CAFOs or other agricultural land uses are not listed as being an important barrier to outdoor recreation in Wisconsin. The SCORP does not list conflict with agriculture as being a recreation barrier. The SCORP did, however, find that environmental damage is the most frequently sited source of conflict for recreation in Wisconsin (SCORP, p. 4-2). It is possible that CAFOs could be perceived as being a portion of that source of conflict.

Public recreation lands

Publicly owned lands are important components of Wisconsin's recreational supply. The three primary public providers of recreation lands are: federal, state and local units of government.

Federal recreation providers in Wisconsin include the United States Department of Interior (the parent agency of the National Park Service and the Fish and Wildlife Service), the United States Department of Agriculture Forest Service, the Bureau of Land Management, and the U.S. Army Corps of Engineers. These providers offer opportunities for both active and passive recreation and are also actively involved in the conservation of forest, prairie, and water resources. Federally owned recreation lands in Wisconsin are therefore tied with the preservation of open space and natural resource management. Recreational activities provided in these areas are generally nature-based and non-destructive: hiking, camping, fishing, hunting, nature study, canoeing, boating, swimming, and similar activities.

The Wisconsin Department of Natural Resources (WDNR) has two divisions, Lands and Forestry, which provide the majority of state-owned recreational lands and facilities. Through these divisions, the WDNR plays a significant role in identifying and conserving areas of unique and valuable natural resources across the state. State WDNR lands that include park and natural areas provide a wide variety of outdoor recreation resources within Wisconsin. The distribution of state parks and wildlife areas affords excellent accessibility to users throughout the state. These lands offer a wide range of recreation such as camping, hunting, fishing, canoeing, bird watching, horseback riding, and hiking. The WDNR Division of Forestry manages six state forests that offer diverse recreational opportunities including hunting, birding, swimming, and interpretive driving tours. Recreation opportunities provided by the State of Wisconsin are similar in type to those provided by federal agencies. As on federal properties, the preservation of open space and conservation of natural resources are critical components of state-owned land management.

In addition to federal and state providers, there are many counties, cities, villages, and towns throughout Wisconsin that provide opportunities for both active and passive outdoor recreation.

Many counties, particularly in the northern part of the state, manage extensive tracts of forest land for hunting, camping, and other forms of outdoor recreation. As Table 19 indicates, these county owned forests and parks provide the largest amount of publicly owned acreage in the state. At the municipal level, the primary focus of outdoor recreation includes the provision of athletic fields, outdoor courts, playfields, playgrounds, and support facilities. Cities, villages, and townships manage the smallest amount of public acreage, together controlling just 1% of total public lands (DNR SCORP, p. 3-2, http://dnr.wi.gov/planning/scorp/plan/WIS_2005-10_SCORP_CHAPTER_1.pdf).

Table 19, below, shows the amounts of conservation and recreation land in the state by type of ownership.

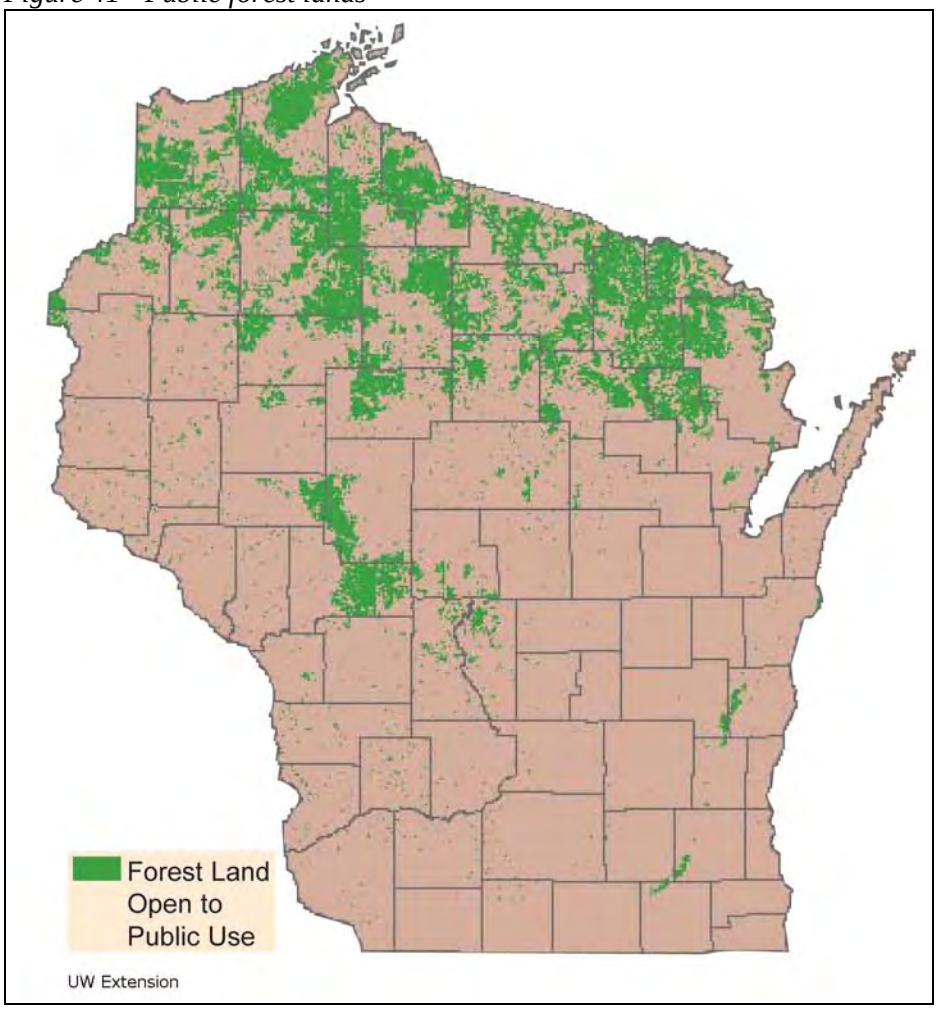
Table 19: Conservation & recreation lands in Wisconsin by ownership in 2004

Public Ownership Type	Total Acreage	Percent of Total
Federal Government	1,795,030	31%
Wisconsin Department of Natural Resources		
Forests and Wild Rivers	624,470	10.4%
Park and Natural Areas	141,246	2.4%
Fisheries and Wildlife	600,978	10.2%
Total	1,366,694	23%
County Parks and Forests	2,594,625	45%
City, Village, and Township		
City	38,571	<1%
Village	12,677	<1%
Town	10,754	<1%
Total	62,004	1%
Total	5,782,353	100%

Source: DNR SCORP

Figure 41, below, shows publicly owned forest lands in Wisconsin. These lands are open to the public for forest recreation activities.

Figure 41 - Public forest lands



Overlaying the current distribution of CAFOs (see Figure 1 - Geographic Distribution of CAFOs in Wisconsin in Section IV.B.1) on this map results in Figure 42, below. As was seen previously with forest cover in general, CAFOs have not been located in public forest areas. There would not, therefore, seem to be a land use conflict between CAFOs and public forest recreation opportunities.

Figure 42 - Public forest lands compared to CAFO distribution

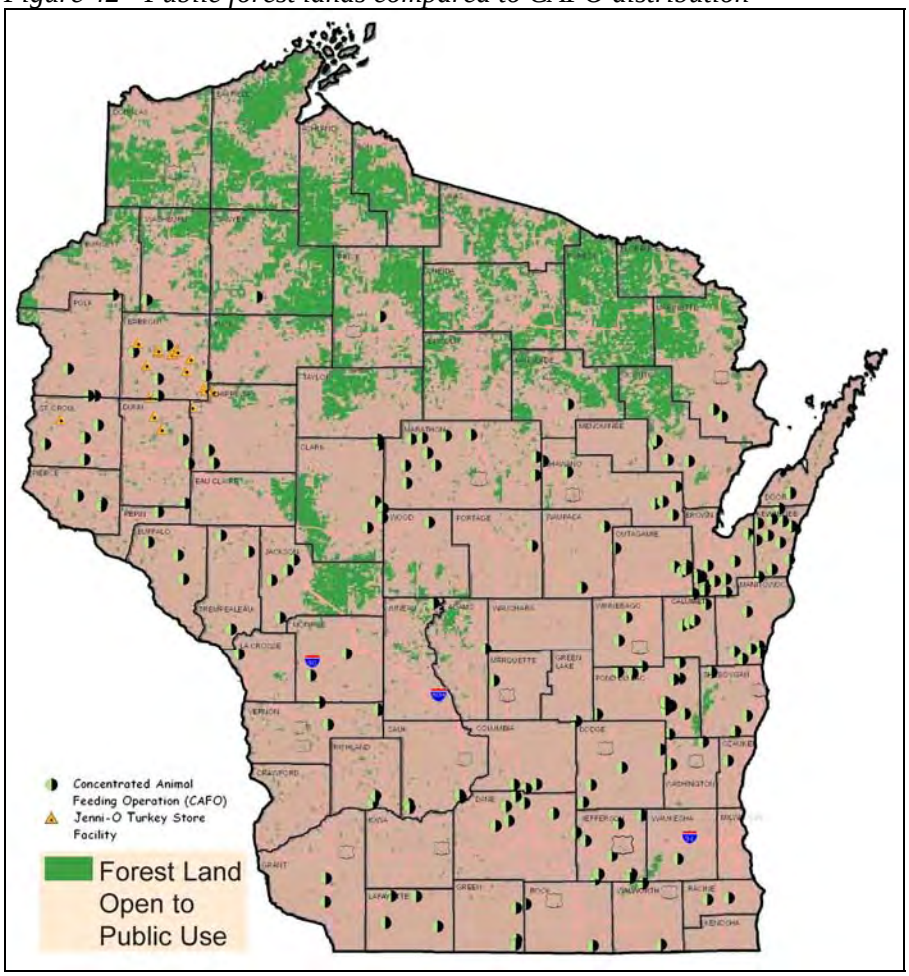


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Figure 43, below, shows the relative miles of recreational trails in each county normalized by the size of the county.

Figure 43 - Relative miles of recreation trails normalized by county size

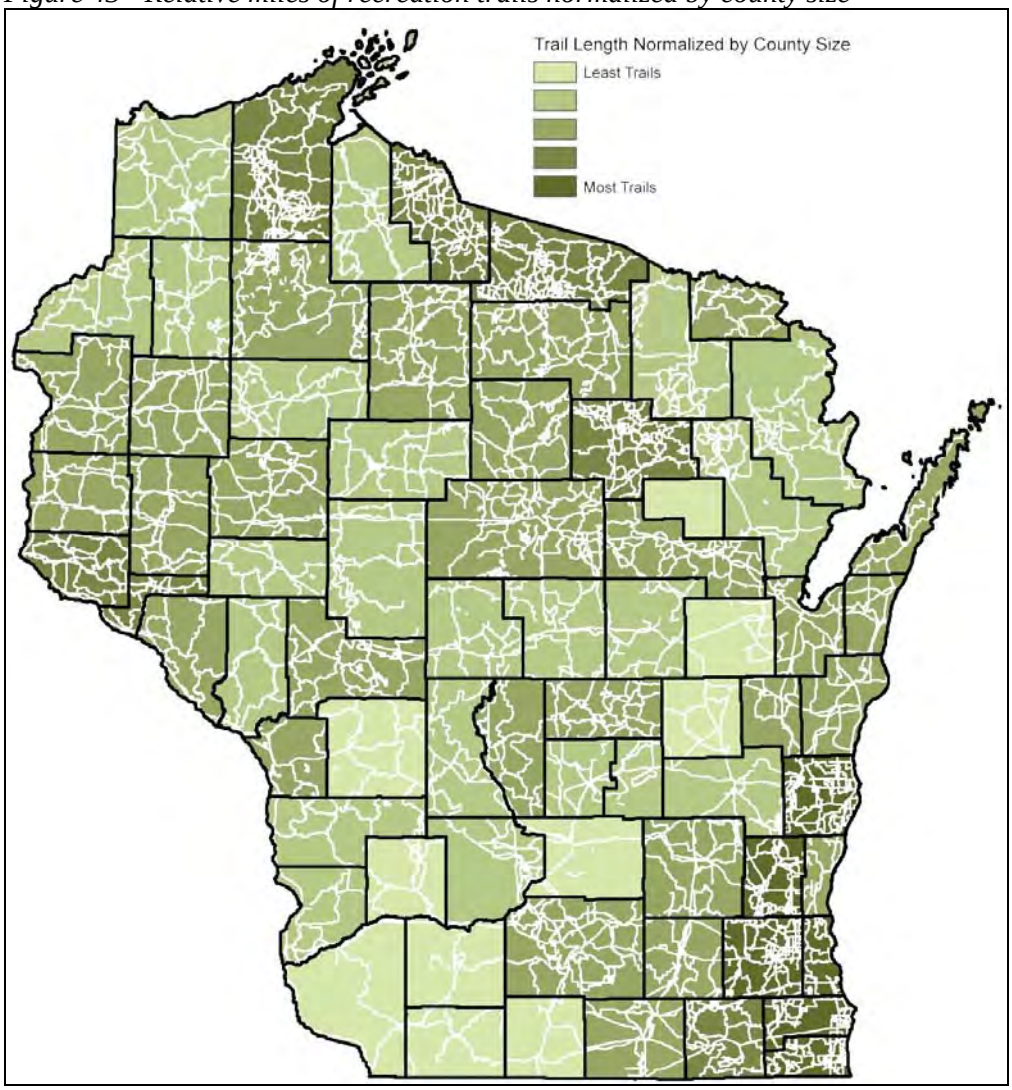
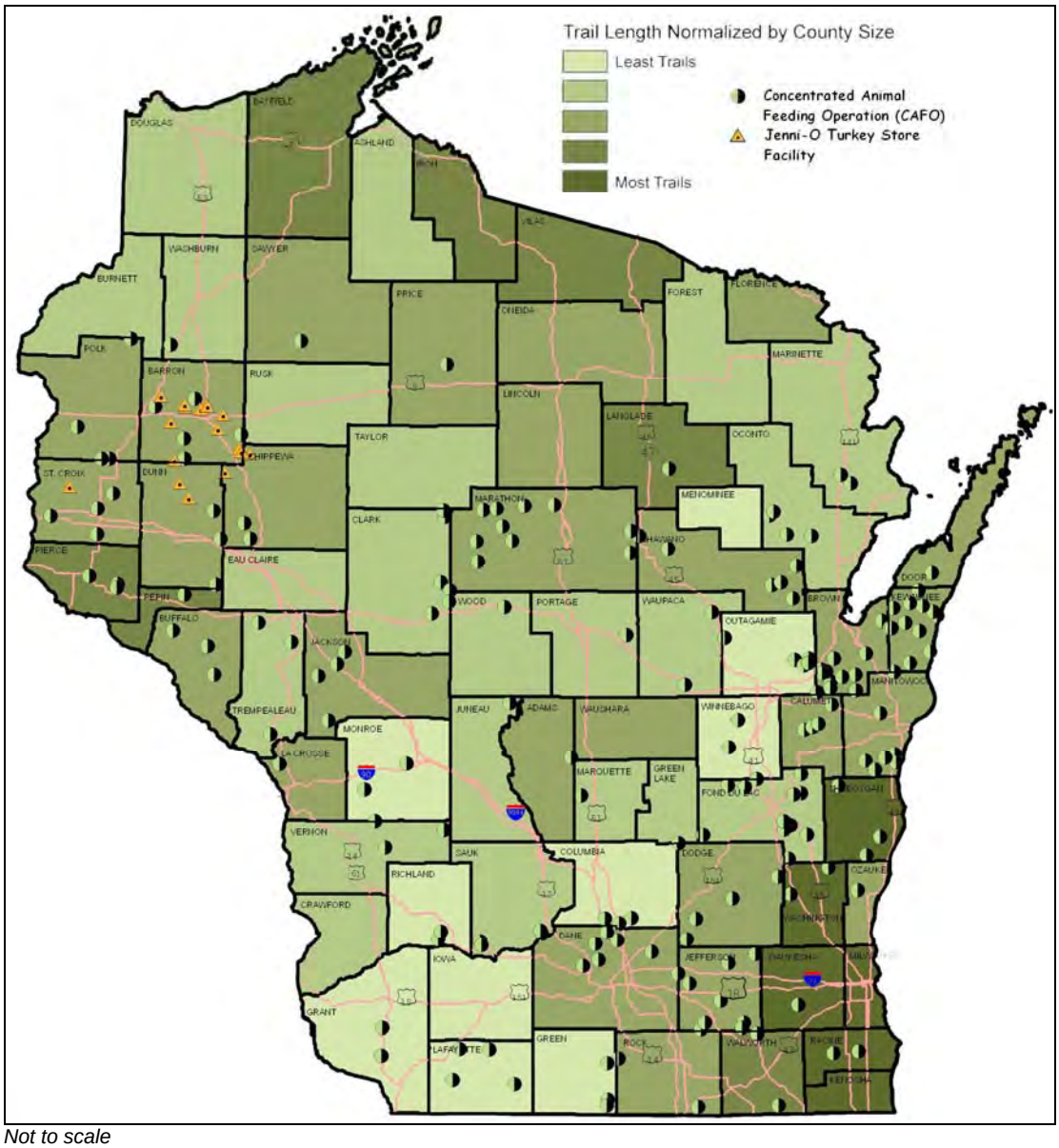


Figure 44, below, shows the current distribution of CAFOs (see Figure 1 - Geographic Distribution of CAFOs in Wisconsin in Section IV.B.1) as compared to the relative miles of recreational trails in each county normalized by the size of the county. The map show that CAFOs are often located in counties with average to above average miles of trails.

Figure 44 - Relative miles of recreation trails normalized by county size compared to CAFO distribution



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As reported in DNR's SCORP, a recent research study (Johnson and Beale, 2002) classified Wisconsin counties according to their dominant characteristics. One type of county identified in the study is the so-called “Non-Metro Recreation County.” These counties are characterized as having high levels of tourism, recreation, entertainment, and seasonal housing. They are defined as being counties with large amounts of undeveloped land available for recreational use and/or development. Natural amenities such as clean lakes, large forested areas, and recreational facilities (such as campgrounds) are also characteristics of Non- Metro Recreation Counties. Figure 45, below, illustrates the location of Non-Metro Recreation Counties in Wisconsin. Most Non-Metro Recreation Counties in Wisconsin are located in the northern and central parts of the state. Non-Metro Recreation Counties are generally considered to be vacation destinations for tourists. These counties provide large natural amenity-rich areas of land for outdoor recreating.

Non-Metro Recreation Counties have experienced especially high net migration rates and higher population growth rates than either Metro Counties or other Non-Metro Counties (Johnson and Beale, 2002). In Wisconsin the population of Non-Metro Recreation Counties has grown at a rate

of 1.9% per year, as compared to a Metro growth rate of 1.7% per year. The rate of housing development in Non-Metro Recreation Counties is also higher than in either other Non-Metro Counties or Metro Counties. In the period from 2000- 2004, Non-Metro Recreation Counties experienced a 7% increase in the number of housing units. During this same period, other Non-Metro Counties experienced a 5.6% growth in housing units and Metro Counties experienced a 6.1% growth in housing units (see Table 20) (DNR SCORP, p. 1-13, http://dnr.wi.gov/planning/scorp/plan/WIS_2005-10_SCORP_CHAPTER_1.pdf).

Table 20: Housing and population changes in non-metro recreation and non-recreation counties

	Number of Counties	Population Change			Housing Change		
		1970-1990	1990-2000	2000-2004	1970-1990	1990-2000	2000-2004
Non-Metro Recreation Counties	21	23.7%	15.3%	4.3%	64.3%	9.9%	7.0%
Other Non-Metro Counties	31	10.1%	8.5%	2.8%	37.0%	11.9%	5.6%
Metro Counties	20	9.4%	9.3%	3.1%	36.0%	13.9%	6.1%

Sources: DNR SCORP, Census (1950-2000), Wisconsin Dept. of Administration (2004)

Figure 45 - Non-Metro recreational counties

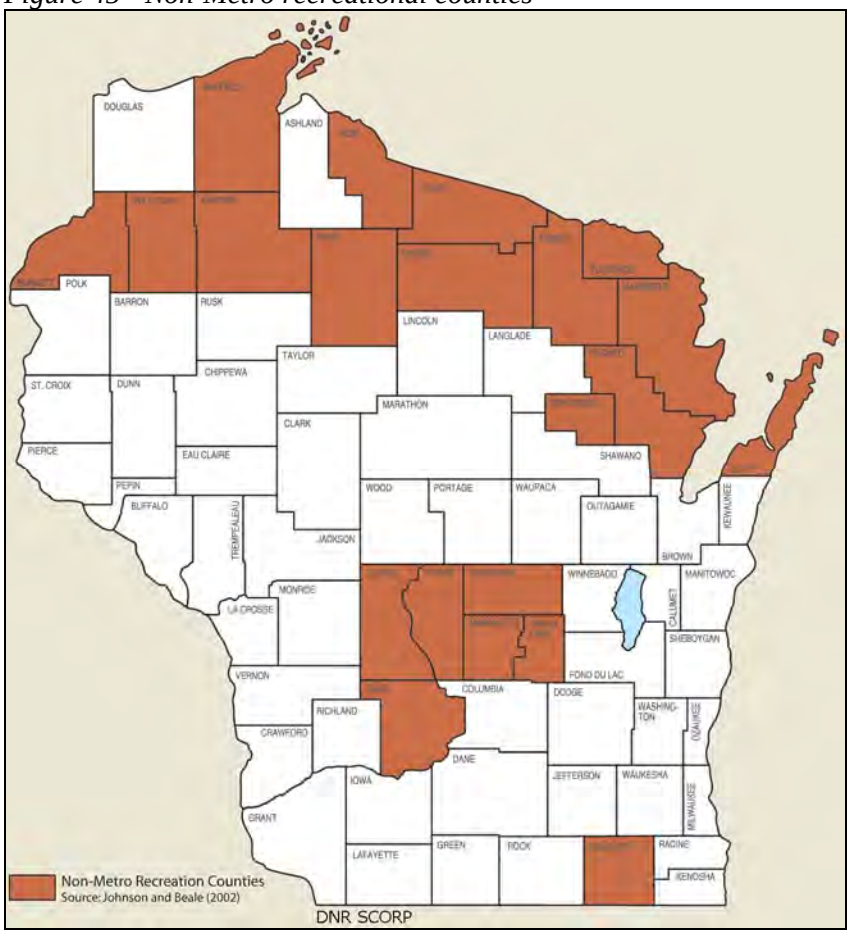
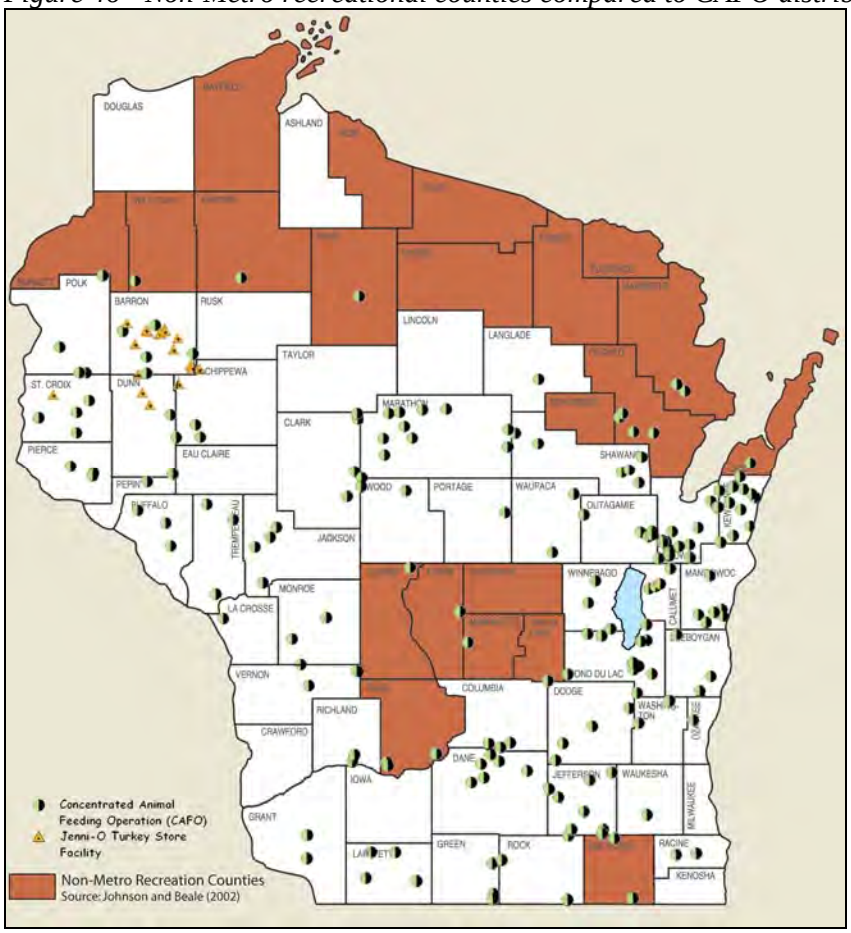


Figure 46, below, shows the distribution of current Wisconsin CAFOs (see Figure 1 - Geographic Distribution of CAFOs in Wisconsin in Section IV.B.1) overlaid on the non-metro recreational counties in the state. This figure clearly shows that the current distribution of CAFOS is not generally associated with non-metro recreational counties.

Figure 46 - Non-Metro recreational counties compared to CAFO distribution



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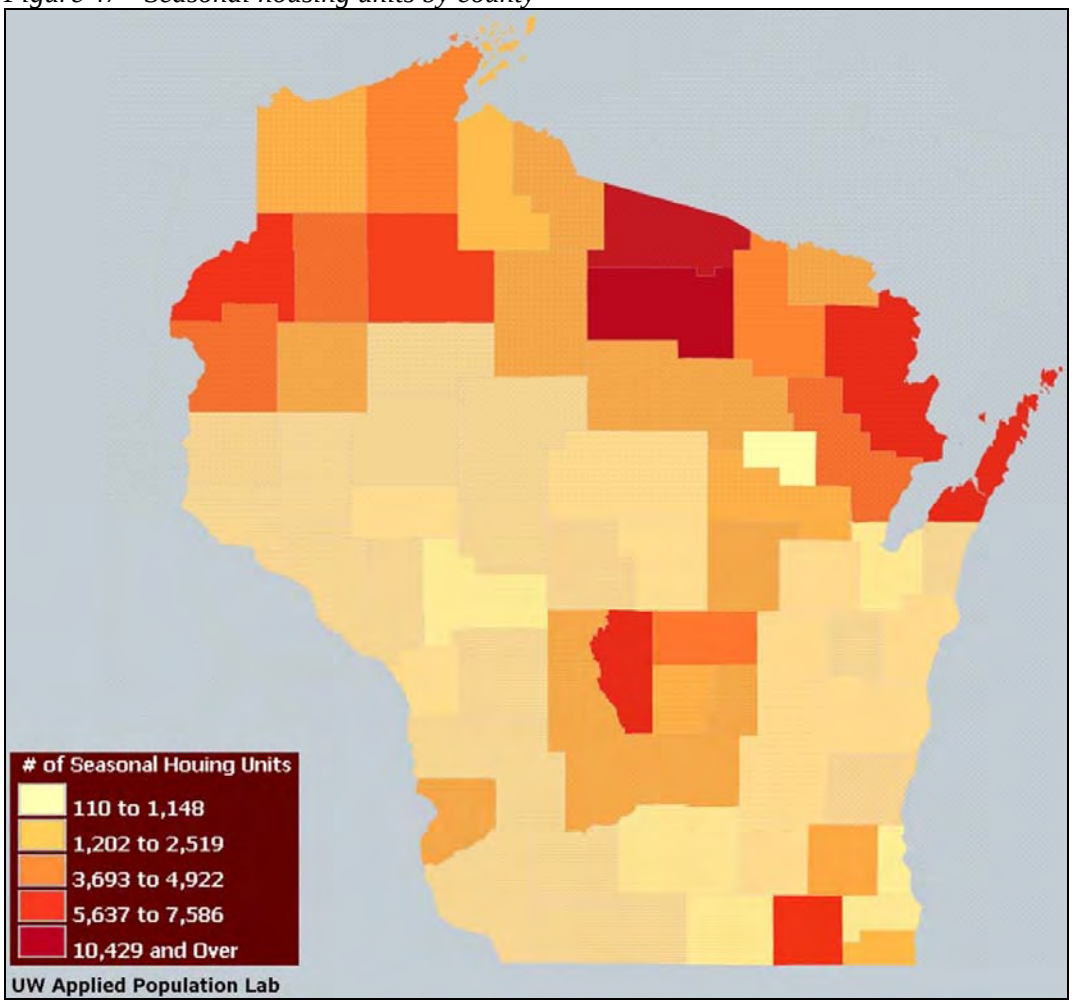
According to the Department's SCORP, seasonal housing has been an important factor in Wisconsin outdoor recreation for a long time. Areas with relatively larger number of seasonal housing units tend to have higher levels of participation in recreation activities because seasonal residents vacation there. Seasonal housing also affects recreational supply by decreasing the amount of land available for recreation. The amount of seasonal housing units has increased from 56,964 units in 1950 to 150,601 in 1990 (DNR SCORP, p. 1-11, http://dnr.wi.gov/planning/scorp/plan/WIS_2005-10_SCORP_CHAPTER_1.pdf).

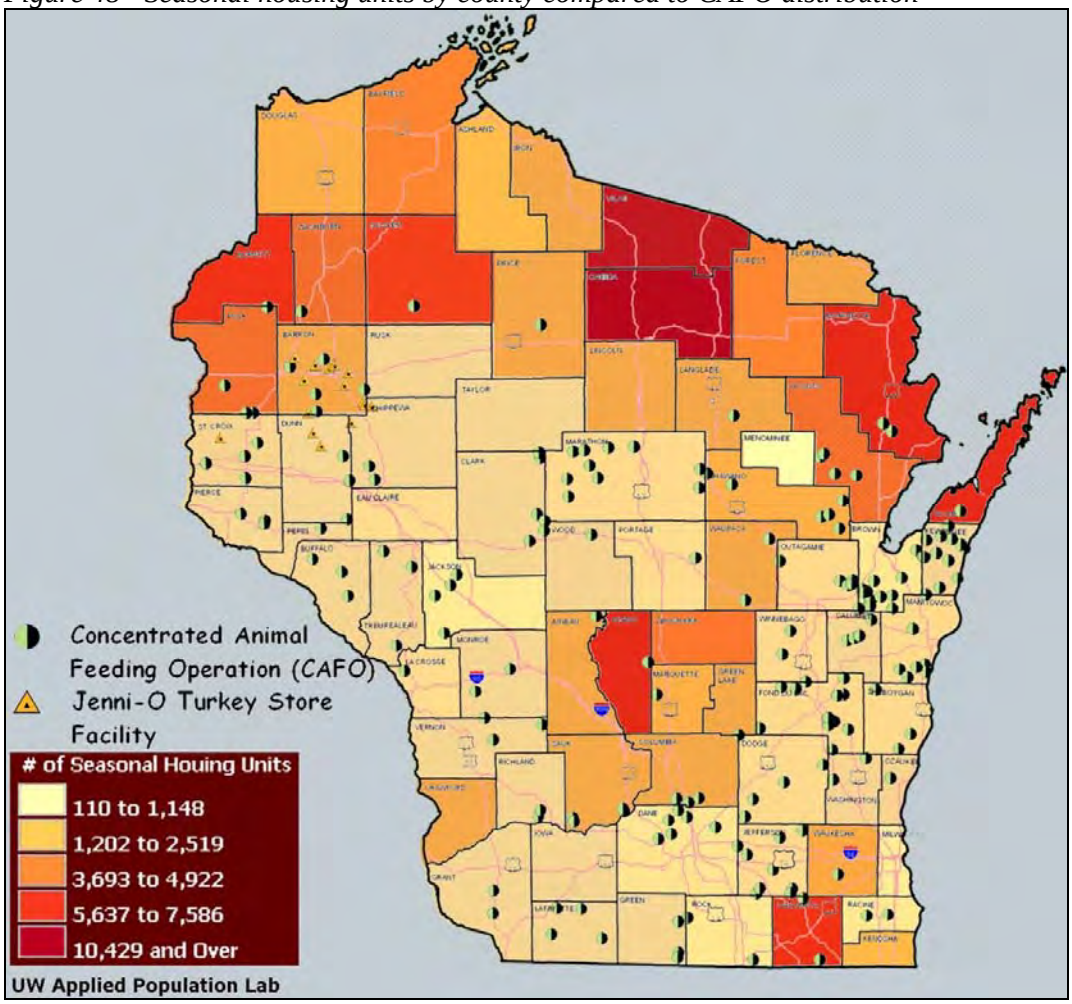
Figure 47, below, shows the number of seasonal housing units by county. As the map shows, seasonal housing units are most prevalent in the northern counties, and counties near the tourist areas of Wisconsin Dells and Lake Geneva.

Figure 47 - Seasonal housing units by county



Overlaying the distribution of CAFOs (see Figure 1 - Geographic Distribution of CAFOs in Wisconsin in Section IV.B.1) on this map results in Figure, 48, below. Figure 48 indicates that currently, CAFOs are not generally located in counties with relatively high numbers of seasonal housing units. This may reflect a general landuse separation between recreational and agricultural areas, rather than being specifically related to the presence of CAFOs.

Figure 48 - Seasonal housing units by county compared to CAFO distribution



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Transportation

Trucking

CAFOs typically add trucking activity to local roads. Much of the truck traffic is seasonal. Hauling of corn and hay silage, sweet corn silage, and manure will be done when the crops are ripe, or the fields available for manure application.

The addition of truck traffic, plus additional large farm machinery will tend to accelerate wear and deterioration of local road systems. This will place a financial burden on counties and towns to repair or reconstruct roads.

Additional traffic may also cause congestion and increase traffic accident risks.

Commuting

Wisconsin commuters that live in non-metropolitan areas tend to commute longer distances to work than those in metropolitan areas. Figure 49, below, illustrates this point. Areas tending to have the longest commute distances are Iron, Burnett, Adams and Crawford counties. Commuting constitutes 28% of miles traveled in Wisconsin. Most workers (89%) drive to work.

Transportation constitutes 25% of state energy use, and vehicle miles have doubled since 1970 in Wisconsin.

Figure 49 - Commuters driving >50 miles to work each way

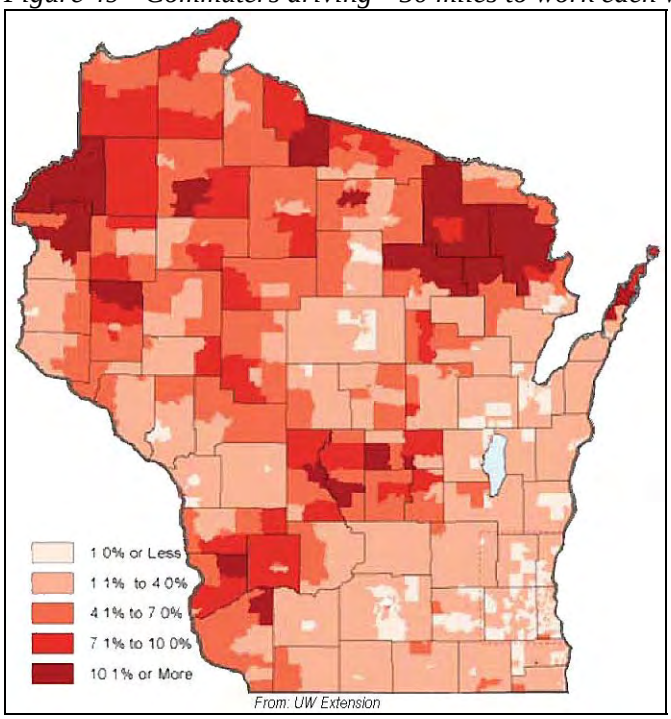
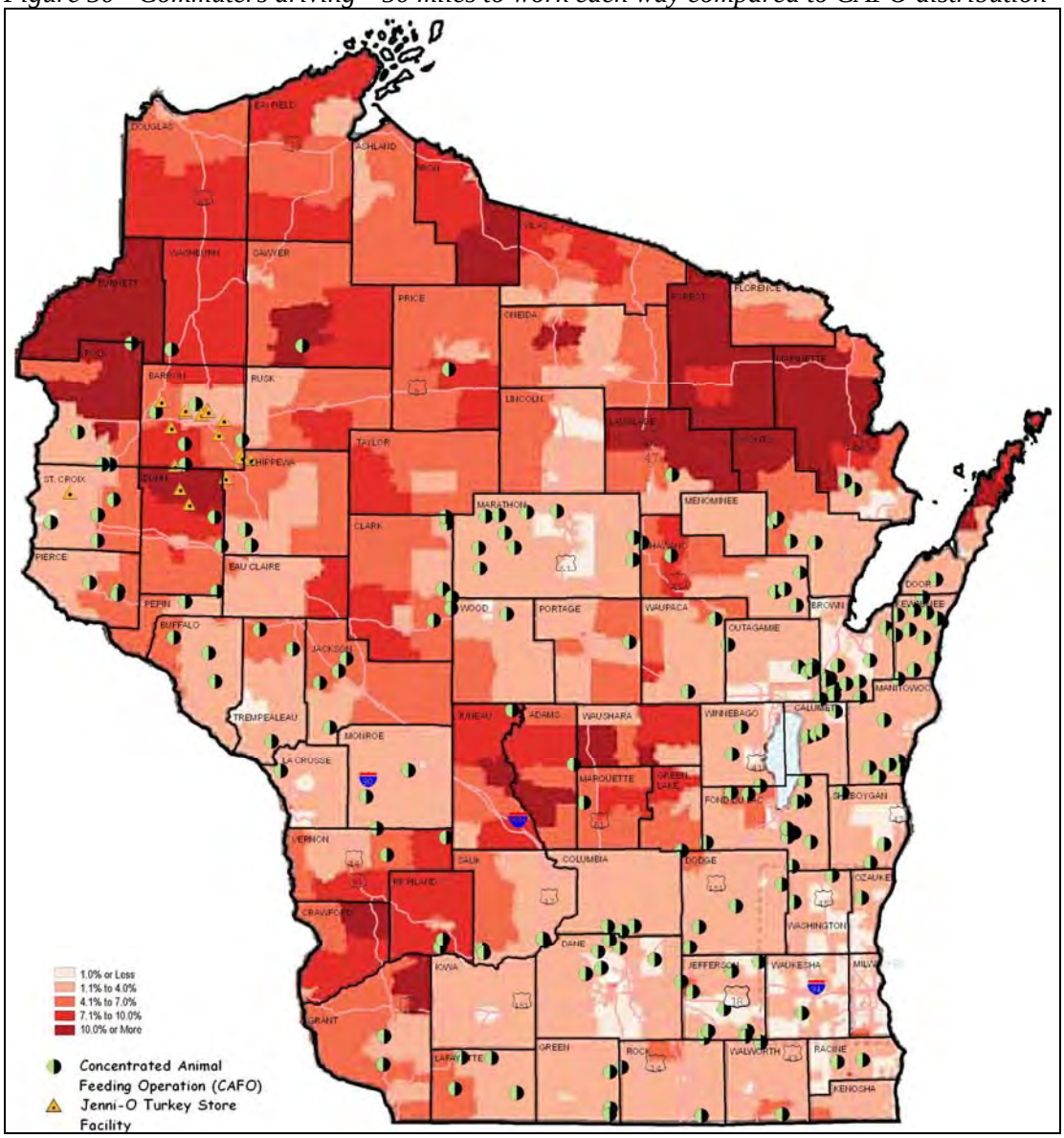


Figure 50, below, compares commuting distance and the current distribution of CAFOs (see Figure 1 - Geographic Distribution of CAFOs in Wisconsin in Section IV.B.1) in Wisconsin. The map shows that current CAFO locations do not appear to be strongly associated with areas in which workers are making unusually long commutes to work.

Figure 50 - Commuters driving >50 miles to work each way compared to CAFO distribution



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V.B.3. Property values & taxes

Property values of CAFO facilities will go up due to the physical improvements to the site, and should hold that value as long as a farm is in operation and is maintained. The value of land needed for raising crops, and perhaps more importantly, acreage needed for manure spreading may increase due to the demand for suitable sites close to a CAFO.

The tax base in local areas may go up in response to the increase in property values and improvements at production sites. Property values may also go up for parcels used for growing crops and application of manure. The value of nearby residential properties may go down due to the close proximity of CAFOs. On a large scale there may be little or no change in the tax base due to the presence of CAFOs (Purdue Extension Guide AY-318-W http://www.ansc.purdue.edu/cafo/).

Property values on adjacent residential parcels may decrease due to proximity to the farm operation and associated concerns about odor, noise, traffic, groundwater degradation, viewscape, *etc*. If a farm is properly managed and uses the best available technologies for dealing with waste and odor the drop in value may be short-term (Purdue Extension Guide AY-318-W http://www.ansc.purdue.edu/cafo/).

The value of housing is based on both the value of the land and the value of the buildings and other improvements to the land. Between 1940 and 2000, median home values in Wisconsin increased from $33,600 to $112,000. Generally, Wisconsin housing values have been consistent with national trends. Land values have gone up primarily due to general demand, but also due to the demand for vacation property. Residential improvements have also increased in value because of increasing house sizes and building quality, both for new houses and for renovations. (Housing Megatrends, UW Extension)

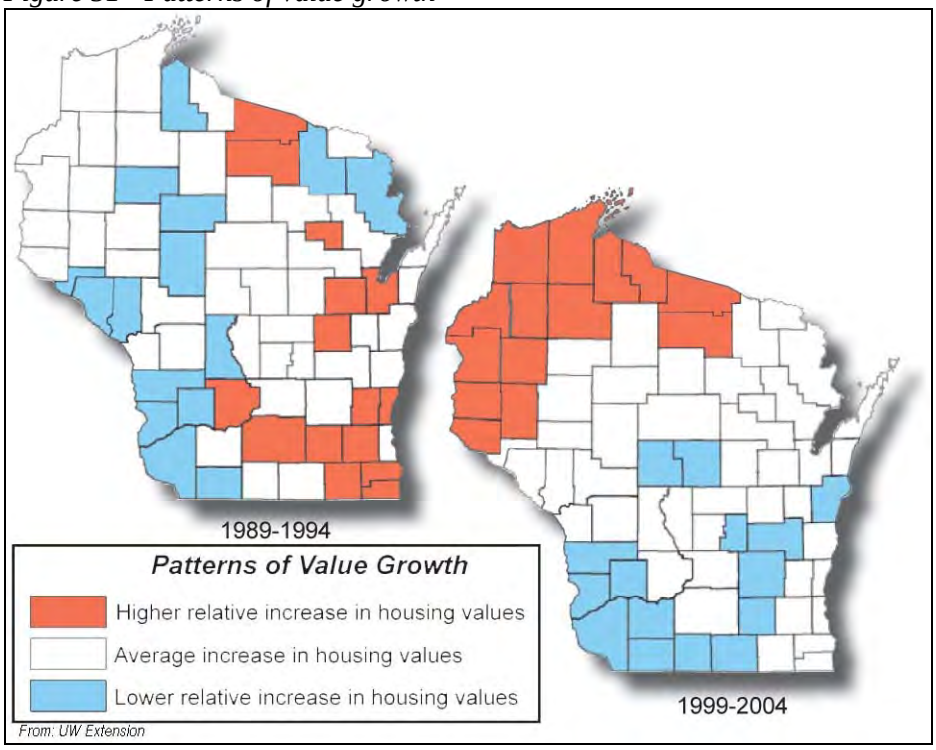
A 2003 study of property values in Berks County, Pennsylvania sheds some light on the effects of CAFOs on nearby residential properties. The following summary is from the executive summary of the report (Ready and Abdalla, 2003, *The Impact of Open Space and Potential Local Disamenities on Residential Property Values in Berks County, Pennsylvania.* Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University. See: http://landuse.aers.psu.edu/study/BerksLandUseShort.pdf).

> *Several potential local disamenities were found to have a negative impact on nearby house prices. Of the potential local disamenities investigated, the impact of landfills on house price was largest, and extended the farthest (up to 3200 meters). A landfill located 800 meters from a house decreases that house's sale price by an estimated 6.9%. The impact of a large-scale animal production facility (over 200 animal equivalent units or aeu's) on house price was about one half to two thirds as large as that from a landfill (4.1% at 800 meters), and did not extend as far (up to 1600 meters). The impacts on house price from mushroom production and from the regional airport were much less (0.4% and 0.2%, respectively, at 800 meters). The impact from high traffic roads was small, and extended only a short distance. No significant impact was found for sewage treatment plants.*
>
> *Additional analysis attempted to investigate whether different types of animal production facilities had different impact on nearby house prices. Differences in the impact due to differences in the size of the operation (number of aeu's) were not statistically significant. Further, medium-sized production facilities (200 to 300 aeu's) were found to have a statistically significant negative effect on house prices when considered apart from larger facilities. Similarly, the impact did not vary significantly by species (poultry, swine, and beef/dairy). An analysis of proximity of animal production facilities and residential properties showed that the density of single family homes around animal production facilities was lower than the average for rural parts of the county. An implication is that some potential for conflicts is avoided due to the way in which these land uses are located on the land.*
>
> *The total impact on surrounding house prices was calculated for a landfill, the regional airport, and an animal production facility. The average impact on the value of 3342 houses located within 3200 meters was $2442 (all values are in 2002 dollars). The total impact on all houses was $8,162,000, which is 2.6% of the assessed value of the affected properties. The average impact of the regional airport on 2256 houses located within 1600 meters of the airport runway and its*

flight paths was $104, and the total impact on the value of these properties was $235,000, or 0.1% of the assessed value of the affected properties. This calculation does not include 2391 properties located near the airport within the City of Reading. The average impact of a single animal production facility on 119 single family residences located within 1600 meters of the facility $1,803. The total impact on all 119 houses is $215,000, or 1.7% of the assessed value of the affected houses. These figures are intended as illustrations, and should not be considered averages for similar facilities. The impact from any given landfill, airport, or animal production facility will depend on the number of houses located near the site, and on the market value of those houses absent the facility.

Figure 51, below, shows the recent geographical shift in relatively higher housing values from the eastern half of the state to the northwest.

Figure 51 - Patterns of value growth



V.B.4. Economy & energy usage

Economy

There are typically positive short-term economic effects to contractors and vendors during the construction phase of CAFOs.

Long-term positive effects are also generated by wages and additional economic activity with vendors, suppliers, and maintenance contractors over the length of CAFO operations.

Several studies presented in the Pew Commission study on Industrial Farm Animal Production indicate that local purchasing patterns of large dairy operations in Wisconsin result in declining rural communities, and the percentage of dairy feed purchased locally decreased as herd size increased. So, while a large dairies may add significantly to the economy in Wisconsin, there may

be little or no positive impact on local economies other those resulting from wages and field crops.

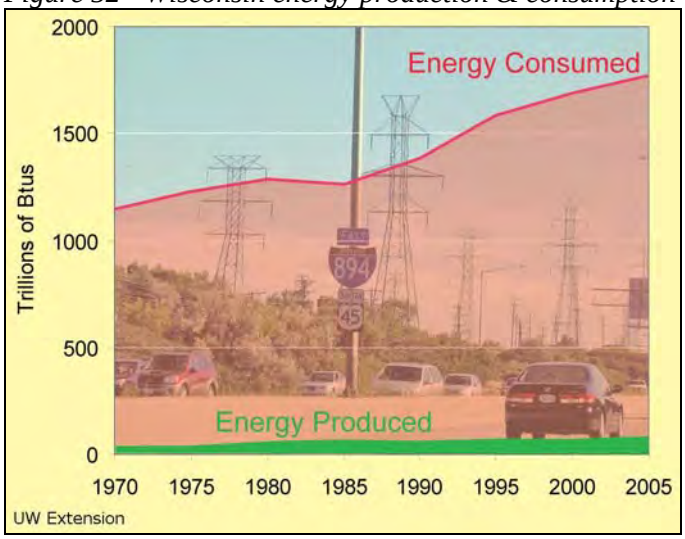
A recent CAFO applicant provided information from the Wisconsin Milk Marketing Board which found a 5x multiplier effect on dairy investments. The applicant claims that each dairy cow generates more than $17,000 a year in economic activity (Rosendale Dairy WPDES permit application).

The tendency for dairy farming operations to become larger (and some to enlarge to the point they must be permitted as CAFOs) in order to remain economically viable, may help to maintain the dairy-based economies of the state.

Energy use

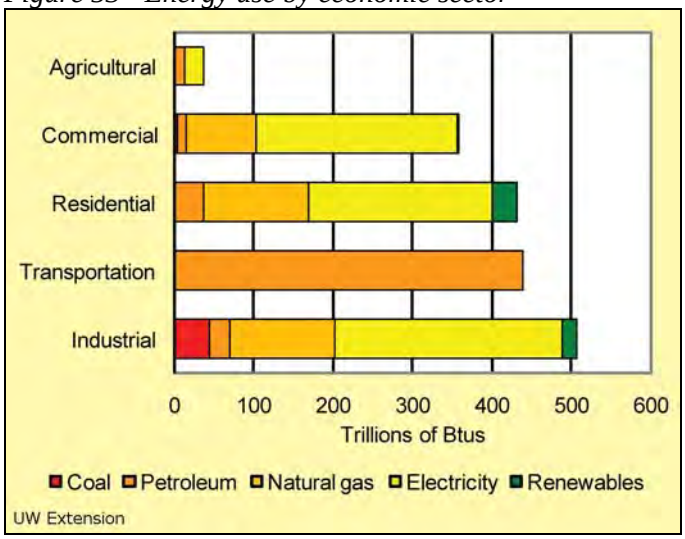
Energy use in Wisconsin increased 55% between 1970 and 2005 which was more than twice the rate of population growth during that period. As shown in Figure 52, below, the use of all types of fuels increased. Wisconsin's per capita energy usage rates in 2005 were comparable to the national and Midwest medians.

Figure 52 - Wisconsin energy production & consumption



Agricultural energy use in Wisconsin is a relatively small component of energy use in the state. Figure 53, below, shows the use of energy by economic sectors. As indicated, most energy use in Wisconsin is associated with industrial, transportation, residential and commercial uses. Energy use by CAFOs is only a fraction of the agricultural energy use in Wisconsin.

Figure 53 - Energy use by economic sector



V.B.5. Archaeological & historical

The state of Wisconsin has archaeological and historical resources scattered about the landscape. Archaeological and historic sites include, among many others: prehistoric villages and burial areas, rock art sites, fur trade era sites, sunken vessels, farmsteads, mining camps and quarries, WPA-era structures, ferries, and lighthouses. Such sites are not considered to be "destroyed" by being buried or plowed over, nor are they considered to be "not historic" simply because they are unattractive or run-down. "Historic" sites are over 50 years old, but not all historic sites are considered to be "significant'. The Wisconsin Historical Society maintains an inventory of recorded archaeological and historic structure sites. Many such sites are as yet unidentified and/or unrecorded.

The following is an overview of Wisconsin's archaeological history, from the Wisconsin Historical Society.

> *Wisconsin archaeological sites and artifacts were left by all peoples who have lived in this area. These peoples include several Native American Tribes and later immigrants. As a consequence of the long human history, the types of archaeological sites discovered vary greatly; from Native American campsites and villages to farms, lumber camps, and rural ghost towns. Evidence of the past can be visible to the eye such as pictographs on rock surfaces, or mounds in the shape of animals. But often discoveries are only made through careful study by archaeologists. Around 8,000 years ago, during the Archaic Period, the climate became warmer and dryer. The large Ice Age mammals were replaced by animals found in the state today. People lived in smaller family groups in caves, rockshelters, along rivers, and around lakes and wetlands. They harvested wild plants, nuts and acorns. They hunted smaller animals such as deer and elk. About 3,000 years ago, during the Woodland Period, people lived in large villages and began to use bows and arrows to hunt. It was during this period that many mounds, including effigies or mounds built in the shape of turtles birds, bears and other animals, were built throughout Wisconsin. These people were Wisconsin's first potters and gardeners. The Mississippian Period began about 1,000 years ago. In Wisconsin these people are called Oneota. They lived in villages and planted gardens to grow crops such as corn, beans and squash. They had a complex trade network which extended to both the Atlantic and Gulf*

coasts. Jean Nicolet, a French explorer, arrived in Wisconsin in 1634. At that time, the Indian tribes present in the state included the Ho Chunk (Winnebago), Potawatomi, Menominee, and Chippewa Indians. This marked the beginning of the Historic Period. Historic archaeologists study the lifestyles of the fur traders, early immigrant settlers, and loggers of the great northern pine forests. [http://www.wisconsinhistory.org/archaeology/overview/, October 2009]

Land application of manure, or other normal or routine agricultural practices would not normally cause adverse impacts or effects to existing archaeological or historical resources. Adverse impacts that would trigger further investigation would those activities which would entail extensive soil disturbance or excavation in areas of recorded sites, or ones that would impact significant historic structures. Any proposed activities of this nature related to specific farm production sites expansion or development, or the NMP would be reviewed by the Department as part of the permitting process. Section 44.40 of Wisconsin Statutes states that "Each state agency shall consider whether any proposed action of the state agency will affect any historic property…" and directs each agency to cooperate with the Wisconsin Historical Society in its efforts to identify and protect the State's cultural resources. DNR maintains maps of archaeological and historic sites statewide for purposes of project reviews. DNR also employs a full time archaeologist to assist in these reviews.

V.B.6. Human health

A Minnesota study evaluated various aspects of CAFOs, including human health. [Minnesota Dept of Administration Env. Quality Board, 1999, Generic Environmental Impact Statement for animal agriculture http://www.eqb.state.mn.us/project.html?Id=18252] The report concluded that there are human health issues of concern, but hard conclusions are difficult to reach. The following is a summary of that report's findings.

Animal agriculture can have a variety of both positive and negative impacts on human health through occupational exposure, other environmental exposures, and exposures through consuming the product.

While human health risks can be associated with different types of animal production systems, it is difficult to make direct comparisons between systems. Most of the human health literature reviewed was not explicit about the type of production system studied. There are countless variations of animal production systems, making all but general classifications of systems nearly impossible in a project of this scope. In addition, there is a preponderance of research focused on confinement production systems and very little research focused on outdoor, alternative, and other types of systems. For these reasons, there is little information contained in this report that compares the human health effects of different types of animal production systems. Unfortunately, this leaves key systems-level questions, especially important in the search to prevent or mitigate human health risks in animal agriculture, unanswered.

Substantial scientific literature exists that human health is adversely affected by the transmission of a number of toxic and noxious agents via the air. Large animal production units are a source of air transmission of toxic and noxious agents, such as gases, dust, odors, and biogenic particles. Those generated within animal and poultry confinement facilities can adversely affect health of people working in those environments and potentially the health of people living or working near such facilities. Acute health effects

are particularly common and frequently involve the respiratory system. Some chemicals have been documented to cause fatalities such as hydrogen sulfide in manure pits. The effects of odors are potentially serious and include loss of appetite, poor respiration, nausea, vomiting and mental distress.

Water-, soil-, and fly-borne pathogens and nutrients are also a concern. Pathogens may be transmitted to humans from animal wastes through contaminated surface drinking water supplies, contaminated ground water supplies, or direct contact with contaminated environment e.g., recreational use of water. Some incidents of human disease attributable to contact with livestock waste have been reported. Water-borne nitrate represents a health risk to infants under the age of six months, because it can cause an acute and potentially fatal condition called methemoglobinemia. Insects, especially flies, are a potential vehicle for the transmission of human disease from manure, dead animal carcasses, and other animal wastes. Escherichia coli (E. coli), Salmonella spp. and Campylobacter jejuni are candidates for transmission by flies. However, the literature on this subject is ambivalent. More research is needed to determine the extent to which flyborne microorganisms are transmitted to humans and cause illness, and on the control of flies in farming.

In terms of which segments of the population are most susceptible to health problems related to animal agriculture, for occupational injuries it is obviously farm workers, especially those who are new and untrained. For airborne contaminants, workers and neighbors are most at risk where geographical factors increase their exposure. For food borne microbial diseases, the young, elderly and immunocomprimised are the most likely to develop severe symptoms and serious consequences. They are also potentially most vulnerable to pathogens transmitted by water, soil, and flies; and to resistant strains.

Outside of issues associated with water quality, environmental and human health issues are not specifically addressed or minimized by adherence to appropriate WPDES permit conditions.

See also sections V.A.1. and V.A.3 for additional health-related information.

V.B.7. Aesthetic

Visual

Because of the scale of production site operations, the physical changes at new sites converting agricultural fields or traditional farm operation sites to large scale animal housing, manure storage and process wastewater storage, and feed storage, represents a dramatic change from an open agricultural landscape that often exists prior to construction. Additional visual changes may include paving driveways and roads. While agricultural in function, CAFOs tend to appear more like industrial sites. Production site facilities are often visible from local roads and highways.

There may also be visual changes due to the potential need to improve some local roads to handle increased trucking traffic from CAFOs. Such improvements could involve lane and shoulder widening, changes to vertical and horizontal alignments, and changes to intersection geometry. Such changes may also involve tree cutting, and changes to roadside ditches. These kinds of road improvements tend to create a more open landscape with less complex topography along the affected roadways.

Noise

Prior to construction of CAFO production sites, typical CAFO sites were agricultural. Typically there would have been equipment used to till the land, to spread fertilizers, and to harvest crops. In their place, CAFO construction and general farm equipment will be generating noise as well as the trucks and other equipment performing services in the normal course of operations.

Additional noise and dust associated with the transportation of livestock, milk, feed, and manure is likely at CAFO production sites. Truck traffic is typically heavy during the spring as operations apply most of the manure and process wastewater prior to planting of crops and during crop harvest. There will also be some application of manure occurring during the fall. Most truck traffic will occur during daylight hours. During crop harvesting, however, traffic will occur whenever necessary to bring in crops.

V.B.8. Drinking water supply

Manure contaminated wells

Since 2002 there have been almost 200 confirmed releases of animal waste. Forty-eight manure spills are listed on the Bureau of Remediation and Redevelopments tracking system as having the potential to impact groundwater. A Manure Management Task Force was convened in 2005 to make recommendations on reducing the impact of manure on the environment. One recommendation was to allow DNR to use Well Compensation Grant money to replace wells contaminated by livestock waste. In March of 2006, revision of Subchapter 281.75 Wis. Statutes addressing establishment of Special Casing Areas and Well Compensation for wells contaminated by livestock waste was signed by Governor Doyle.

The statute states that compensation can be granted if 1) fecal bacteria is present and 2) evidence demonstrates that bacterial contamination is caused by livestock (281.75 (2)(e) Wis. Stats). To date, 41 well compensation grants totaling over $470,000 have been awarded (see Table 8 in Section V.A.1.). Additional costs have been incurred by well owners to cover costs not covered by the grants.

<u>Well contamination cases involving CAFOs</u>

In 2004, a dairy CAFO in Kewaunee County settled a law suit related to private well contamination. The operation paid damages, and was required to install more manure storage and change their land spreading schedule. This case occurred before changes to the Well Compensation Grant program that now allow compensation from the grant fund.

In 2005, a Dodge County CAFO was the subject of the first case in which Microbial Source Tracking was used to determine that well contamination was due to livestock waste. Four wells were contaminated and the CAFO was fined.

A 20,000 gallon spill of manure resulted in well contamination and a fine for a dairy CAFO in Brown County.

In 2005 enforcement action was taken against a Brown County CAFO, after an investigation showed that a 5,000 gallon manure spill resulted in well contamination. Forty-three of 237 wells tested showed contamination by fecal coliform. Using Microbial Source Testing, livestock was confirmed as the source of contamination. Twenty-five wells were replaced using Well Compensation Grants.

Impact of CAFOs on surface water drinking water systems

Under Wisconsin's Source Water Assessment, animal feeding operations are listed as a potential source of drinking water contamination for surface water systems. Animal feeding operations generally congregate animals, feed, manure, dead animals, and production operations on a relatively small area of land. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures. Animal waste and wastewater can enter water bodies from spills or breaks in waste storage structures (due to accidents or excessive rain), and manure spreading practices. Animal feeding operations have the potential to contribute pollutants such as inorganic, synthetic organic, and microbial contaminants as well as hormones and antibiotics to the source water. Tables GW 7, 8, and 9 summarize information in the Source Water Assessment reports for communities that rely on surface water for drinking water. For more information on each system, please see the Source Water Assessment for each community (http://dnr.wi.gov/org/water/dwg/swap/index.htm).

Drinking water from Lake Winnebago has a relatively high susceptibility to contamination and is significantly impacted by land use in the source water area. Potential contaminant sources in the eastern and southern portions of the source water area include stormwater and agricultural runoff. The turbid nature of Lake Winnebago and the source water area's high concentrations of urbanized and agricultural land, make these communities source water particularly susceptible to microbial, volatile organic and synthetic organic contamination (see Table 21, below). Blue-green algae blooms have been a concern in Lake Winnebago. In order to provide safe drinking water, blue-green algal toxins are removed by the local utilities water treatment processes. Microcystin is a blue-green algal toxin and is expensive to remove from drinking water during the treatment process. For more information on blue-green algae see: http://dnr.wi.gov/lakes/bluegreenalgae/.

Table 21 - Communities utilizing Lake Winnebago as a drinking water source

City	Population	Treatment
Appleton (with Grand Chute and Waverly)	96,825	Lime softening, granular activated carbon contractors, ultrafiltration and chlorination.
Oshkosh	63,000	Flocculation, sedimentation, filtration, ozonation, granular activated carbon filtration, chlorination and fluoridation.
Neenah	24,500	Flocculation, sedimentation, filtration and chlorination.
Menasha	23,275	Aeration, flocculation, sedimentation, filtration and chlorination.

Drinking water from Lake Michigan can be impacted locally due to land use in the source area (see Table 22, below). Pharmaceuticals have been found in the Great Lakes at trace levels. In 1993 there was an outbreak of Cryptosporidium in Milwaukee that sickened over 400,000 people. Over 100 people died. The specific source of the Cryptosporidium was determined to be human (Hrudey and Hrudey, 2004).

Hrudey, S.E. and E.J. Hrudey, 2004. Safe Drinking Water: Lessons from recent outbreaks in affluent nations, IWA Publishing, London UK, 486 pgs.

Table 22 - Communities utilizing Lake Michigan as a drinking water source

City	Population	Treatment
Ashwaubenon (with Hobart)	450	See Green Bay
Caldonia (with Wind Point)	1834	See Racine
Central Brown County (includes Allouez, Bellevue, De Pere, Howard, Lawrence and Ledgeview)	73,000	Chlorination and Polyphosphate for corrosion control
Cudahy	18,600	Chlorination and Polyphosphate for corrosion control
Green Bay (with Ashwaubenon and Scott)	103,000	Chlorination at the intake to control zebra mussels, ozonation, flocculation, sedimentation, filtration, chlorination and fluoridation prior to distribution.
Kenosha (with East Bristol, Pleasant Prairie and Somers)	93,000	Flocculation, sedimentation, filtration, chlorination, microfiltration and chlorination
Manitowoc (with Central Brown County)	34,500	Treatment of the source water from Lake Michigan includes microfiltration and chlorination
Marinette	12,700	Flocculation, sedimentation, filtration, chlorination, fluoridation and phosphate addition.
Milwaukee (with Brown Deer, Butler, Greendale, Menomonee Falls, Mequon, Milwaukee County, New Berlin, Shorewood, Wauwatosa and West Allis	680,000	Ozonation, flocculation, sedimentation, filtration and chlorination.
North Shore (with Fox Point, Glendale, Mequon, Whitefish Bay)	35,000	Flocculation, sedimentation, filtration and chlorination
Oak Creek (with Caldonia and Franklin)	46,000	Flocculation, sedimentation, filtration and chlorination
Port Washington	10,000	Flocculation, sedimentation, filtration, chlorination and fluoridation
Racine (with Caledonia, North Park, and Sturtevant)	109,100	Potassium Permanganate at the intakes to control zebra mussel growth, chemical flocculation and physical sedimentation to remove larger contaminants, filtration and chlorination.
Sheboygan (with Kohler and Sheboygan Falls)	62,000	Flocculation, sedimentation, filtration, chlorination and fluoridation
South Milwaukee	21,000	Flocculation, sedimentation, filtration and chlorination
Two Rivers	13,000	Flocculation, sedimentation, filtration, chlorination and fluoridation

Drinking water from Lake Superior is generally of high quality although as a surface water source it is vulnerable to contamination from land use locally (see Table 23, below). In October 1997, the Medical Officer of Health for the Thunder Bay District Health Unit issued a Boil Water Advisory to the residents of the south side of the city of Thunder Bay following the receipt of a laboratory report confirming the presence of Giardia in the water distribution system. Giardia is a parasite found in human or animal waste.

Table 23 - Communities utilizing Lake Superior as a drinking water source

City	Population	Treatment
Ashland	9,000	Microfiltration and chlorination
Superior	29,000	Flocculation, sedimentation, filtration, chlorination and fluoridation

See also Section V.A.1. for additional discussion of effects of CAFOs on drinking water supplies.

VI. Alternatives

VI.A. No action

Since 1984, WDNR has issued individual Wisconsin Pollutant Discharge (WPDES) permits to Concentrated Animal Feeding Operations (CAFOs). Wisconsin may be the only state in the union with a CAFO Program that has not issued general permits for CAFOs. CAFO permit applications have markedly increased in recent years. In 1990, Wisconsin had issued fewer than 20 CAFOs. By 2000 the number of Wisconsin CAFOs had grown to 50. As of this writing, the number of CAFOs approaches 200, with more applications pending. Individual permit issuance requires a significant investment of staff time. Because DNR is obligated to maintain a low backlog of permit applications, staff has been unable to adequately address other facets of the CAFO program, most notably compliance assistance and enforcement. On the other hand, individual permit issuance has provided a forum on individual permit actions for public input via public informational hearings.. In addition to water quality issues, other areas of public concern that are associated with CAFOs typically include odors, traffic, and noise. The WPDES CAFO permit process does not offer regulatory relief for issues like these or others that are not germane to water quality protection. All credible and well-documented WPDES CAFO permit applications that conform to state law have resulted in issuance of individual permits with generally consistent permit requirements with or without a public hearing.

Sustaining individual permit issuance would perpetuate the current system of expenditure of scarce staff time with the predictable outcome of perfunctory permit issuance for all conforming applications and, at times, public disappointment with the outcomes of public hearings. On the other hand, the proposed system of general permits would sustain all requirements for permit application and all regulatory scrutiny as is the case under the status quo. The primary differences between the proposed system of general permits and the status quo is that scarce staff time would no longer be diverted from compliance and enforcement work.

VI.B. Extend large CAFO GP coverage to other livestock types

Operations that house 1000 animal units or greater are deemed to be CAFOs under the Federal Clean Water Act. Among other eligibility criteria, dairy operations housing 1000 animal unit up to a maximum of 5,600 animal units are eligible to seek coverage under the proposed general permit. Coverage under the proposed general permit for large CAFOs is limited to dairy operations only. As an alternative, the Department could extend permit coverage to all livestock types, including beef and pork production facilities, poultry operations, and others. However, the Department's planning and analysis has largely been limited to dairy operations. Further deliberation would be needed in order to understand anticipated results from extending the large CAFO general permit beyond dairy operations.

VI.C. Different size thresholds & other criteria for GP coverage

The maximum CAFO size that is eligible for general permit coverage has been proposed at 5,720 animal units. This number was selected on the basis of a business case from the dairy industry. That business case asserts that a 4,000 cow (5,750 animal units for a dairy CAFO with only milking/dry cows) dairy is the most economical size to build in the current market, allowing construction of a 70 stall rotary parlor with three milkings per day and with a manageable workforce. An alternative number could be derived on the basis of animal unit populations that are currently housed on Wisconsin's CAFOs. Note Table 24, below.

Table 24 - Dairy CAFO size distribution

Operation size AU)	# of Operations	% of Operations
0-999	2	1
1,000-1,499*	46	29
1,500-1,999*	31	20
2,000-2,499*	26	16
2,500-2,999	15	9
3,000-3,499	14	9
3,500-3,999	6	4
4,000-4,999	8	5
5,000-5,999	6	4
6,000-6,999	1	1
7,000-7,999	1	1
>8,000	2	1
Total	**158**	**100**

As the table indicates, most CAFOs in Wisconsin are well below the 5,720 animal unit threshold as proposed in the general permit. An alternative animal unit threshold could be set at a lower number, at least for the short term, and still provide general permit eligibility for the majority of current WPDES permit holders and, possibly, new applicants. Conversely, the threshold could be set at a higher number or perhaps no maximum threshold at all. The industry has not pressed for a number beyond 5,720 animal units nor does the Department believe that a “no-threshold” general permit would be in the best public interest.

There are other criteria that would limit eligibility for general permit coverage, over and above animal unit numbers, that include:

- Conviction of a criminal violation within 60 months before the date of application that resulted in substantial harm to public health or the environment or that presented an imminent threat to public health or the environment.

- Referral to the Department of Justice within the last 60 months for water quality violations.

- Having a civil judgment entered against them within the last 36 months related to water quality impacts or violations that resulted in substantial harm to public health or the environment.

- Issuance of an environmental citation or Notice of Violation for water quality related impacts within the last 36 months.

- Having not addressed discharges identified as part of a Notice of Discharge (NOD) issued in accordance with ch. NR 243, Wis. Adm. Code.

- Having less than 180 days of liquid manure storage.

- Not in substantial compliance with an individual permit.

One alternative to items 1 through 5, above, would be to ignore past environmental behaviors and cover all CAFOs under the general permit. While the Department anticipates greater capability to conduct compliance and enforcement work it a general CAFO permit is issued, the industry anticipates faster and more efficient permit issuance with the general permit. Clearly, ignoring

past environmental behaviors would create disincentives for environmental compliance and could further exacerbate necessity of Department enforcement actions.

Items 1 through 4 specify minimum time periods that must transpire after enforcement actions or civil actions related to water quality behaviors. These time periods could be shortened or lengthened. The Department believes that the time periods as proposed are reasonable and balanced.

Ch. NR 243 requires that all new CAFOs have a minimum of 180 days of liquid manure storage available. This requirement was part of the revisions to Chapter NR 243, promulgated in 2007, in response to problems occurring with landspreading of liquid manure during frozen and snow-covered conditions. Some CAFOs did not have sufficient manure storage to avoid the need to empty and subsequently landspread liquid manure during the winter months with potential for subsequent runoff and water quality impacts. Removal of this eligibility requirement, item 6, would entail revision of the administrative code. It would also be environmentally regressive.

As item 7 indicates, CAFO operators who are not in substantial compliance with individual permits are ineligible for general permit coverage. Removal of this eligibility requirement would likely violate statutory language that disallows reissuance of any WPDES permit, whether individual or general, to permittees that are not in substantial compliance with their permits.

VI.D. Different permit requirements

VI.D.1. Include additional water-quality based restrictions with the LDCAFO GP

Ch. NR 243, Wis. Adm. Code, was revised in July of 2007 to require certain best management practices to protect groundwater, surface waters and wetlands for all operations covered under a WPDES permit. The Department does have authority to require more restrictive best management practices on a case-by-case basis where these practices are deemed necessary to provide additional levels of groundwater quality protection. The Department has limited authority to require more restrictive practices as it relates to surface water quality protection. In either case, the Department would not have capability to account for all unique and individual water quality concerns in a general permit. While the department has proposed to issue a general permit, it is not foreclosing the possibility of issuing individual permits when warranted. In instances of unique water quality concerns, the Department should issue individual permits with specific permit language that addresses the concerns.

VI.D.2. Require additional land application requirements

For land application activities, the Department could include additional or more restrictive best management practices beyond s. NR 243.14, primarily to ensure additional levels of protection for groundwater resources. CAFOs must submit Nutrient Management Plans that conform with s. NR 243.14. The Department has authority to require additional best management practices in the WPDES permit and has included a limited number of additional restrictions. Where additional requirements beyond the restrictions in NR 243 and the General Permit are necessary, these issues would need to be best addressed in an individual permit.

VI.D.3. Require installation of groundwater monitoring systems

For structures associated with manure and process handling (*e.g.*, manure and feed storage), potential options include requiring additional separation distances from groundwater, bedrock or surface waters, increased thickness of clay or concrete liners in storage facilities or secondary

containment for above ground storage facilities in case of overflow or failure. The Department could also require groundwater monitoring around structures where there are water quality concerns. Including additional design requirements could reduce the potential for leakage from designed structures to impact groundwater (*e.g.*, pathogens, nitrates). Requiring installation of groundwater monitoring could provide an indication of whether or not structures have been designed and built properly to protect groundwater. The need for either of these actions would be evaluated as part of the permit issuance process. Again, in these instances, the Department should issue an individual permit rather than extending coverage under the general permit.

VI.D.4. Require the use of manure/process wastewater treatment or other emerging technologies

There are an increasing number of technologies that have the potential to address potential water quality impacts, and other impacts, associated with livestock operations. Generally, these technologies fall into categories of: 1) solid/liquid separation (including membrane filtration), and 2) manure/process wastewater digestion.

Solids separation technologies help to recycle materials (*e.g.*, sand) and/or concentrate nutrients in solids or liquids that help reduce the volume of wastewater that needs to be land applied. This can help to reduce potential for runoff or leaching to groundwater by allowing decreased volumes of water that are subject to potential runoff directly or as a result of precipitation.

Digestion technologies provide reductions in pathogens present in materials that are land applied and create a more stable organic material that has reduced biochemical oxygen demand should it get into surface waters during land application. In addition, digestion technologies can have added benefits of providing for energy production and odor reduction. More information on anaerobic digesters is provided below.

Neither of these technologies significantly reduces the amount of nutrients that need to be land applied. In some instances, these two technologies can be combined to create a liquid portion that is treated to the point that it could be discharged to surface waters, spray irrigated or seeped to groundwater in compliance with state water quality standards.

The authority for requiring additional technologies under a WPDES permit are limited to those providing water quality benefits, and are not based on other potential benefits such as odor reduction and/or energy production. While these technologies may offer incremental decreases in the potential for water quality impacts associated with the storage and land application of manure/process wastewater at a given CAFO, the actual decrease in impact potential is difficult to assess. For example, following the land application restrictions in ch. NR 243, Wis. Adm. Code, reduces the potential for pathogen contamination of groundwater associated with CAFOs land application activities. Treatment technologies exist that may reduce or eliminate pathogens in manure (*e.g.* anaerobic digestion), thus further reducing the potential for pathogen contamination of groundwater associated with land application practices. Another option to reduce impact potential is to require additional best management practices that are more restrictive than the specific requirements contained in NR 243, Wis. Adm. Code, (*e.g.* additional field investigative work prior to land application, increased setbacks from areas of concern, and further restrictions on timing of manure applications). As a matter of current and past practice when issuing WPDES permits for CAFOs, the Department has relied on the implementation of best management practices rather than requiring treatment technologies when additional levels of water quality protection are determined to be necessary. It should be noted that EPA recently promulgated additional revisions to its federal CAFO rule and has upheld proper storage and land application of manure as best conventional technology (BCT) for CAFOs. In addition, federal

CAFO rules and ch. NR 243, Wis. Adm. Code, have only recently provided allowances for "treat and discharge" from CAFOs which are considered "voluntary" under state and federal law.

VI.E. Permittee technology alternatives

VI.E.1. Anaerobic digestion

In anaerobic digestion, organic material is broken down by bacteria in the absence of oxygen converting the material into fatty acids and biogas. A digester is a sealed tank where manure or other organic materials can undergo anaerobic digestion (MDA Anaerobic Digester Terms & Definitions).

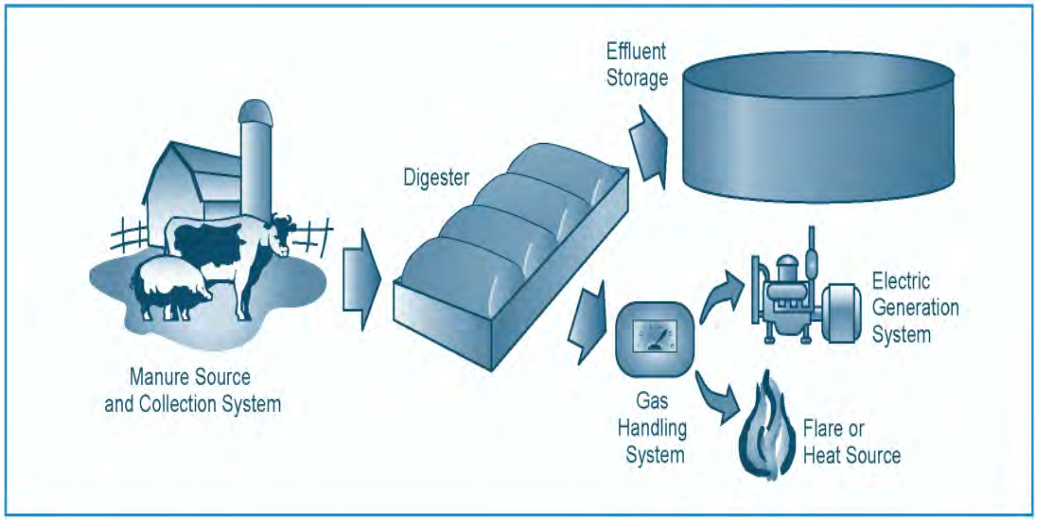
Potentially, any agricultural operation could utilize an anaerobic digester (AD) to process organic waste material. However, according to US EPA's AgStar Program, at least five-hundred (500) dairy cows or steers are necessary to produce enough organic waste to for biogas production and ensure the project remains financially viable. Site location and market dynamics also play a key role in determining the financial viability of digester projects.[12]

Anaerobic digestion for biogas production essentially concentrates the natural process of digestion within a closed container to allow for economical recovery. During the process of digestion, whether it occurs within an AD or within a manure storage lagoon, complete digestion is not achieved. Organic material with the potential for methane production remains following the process.

The animal and manure management systems chosen by the farm and how the manure digester is operated (hydraulic residence time, temperature, volatile solids, other feedstocks, *etc.*) will determine quantity and quality of biogas generated as well as the solid and liquid effluent characteristics.

A typical system for anaerobic digestion and biogas recovery is shown in Figure 54. There are four main components: a digester, a system to handle the biogas, a system to use the biogas, and an effluent storage and land application system (Managing Manure with Biogas Recovery Systems Improved Performance at Competitive Costs).

Figure 54 - Typical farm anaerobic digester system components



Source: Managing Manure with Biogas Recovery Systems Improved Performance at Competitive Costs

[12] *US EPA's AgStar Biogas Handbook (http://www.epa.gov/agstar/pdf/handbook/full_pdf.pdf)*

Types of anaerobic digesters

At least five types of anaerobic digesters are being utilized and are summarized in the following paragraphs (from MDA Anaerobic Digester Terms & Definitions).

Complete mix digester: A tank designed above or below ground as part of a manure management system to handle manure containing 2-10 percent solids. The digester is heated and mixed mechanically or with gas-mixing systems to keep the solids suspended. This maximizes biological activity for destruction of volatile solids, methane production, and odor reduction.

Covered lagoon digester: An anaerobic lagoon is commonly used when manure has less than two percent solids. Decomposition of the manure occurs and methane is produced. The lagoon is covered with a gas-tight cover to capture the biogas.

Fixed film digester: A tank designed as part of a manure management system to handle manure up to 3 percent solids. The digester is temperature controlled and a media is placed inside the digester. This design allows the microbial populations to attach to the media and grow as a biofilm (fixed film), thus preventing the microbes from being removed with the effluent.

Plug-Flow digester: A tank designed for a manure management system which handles organic material containing 11-14 percent solids. The digester is given daily influent plugs that flow through the digester. The digester is heated. This helps with the destruction of volatile solids.

Temperature-Phased anaerobic digester (TPAD): Two tanks designed as part of a residuals management system. The digesters are heated, the first digester in the thermophilic temperature range and the second digester in the mesophilic temperature range. This will maximize biological activity for the destruction of volatile solids, methane production and odor reduction.

Biogas uses

Injection into an Existing Natural Gas Pipeline: Biogas can be treated to remove impurities (*e.g.* condensate and other trace contaminants), compressed, and injected into a natural gas pipeline. The scrubbing and compression make injection a more costly option than combustion for electrical generation. Injection, however, may avoid fuel loss through incomplete or inefficient combustion (An Assessment of Technologies for Management and Treatment of Dairy Manure in California's San Joaquin Valley).

Flares: The biogas handling system may treat the gas as a waste product. In these systems, the gas is burned off using a flare.

Heating: Biogas can be used for heating or steam production. Biogas has a medium BTU heat content, so minor modifications to natural gas burners are needed in order to burn biogas. In such systems, condensate and particulates are removed, and the gas is compressed and piped to the boiler or burner. The steam must be used near the boiler in such systems because of the high cost of the insulated high pressure steel pipe and heat loss during transport (An Assessment of Technologies for Management and Treatment of Dairy Manure in California's San Joaquin Valley).

Electrical generation: A reciprocating engine or a gas turbine can be used to burn biogas and produce electricity. The biogas must have condensate and, likely, hydrogen sulfide removed before being used. Also, to be used in a turbine, the gas must be compressed. So-called "microturbines," as small as 30 kW capacity, can be used to combust the biogas. Lower running

times and the cost of treating the gas have limited the use of microturbines (An Assessment of Technologies for Management and Treatment of Dairy Manure in California's San Joaquin Valley).

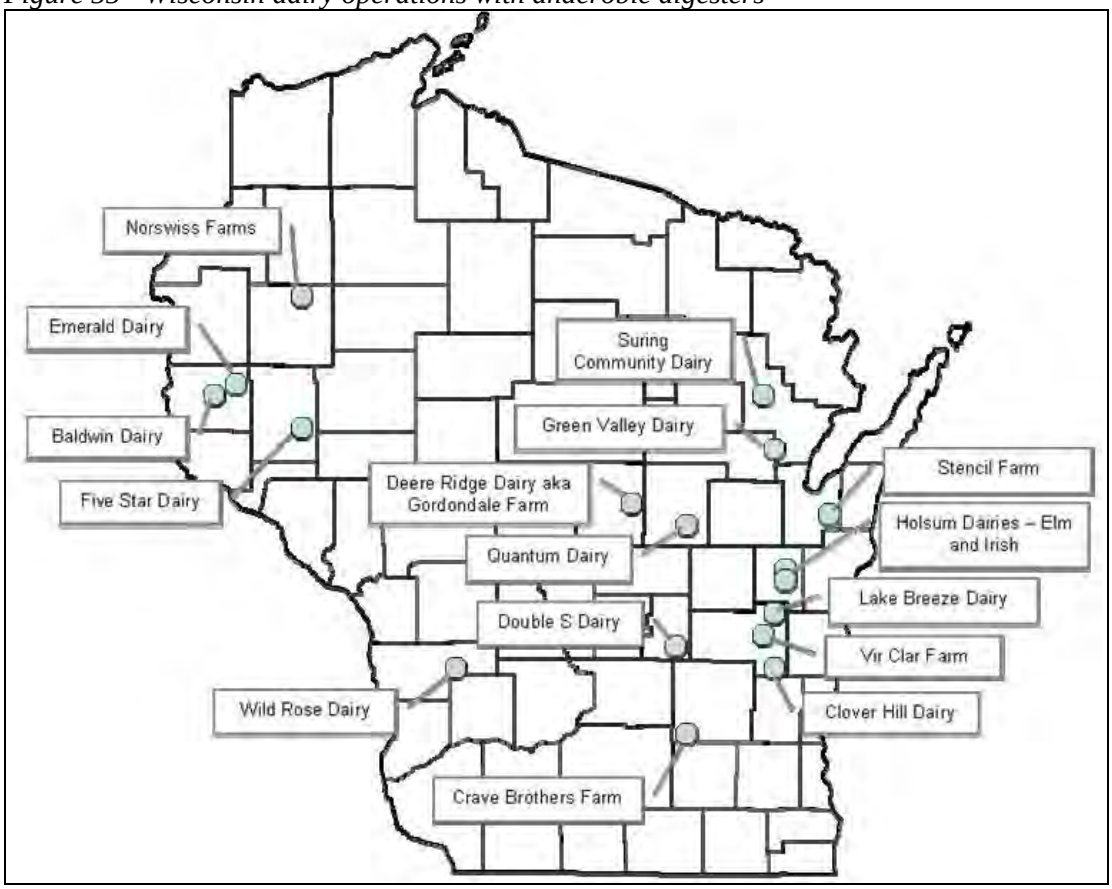
Use of digesters on farms

Digesters as part of manure management

Three types of digesters are generally suitable for use in Wisconsin's climate: plug flow digester, complete-mix digester, and temperature-phased digester (Renewable Energy – Farm Energy from Manure – Fact Sheet)

According to the Wisconsin Biogas Casebook, published in July of 2008, seventeen (17) Wisconsin dairy farms were home to twenty-two (22) anaerobic digesters, including five (5) farms with two (2) digesters. Figure 55, below, shows 16 of these farms.

Figure 55 - Wisconsin dairy operations with anaerobic digesters



Environmental consequences of anaerobic digesters

The large amount of manure generated at livestock confinement operations can create environmental problems such as surface and groundwater contamination, and air emissions including odor, ammonia, hydrogen sulfide, and methane. The use of anaerobic digestion as part of manure management systems has been claimed to help to alleviate these environmental issues. These issues are summarized in Table 25, below.

Table 25 - Environmental effectiveness of manure management options

Environmental Effectiveness of Manure Management Options

Options	Odor Control	Greenhouse Gas Reduction	Water Quality Protection	Cost Range†† (per 1,000 lbs/ live weight)
Covered lagoon digesters with open storage ponds	E	H	G	$150-400
Heated digesters (i.e., complete mix and plug flow) with open storage tanks	E	H	G	$200-400
Aerated lagoons with open storage ponds†	G-E	H	F-G	$200-450
Separate treatment lagoons and storage ponds (2-cell systems)	F-G	L	G	$200-400
Combined treatment lagoons and storage ponds	P-G	L	F-G	$200-400
Storage ponds and tanks	P-F	M-H	P-F	$50-500

Key: P=poor, F=fair, G=good, E=excellent, L=low, M=medium, H=high

†Aerated lagoon energy requirements add an additional $35-50 per 1,000 lbs/year.

††Cost ranges do not include annual operation and maintenance (O&M) costs.

Source: US EPA AgStar "Managing Manure with Biogas Recovery Systems Improved Performance at Competitive Costs" http://www.epa.gov/agstar/pdf/manage.pdf

Surface water

The use of anaerobic digestion may provide water quality benefits. A properly managed AD system, especially a digester processing manure from a covered lagoon, may allow phosphorous and metals, such as copper and zinc, to settle out in the process cells, potentially reducing loadings to surface waters when manure is land-applied. Disease-causing organisms may be destroyed in a heated digester, thereby reducing health risks from contaminated surface water (Managing Manure with Biogas Recovery Systems Improved Performance at Competitive Costs). Additional research and monitoring are necessary to fully understand how manure management systems utilizing anaerobic digestion impact surface water quality.

Biological oxygen demand

Additional monitoring is necessary to fully understand whether digestion impacts BOD levels, and if so, to what degree.

Nitrogen

It is claimed that most of the organic nitrogen present in manure is converted to ammonia in a digester. Ammonia can be used as a fertilizer readily utilized by plants, depending on how the ammonia is handled and land applied (*i.e.* ammonia is highly subject to volatilization). The treated liquid effluent from a digester can be spread on fields, and the remaining solids can be sold as a soil amendment. (Managing Manure with Biogas Recovery Systems Improved Performance at Competitive Costs)

Phosphorus

In a plug-flow digester, the available nitrogen and phosphorus content may be higher than in the effluent from a covered or facultative lagoon, which could pose a nutrient problem when

insufficient cropland is available for spreading. (An Assessment of Technologies for Management and Treatment of Dairy Manure in California's San Joaquin Valley)

Pathogens

Pathogens such as *E. coli, Salmonella* and *Cryptosporidium* could be destroyed in heated digesters with sufficiently high temperatures. (Renewable Energy – Farm Energy from Manure – Fact Sheet) Pathogen destruction is a function of temperature and time. Manure digested for longer periods of time and at higher the temperatures decreases the probability of pathogen survival. Sustained temperatures may provide for significant destruction. Ambient temperature may also affect operating temperature, thus impacting the digesters ability to destroy pathogens.

Groundwater

Ground water resources may also be protected through the use of anaerobic digesters. While the extent to which digesters facilitate pathogen destruction is unclear, it is conceivable that digesters may reduce the risk of groundwater contamination.

Air Quality

Odors

Numerous digester manufacturers report that effluent odor from anaerobic digesters is less than odors from conventional manure management systems, and that odor reduction using anaerobic digestion can be cost-effective compared to other alternatives such as aeration. (Managing Manure with Biogas Recovery Systems Improved Performance at Competitive Costs Preliminary results from the Wisconsin's Dairy and Livestock Air Emission/Odor Project have not shown a significant difference for odor and ammonia reductions between typical manure management systems and a manure management system utilizing an AD.

Ammonia

The digestion process releases organic nitrogen into the form of ammonia, because of the anaerobic conditions inside of the digester. This ammonia is therefore more readily available for use as a nutrient, but it is also more easily volatilized during storage after the effluent has left the digester. Indeed, results from Wisconsin's Dairy and Livestock Air Emission/Odor Project suggest that ammonia levels around digested manure storage lagoons are elevated relative to undigested manures.

Covers for lagoons can help to temporarily manage ammonia emissions. This is more easily done with a digester than in a conventional system since with a digester treatment and storage are separate, and the storage structure is therefore smaller and more easily and cheaply covered (Managing Manure with Biogas Recovery Systems Improved Performance at Competitive Costs). Both permeable (geotextile) and impermeable covers show appreciable reduction of ammonia volatilization from lagoon surfaces, with impermeable covers being significantly more effective.

Hydrogen Sulfide

Hydrogen sulfide gas is generated from the breakdown of sulfur containing proteins under anaerobic conditions, and is therefore a definite by-product of manure digestion. Scrubbing biogas before combustion or other use is a general requirement, in part to remove the hydrogen sulfide which can cause corrosion and premature failure of gas handling equipment. This removal

process, combined with the accelerated release of the sulfur from its organic matrix during digestion, should lead to a reduced hydrogen sulfide potential in digested manures.

It should be noted that parameters such as retention time and the completeness of digestion inside the digester play a significant role in whether or not odors and gaseous emissions are actually reduced. In almost all real world situations, the effluent will be stored in a lagoon following digestion, and the storage systems will frequently generate anaerobic conditions inside them. Therefore, any remaining undigested organic materials will be a potential source of odors and hydrogen sulfide.

Greenhouse Gases

Biogas recovery systems capture and burn methane, whereas large amounts of methane are released to the atmosphere by conventional systems. (Managing Manure with Biogas Recovery Systems Improved Performance at Competitive Costs) Anaerobic digesters can impact greenhouse gas emissions in two ways: first, through capturing and burning methane (often referred to as "methane destruction"), and second, by displacing the use of fossil fuels.

If a digester and biogas recovery system simply capture and burn off methane, CO2 is emitted into the atmosphere. As methane is estimated to have a global warming potential 25 times greater than CO2, there is significant greenhouse gas benefit to this conversion[13]/[14].

However, estimating an actual greenhouse gas benefit from methane destruction is difficult because of the large number and complexity of variables involved. These variables complicate determining whether any greenhouse gas benefit from the digester can be considered additional to what would have occurred without the digester.[15] In more simple terms, in order for any greenhouse gas benefit to be recognized, it must be greater than what is required by regulation, and beyond what would have occurred absent the project, or in a "business as usual" scenario. Examples of the variables which must be accounted for include: existing manure management practices, average animal population, accounting for varying animal age and weight classes, applicable federal, state or local regulations, determination of an emission baseline, and accounting for existing manure management system/facility and farm specific data when possible.[16] Given this complexity, protocols for establishing greenhouse benefits from methane destruction have been developed by the EPA, the Chicago Climate Exchange, the Kyoto Protocol's Clean Development Mechanism, the California Climate Action Registry and others.

The use of a digester and biogas recovery system can reduce methane emissions of at least three tons per cow per year. For an 800 cow dairy operation, this is about 2,600 tons per year.

Additional greenhouse gas benefits are possible from the uses of biogas, and all of these benefits stem from the displacement of traditional fossil fuels. For example, if the biogas is treated, compressed and injected into a pipeline, an end user will consume less natural gas as a result, or if the biogas is used onsite for heating purposes (water, building or steam) the farm itself would

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[13] *[Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland, 2007: Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007:The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]*

[14] *Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Table 2.14, page 212. http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter2.pdf].*

[15] *Additionality is one of four key accounting principles used broadly in determining greenhouse gas reductions. The other three principles are: reality of a reduction, permanence of a reduction and verifiability of a reduction.*

[16] *[Climate Leaders Greenhouse Gas Inventory Protocol Offset Project Methodology for Project Type: Managing Manure with Biogas Recovery Systems, U.S. Environmental Protection Agency, August 2008, Version 1.3, http://www.epa.gov/climateleaders/documents/resources/ClimateLeaders_DraftManureOffsetProtocol.pdf]*

displace natural gas use. If the biogas is used to run a reciprocating engine or gas turbine in order to produce electricity, fossil fueled electrical generation elsewhere on the grid will be displaced.

In each of these examples the primary greenhouse gas benefits are not necessarily a result of less actual greenhouse gas emissions. In some instances this may be the case, for example, when biogas displaces coal-fueled electrical generation. The primary greenhouse gas benefits result from the fact that CO2 emissions from biogas are considered *biogenic* (and do not add to net atmospheric CO2 levels) and these replace the *anthropogenic* CO2 emissions (which do add to net atmospheric CO2 levels) of traditional fossil fuels.[17]

Because biogas/biomass CO2 emissions are considered biogenic (defined by NASA's Earth Observatory Library Glossary as "produced by natural processes"), it is assumed that the carbon released during the consumption of biomass was already present in the ecosystem and is recycled as forests and crops regenerate, causing no net addition of CO2 to the atmosphere. Conversely, fossil fuel CO2 emissions are considered anthropogenic (defined by NASA's Earth Observatory Library Glossary as "made by people or resulting from human activities"), and it is assumed that the carbon released during the consumption of fossil fuels was not already present in the ecosystem, and thus results in a net addition of CO2 to the atmosphere[18]

Estimating potential for greenhouse gas benefits from fossil fuel displacement is also complicated by the large number and complexity of variables involved. A 2005 technical report from Alliant Energy attempted this exercise assuming use of biogas for electricity generation.[19] The report estimated electric generation capacity of anaerobic digesters from Wisconsin dairy herds over 500 head to be approximately 39MW.[20] Alliant calculated capacity using a 5 cows / kW "productivity" assumption. Using Alliant's assumption of a 0.95 capacity factor, the 39MW capacity would yield 324,558 MWh of electricity.[21] In 2002 Focus on Energy suggested a "productivity" rule of thumb of 7-10 cows / kW.[22] Using Focus' "productivity" rule of thumb with Alliant's other parameters yields alternative estimates of 233,016 MWh[23] and 158,118 MWh[24] of electricity.

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[17] [Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006, April 15, 2008, page 3-13, U.S. Environmental Protection Agency, Washington, DC, EPA 430-R-08-005, http://www.epa.gov/climatechange/emissions/downloads/08_CR.pdf]

[18] [Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006, April 15, 2008, page 3-1, U.S. Environmental Protection Agency, Washington, DC, EPA 430-R-08-005, http://www.epa.gov/climatechange/emissions/downloads/08_CR.pdf].

[19] [Anaerobic digesters and methane production in the agricultural sector of states served by Alliant Energy. Technical report, Alliant Energy, 2005. http://www.alliantenergy.com/docs/groups/public/documents/pub/p013122.pdf].

[20] 500-999 head: 187 herds, 117,085 animals; 1000+ head: 55 herds, 82,171 animals; total of 199,256 animals; Alliant calculated capacity using 5 cows / kW assumption; 199,256 cows @ 5 cows / kW = 39,851 kW, ~39 MW

[21] 39MW X 24hrs/day X 365days/yr X .95 = 324,558 MWh

[22] [Renewable Energy – Farm Energy from Manure – Fact Sheet, 2002, Focus on Energy, Publication REN2003-0602, http://www.focusonenergy.com/files/Document_Management_System/Renewables/W_RB_MKFS_Farm_energy_from_manure.pdf].

[23] 199,256 cows @ 7 cows / kW = 28,465 kW, ~28 MW; 28MW X 24hrs/day X 365days/yr X .95 = 233, 016 MWh

[24] 199,256 cows @ 10 cows / kW = 19,925 kW, ~19 MW; 19MW X 24hrs/day X 365days/yr X .95 = 158, 118 MWh

It is possible to get a rough approximation of potential greenhouse gas benefits from this range of generation estimates by using the DNR's Energy Reduction to Emission Reduction Calculation Tool CO2 emission factor of 1851.461 pounds/MWh.[25] The potential greenhouse gas benefit for each generation estimate is as follows:

- 324,558 MWh (5 cows / kW): 272,569 metric tons of CO2[26]
- 233,016 MWh (7 cows / kW): 195,691 metric tons of CO2[27]
- 158,118 MWh (10 cows / kW): 132,790 metric tons of CO2[28]

To provide scale for these potential benefits it is useful to look at statewide greenhouse gas emissions. The most recent Wisconsin greenhouse gas inventory was tabulated for the DNR by World Resources Institute as part of the Governor's Task Force on Global Warming. This inventory used data from 2003, the most recent year for which data was available. Wisconsin's greenhouse gas emissions from electricity generation for that year were estimated to be 43,100,000 metric tons of CO2 equivalents. Total statewide greenhouse gas emissions from that year were estimated to be 123,100,000 metric tons of CO2 equivalents.[29]

It is important to note that these are rough approximations of gross greenhouse gas benefits resulting from displaced electricity generation. Net benefits may be less due to "line loss" of generated electricity, as well as some additional emissions that may occur, which are not accounted for here (*e.g.* emissions resulting from electricity used for digester operation, including blowers, heaters, *etc.*, emissions resulting form the transportation of manure specifically related to the project, emissions resulting from the construction of the digester). Furthermore, other utilization of biogas would lead to different greenhouse gas benefits. The above estimates are of displaced electricity generation, but biogas used to displace natural gas, as discussed earlier (*e.g.* if the biogas is used for heating purposes such as water, building/space heat, or steam generation), would produce markedly smaller greenhouse gas benefits.

Biogas recovery systems capture and burn methane (a greenhouse gas), whereas large amounts of methane are released to the atmosphere by conventional systems.[30]

The use of a digester and biogas recovery system can reduce methane emissions of at least three tons per cow per year. For an 800 cow dairy operation, this is about 2,600 tons per year. Methane has been reported to be 221 times more potent than carbon dioxide as a greenhouse gas (Renewable Energy – Farm Energy from Manure – Fact Sheet, and An Evaluation of a Mesophilic, Modified Plug Flow Anaerobic Digester for Dairy Cattle Manure).

The following paragraphs are from the Wisconsin Task Force on Global Warming Policy Template: Agriculture and Forestry Work Group - Production, Capture and Use of Animal Methane.

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[25] *[Energy Reduction to Emission Reduction Calculation Tool, Wisconsin DNR, accessed on 9/5/08, http://dnr.wi.gov/air/vol/registry/quantwattcalc.html]*

[26] *324,558 MWh X 1851.461 lbs/MWh = 600,906,479.24 lbs / 2,204.6 lbs/metric ton = 272,569.39 metric tons*

[27] *233,016 MWh X 1851.461 lbs/MWh = 431,420,036.376 lbs / 2,204.6 lbs/metric ton = 195,690.84 metric tons*

[28] *158,118 MWh X 1851.461 lbs/MWh = 292,749,310.398 lbs / 2,204.6 lbs/metric ton = 132,790.22 metric tons*

[29] *[Wisconsin Greenhouse Gas Emissions Inventory and Projections, June 25, 2007, Prepared for: Wisconsin Department of Natural Resources and the Governor's Task Force on Global Warming, Prepared by: World Resources Institute, 10 G St. NE. 8th Floor, Washington, DC 20002, Publication Number: AM-393-2008, http://dnr.wi.gov/environmentprotect/gtfgw/documents/WI_GHG_inventory.pdf]*

[30] *[Managing Manure with Biogas Recovery Systems Improved Performance at Competitive Costs]*

Biogas recovery and use can help to reduce carbon dioxide emissions (Managing Manure with Biogas Recovery Systems Improved Performance at Competitive Costs). It has been estimated that one kilowatt of electricity could be generated from every seven to 10 cows (Renewable Energy – Farm Energy from Manure – Fact Sheet).

Based on 2008 information, 18 digesters on large farms in Wisconsin could potentially produce enough electrical energy to power 2,000 average Wisconsin homes, or about 5,000 KW. As much as 50,000 KW of electricity could potentially be produced from animal manure if all of the states 150 large animal feeding operations had an operating digester system (based on 2008 information). This would offset the generation from coal for a community of about 30,000 people. (Renewable Energy – Farm Energy from Manure – Fact Sheet Biosolids: A case of waste not, want not?; and Agricultural Biogas Casebook – 2004 Update – http://www.cglg.org/biomass/pub/AgriculturalBiogasCasebook.pdf])

Power generation from manure digestion could eliminate about 1.33 tons per year of carbon dioxide emissions, or about 1,00 tons per 800 cow dairy (An Evaluation of a Mesophilic, Modified Plug Flow Anaerobic Digester for Dairy Cattle Manure).

The above estimates of energy production and greenhouse gas reduction potential from digesters are based mainly on converting only animal manure to fuel. Many other types of organic material can be digested to produce biogas. Only a small portion of these materials are being used for energy production. A great quantity of by-products from food processing is also available. These materials could be digested for biogas production before land application. Opportunities for energy and digester expansion in Wisconsin include wastewater treatment sludge, food waste currently being landfilled, and by-products from food processing currently being land applied.

Twenty three communities have been identified that may be able to use digester gas for cogeneration, and could generate over 2,300 kW of electricity, with a payback of not more than eight years (Anaerobic Digester Methane to Energy - A Statewide Assessment).

Flare/Generator emissions

Little is known about actual emissions from the vast majority of engines or microturbines currently in operation in Wisconsin. There are “biogas” engines permitted at municipal wastewater treatment plants and solid waste landfills (AM and Anaerobic Digester Gas from Dairies).

There is limited emissions data worldwide, and some appears contradictory, such as data indicating high levels of NOx reported from biogas engines in Denmark (AM and Anaerobic Digester Gas from Dairies).

Based on one Research and Testing project at Five Star Dairy, NOx levels were found to be below NR 406 emission thresholds. Additional testing is needed to determine HAPs (*e.g.* formaldehyde) emitted from engines emitting low NOx (AM and Anaerobic Digester Gas from Dairies).

Many engine/turbine manufacturers require gas treatment prior to combustion (*e.g.* reduction of H2S, moisture). Siloxanes are not an issue with AD gas from dairy waste, but could be if other substrates (biosolids/sludge from municipal WWTP for example) are added to the AD or to the combustion unit (landfill biogas or WWTP biogas, for example), (AM and Anaerobic Digester Gas from Dairies).

Power generation technology [internal combustion (IC) engine vs. microturbine vs. Sterling engine vs. fuel cells, *etc.*] and the subsequent treatment of AD biogas to meet fuel specifications (*i.e.* moisture, H2S) will directly affect air emissions from these units. Looking strictly at NOx and CO, the lowest emissions for these two pollutants are expected from fuel cells, followed by microturbines, Sterling engines, and last, spark ignition IC engines. SO2 emissions will be directly based on the fuel sulfur content. Both microturbines and Sterling engines can tolerate high H2S fuel specifications followed by IC engines. Fuel cells require very low H2S fuel specification concentrations (less than 0.10 ppmv H2S) (EPRI Distributed Energy Resources Program, 2004).

Interestingly, AD biogas produces lower NOx emissions than natural gas, because the additional CO2 in the fuel cools the combustion temperature (AD Gas Utilization Techn. Fuel Cells, Co-Generation, and other Options; L. Kevin Mosteller, HDR Engineering).

Economic effects of anaerobic digesters for dairy farms

There are a variety of costs for initial investment, operation and maintenance for a wide variety of waste management system options, vendors and suppliers. Costs may range from $60 per AU for a conventional pond, to $300 per AU for a prefabricated above-ground tank. Depending on annual rainfall and process water use, an open-air conventional lined lagoon combining treatment and storage may cost between $200 and $400 per AU. An anaerobic digestion system may be cost-competitive with conventional manure management systems. The cost of a covered lagoon and heated digester may range in cost from about $200 to $450 per AU. Payback on such systems may be about seven years (Managing Manure with Biogas Recovery Systems Improved Performance at Competitive Costs).

Gas or electrical generation economic effects

Economies of scale may make digesters a benefit for larger farms where installation costs are about $400 to $500 per cow. Smaller farms may also be able to benefit from digester systems (Renewable Energy – Farm Energy from Manure – Fact Sheet; and Biosolids: A case of waste not, want not?). The Wisconsin Task Force on Global Warming found that smaller farm installation costs may be greater than $700 per AU, however. (Wisconsin Task Force on Global Warming Policy Template: “Production, Capture and Use of Animal Methane) While large farm digesters are the most economically attractive, it’s conceivable that greater potential exists in capturing biogas from medium to small animal operations.

It has been claimed that cogeneration of electricity with digester-generated biogas would be cost effective with a 10 year payback for farms with 600 or more cows, and that higher prices for future power would make these systems more cost effective. (Anaerobic Digester Methane to Energy - A Statewide Assessment; and calculation using conversion factor of 1000 animal units equaling the pollution potential of a community of 18,000 people).

Some studies, however, question the economic viability of electrical generation from biogas on farms.

Electrical generation equipment is an expensive component that has not been shown to fulfill the promise of cogeneration sales of electricity back to utilities. Most system owners who initially included electrical generation abandoned the generators after two to three years of operation. If generators are not included, it is estimated that initial digester system costs would be reduced by about 36%. Direct burning of biogas for heating water and buildings is a more attractive option where natural gas costs in the range of $12 per 1000 cubic feet can be replaced with biogas. Biogas can be burned in space heaters or boilers without high gas cleaning costs (An Analysis of

Energy Production Costs from Anaerobic Digestion Systems on U.S. Livestock Production Facilities).

Electrical generation from manure anaerobic digestion systems has not been shown to provide positive cash flow. Other benefits of digesters like the ability to use other waste streams and pollution reduction may make digesters economically advantageous. On-site heat generation appears to be the best use of biogas economically (An Analysis of Energy Production Costs from Anaerobic Digestion Systems on U.S. Livestock Production Facilities).

Treated manure as bedding

A claimed benefit of anaerobic digestion is the ability to utilize the solids as bedding as opposed to the more conventional sand, sawdust, *etc.* However, the benefit of bedding from digestion solids is a function of whether or not the bedding is free of bacteria and pathogens, which in turn is a function of treatment temperature and time.

VI.E.2. Other waste-to-energy technologies

Thermal Conversion

Thermal conversion are technologies that treat waste and/or produce energy by burning. Such technologies include direct combustion, pyrolyis, gasification, and hydro thermal liquefaction. Pyrolisis uses heat without air to produce a low BTU gas that can be burned in a boiler or engine, and pyrolysis oil. Gasification uses higher heat and restricted oxygen to produce a low to medium BTU gas for use in boilers or engines. Hydrothermal liquefaction is another thermal conversion technology that produces oils and char that can be used as fuels. Potential advantages of thermal conversion include: replacement of fossil fuels with manure, nutrient reduction, reducing land application concerns, pathogen reduction, odor reduction, beneficial ash reuse, and stimulation of local economies. Problems include: air emissions, manure quality variability, and high capital and operating costs. Operating costs from manure drying and other pretreatment, air emission controls, electrical generation, and ash disposal are widely estimated. These systems do not currently appear to be economically viable without additional income streams (An Assessment of Technologies for Management and Treatment of Dairy Manure in California's San Joaquin Valley).

Use of thermal conversion on dairy farms

The high moisture content of dairy manure (10 - 12 % solids and only 2% solids in flush dairies), and the high energy costs for manure drying make most thermal conversion technologies unsuitable for dairy operations. Only those dairy operations that separate manure solids are likely to be able to take advantage of thermal systems. While thermal conversion has been used for conversion of various dry organic fuels, few examples exist in the dairy industry. As of 2005, there was a commercial-scale thermal conversion facility at the University of Southern Illinois that may have tested dairy manure (An Assessment of Technologies for Management and Treatment of Dairy Manure in California's San Joaquin Valley).

VI.E.3. Other manure management technologies

Other possible technologies that could be implemented at a CAFO, either alone or in concert with others include: 1) covering manure storage facilities to capture emissions and reduce odor, 2) mechanical solids separation, 3) use of a rotary drum thickener to improve solids recovery, 4) centrifuge/cyclone solids separation, 5) ultra filtration (using reverse osmosis to filter liquid

manure into cleaner water form, and 6) dissolved air floatation (using proven municipal water treatment technology, solids are 'floated' out of manure using dissolved air and polymers).

Each of these has a cost associated with the construction and operation (including energy consumption) of the given technology.

The Department currently has a Green Tier program designed to create incentives for operations to go “beyond compliance” and implement additional practices, technological or otherwise. The program encourages operations to look at reducing impacts across all media, beyond that required under current rules, in exchange for certain regulatory benefits.

VII. Evaluation

VII.A. Degree of risk or uncertainty

The fact that permit compliance is based on self-monitoring and self-reporting has been criticized. While it is understandable that people often view self-monitoring and reporting with suspicion, in practice it has served as a critical and effective component of the Department's compliance monitoring efforts. One of the reasons that the system of self-monitoring and self-reporting is effective is that self-monitored and self-reported exceedances or violations of permit requirements are "admissions" that are almost impossible to refute in an enforcement action. And, because of the relative ease of verification of self-monitoring (and the fact that much of the work is done by contractors who employ professionals whose reputation and livelihood depend on producing valid results) the frequency of false monitoring or reporting is low. Enforcement of environmental permits has been as successful as it has in very large part due to the system of self-monitoring and self-reporting.

Another potential issue is the perception that GPs would provide less protection for the environment. GPs provide for a streamlined permit process by reducing the time needed to issue what has become a very standardized WPDES permit template for each permitted operation. Not needing to repeat the permitting process for each operation will allow Department staff to spend less time on permit issuance and more time on other activities such as permit compliance and inspections, enforcement actions where needed, and addressing impacts from smaller-scale operations that do not have permits.

The proposed LDCAFO GP is not known to conflict with plans or policy of local, state, or federal agencies. Operations covered under the GP will need to apply for and receive the appropriate approvals from all agencies when necessary. Permitting these operations via a GP would not foreclose future options for taking necessary actions to protect the environment such as pursuing enforcement action for discharges that impact water quality or other types of permit violations.

VII.B. Degree of precedence

While the Department has issued other WPDES GPs in the past, issuance of the Large Dairy CAFO GP will set a precedent in that the Department expects that most operations that meet the size thresholds and other eligibility criteria in the permit will be covered under the GP rather than an individual permit. However, the issue is not whether or not an operation will receive a permit, but rather, what type of permit the operation will receive. There will likely be limited instances where the Department issues an individual permit to an operation that meets the edibility criteria of the Large Dairy CAFO GP.

VII.C. Degree of controversy

Issuance of the LDCAFO GP is expected to be controversial. An increasing number of citizens of Wisconsin are concerned about the real or perceived impacts CAFOs have on the environment, as well as other socio-economic concerns. There is concern that issuance of the permit will result in a growing number of CAFOs and decreased public input on these operations. A portion of this controversy may be related to misperceptions regarding the GP. Informal comments received from members of the public on the concept of GPs indicate the following key concerns about the Large Dairy CAFO GP.

One concern is that there will be less DNR review of permit application materials and review of the operation's environmental impacts in general. The application process and level of review for

individual permits and general permits will not differ as it relates to water quality concerns. The use of a GP only streamlines the final stage of issuing coverage under a permit, not the water quality review that is done prior to issuing coverage.

Another concern is that the permit requirements under the GP will be less stringent than individual permit. Permit requirements for large CAFOs are standardized in ch. NR 243. Where more restrictive requirements are necessary to protect water quality or where an operation does not meet GP eligibility requirements, an individual permit will be issued.

Concern has been expressed that opportunities for public input will be limited. Changes to the federal CAFO rule require that the Department issue a public notice when it proposes to cover an individual operation under the GP, including public notice of the operation's nutrient management plan.

VII.D. Overall cumulative effects

Animal waste from livestock CAFOs can negatively affect all water resources and contaminate both surface and groundwater drinking water systems. Pollutants of concern related to manure storage and land application in drinking water systems include nitrate, phosphorus, pathogens, viruses, hormones, antibiotics, heavy metals and dissolved organic carbon. Groundwater pollutants of concern from production of grain to feed livestock include nitrate and pesticides. The most commonly detected pesticides in Wisconsin groundwater are alachlor ESA, metolachlor ESA, and Atrazine and its metabolites (WDATCP, 2008[31]). While there have been instances of surface water and groundwater contamination resulting from CAFO operations, there has not been a wide-spread reduction in surface or groundwater quality in areas in which CAFOs occur. The presence of CAFOs may impact local economies in both positive and negative ways, but the overall trend toward larger farms appears to be driven by factors in the agricultural economy, and not by permitting issues. The Department does not anticipate changes in the growth of CAFOs due to this proposed LDCAFO GP.

[31] *DATCP, 2008. Groundwater Quality: Agricultural Chemicals in Wisconsin Groundwater. Wisconsin Department of Agriculture, Trade and Consumer Protection, Water Quality Section, 77 ARMPUB180.qxd. 22 p. Copies of this survey, as well as summaries of other DATCP monitoring projects are available at http://datcp.state.wi.us/arm/agriculture/landwater/environ_quality/monit_proj.jsp*

VIII. Appendices

VIII.A. Proposed large CAFO general permit

VIII.B. Proposed large CAFO general permit fact sheet

VIII.C. Dairy animal numbers by county and year (from USDA's National Agricultural Statistics Service website)

Year	County	Annual Average Milk Cows	Year	County	Annual Average Milk Cows	Year	County	Annual Average Milk Cows
1978	Adams	3600	1978	Calumet	30500	1978	Door	15500
1983	Adams	3700	1983	Calumet	31900	1983	Door	14900
1988	Adams	3100	1988	Calumet	30400	1988	Door	14200
1993	Adams	2400	1993	Calumet	27300	1993	Door	12400
1998	Adams	2000	1998	Calumet	22500	1998	Door	11000
2003	Adams	1300	2003	Calumet	22500	2003	Door	8500
2008	Adams	1100	2008	Calumet	28000	2008	Door	8000
1978	Ashland	3800	1978	Chippewa	50600	1978	Douglas	2400
1983	Ashland	3900	1983	Chippewa	54300	1983	Douglas	1900
1988	Ashland	3300	1988	Chippewa	52600	1988	Douglas	1600
1993	Ashland	2200	1993	Chippewa	46800	1993	Douglas	1300
1998	Ashland	2000	1998	Chippewa	42000	1998	Douglas	1100
1978	Barron	47300	2003	Chippewa	33500	1978	Dunn	40900
1983	Barron	48700	2008	Chippewa	32500	1983	Dunn	43100
1988	Barron	46000	1978	Clark	67800	1988	Dunn	40300
1993	Barron	39300	1983	Clark	70000	1993	Dunn	33900
1998	Barron	34000	1988	Clark	65800	1998	Dunn	27500
2003	Barron	27000	1993	Clark	60900	2003	Dunn	21000
2008	Barron	24200	1998	Clark	61000	2008	Dunn	22300
1978	Bayfield	5600	2003	Clark	63000	1978	Eau Claire	22200
1983	Bayfield	5700	2008	Clark	63000	1983	Eau Claire	19900
1988	Bayfield	4800	1978	Columbia	23300	1988	Eau Claire	20000
1993	Bayfield	4300	1983	Columbia	26400	1993	Eau Claire	18500
1998	Bayfield	3500	1988	Columbia	24000	1998	Eau Claire	15500
1978	Brown	39000	1993	Columbia	22000	2003	Eau Claire	10400
1983	Brown	40500	1998	Columbia	17500	2008	Eau Claire	10900
1988	Brown	38000	2003	Columbia	16000	1978	Florence	1100
1993	Brown	35200	2008	Columbia	15300	1983	Florence	1100
1998	Brown	36500	1978	Crawford	19000	1988	Florence	900
2003	Brown	41500	1983	Crawford	19600	1993	Florence	700
2008	Brown	41000	1988	Crawford	19800	1998	Florence	600
1978	Buffalo	28400	1993	Crawford	16800	1978	Fond Du Lac	50500
1983	Buffalo	30700	1998	Crawford	13500	1983	Fond Du Lac	53200
1988	Buffalo	29700	2003	Crawford	10000	1988	Fond Du Lac	52300
1993	Buffalo	27900	2008	Crawford	9200	1993	Fond Du Lac	47000
1998	Buffalo	25000	1978	Dane	64900	1998	Fond Du Lac	41000
2003	Buffalo	19300	1983	Dane	66300	2003	Fond Du Lac	41000
2008	Buffalo	18900	1988	Dane	64100	2008	Fond Du Lac	46500
1978	Burnett	7200	1993	Dane	56500	1978	Forest	1800
1983	Burnett	6600	1998	Dane	51000	1983	Forest	1500
1988	Burnett	5600	2003	Dane	48000	1988	Forest	1400
1993	Burnett	4700	2008	Dane	50500	1993	Forest	900
1998	Burnett	3800	1978	Dodge	63100	1998	Forest	600
2003	Burnett	3300	1983	Dodge	59500	1978	Grant	56100
2008	Burnett	3300	1988	Dodge	57300	1983	Grant	64500

			1993	Dodge	54800	1988	Grant	64800
			1998	Dodge	48500	1993	Grant	58000
			2003	Dodge	42500	1998	Grant	52000
			2008	Dodge	41500	2003	Grant	50500
						2008	Grant	46500
Year	**County**	**Annual Average Milk Cows**	**Year**	**County**	**Annual Average Milk Cows**	**Year**	**County**	**Annual Average Milk Cows**
1978	Green	50200	1978	Kewaunee	30200	1978	Marinette	14200
1983	Green	49500	1983	Kewaunee	30300	1983	Marinette	14600
1988	Green	46200	1988	Kewaunee	30800	1988	Marinette	14600
1993	Green	43800	1993	Kewaunee	28700	1993	Marinette	12600
1998	Green	38000	1998	Kewaunee	26000	1998	Marinette	10500
2003	Green	31000	2003	Kewaunee	28500	2003	Marinette	12000
2008	Green	31000	2008	Kewaunee	34000	2008	Marinette	11400
1978	Green Lake	14600	1988	La Crosse	17200	1978	Marquette	7300
1993	Green Lake	12300	1993	La Crosse	15400	1983	Marquette	7600
1998	Green Lake	9500	1998	La Crosse	13500	1988	Marquette	7600
2003	Green Lake	9000	2003	La Crosse	11000	1993	Marquette	6400
2008	Green Lake	8300	2008	La Crosse	9300	1998	Marquette	5500
1978	Iowa	37800	1978	Lafayette	41900	2003	Marquette	6000
1983	Iowa	39500	1983	Lafayette	42100	2008	Marquette	5700
1988	Iowa	41000	1988	Lafayette	42600	1978	Milwaukee	200
1993	Iowa	34400	1993	Lafayette	39600	1983	Milwaukee	300
1998	Iowa	30500	1998	Lafayette	34500	1988	Milwaukee	300
2003	Iowa	25000	2003	Lafayette	30000	1978	Monroe	37600
2008	Iowa	24700	2008	Lafayette	29800	1983	Monroe	37800
1978	Iron	600	1978	Langlade	13300	1988	Monroe	37300
1983	Iron	500	1983	Langlade	12200	1993	Monroe	34100
1988	Iron	400	1988	Langlade	10900	1998	Monroe	29500
1978	Jackson	19000	1993	Langlade	8900	2003	Monroe	24700
1983	Jackson	18200	1998	Langlade	8300	2008	Monroe	24600
1988	Jackson	17900	1978	Lincoln	11500	1978	Oconto	30400
1993	Jackson	17000	1983	Lincoln	11600	1983	Oconto	29400
1998	Jackson	15000	1988	Lincoln	9600	1988	Oconto	27200
2003	Jackson	13400	1993	Lincoln	7000	1993	Oconto	24300
2008	Jackson	13300	1998	Lincoln	6200	1998	Oconto	21500
1978	Jefferson	28800	2003	Lincoln	5200	2003	Oconto	21000
1983	Jefferson	29200	2008	Lincoln	4400	2008	Oconto	19500
1988	Jefferson	26100	1978	Manitowoc	44800	1978	Oneida	400
1993	Jefferson	21500	1983	Manitowoc	49000	1983	Oneida	300
1998	Jefferson	17500	1988	Manitowoc	47300	1988	Oneida	200
2003	Jefferson	16800	1993	Manitowoc	41700	1978	Outagamie	45800
2008	Jefferson	15300	1998	Manitowoc	43000	1983	Outagamie	49700
1978	Juneau	14400	2003	Manitowoc	44500	1988	Outagamie	46000
1983	Juneau	14900	2008	Manitowoc	45500	1993	Outagamie	39800
1988	Juneau	15300	1978	Marathon	85800	1998	Outagamie	34500
1993	Juneau	12300	1983	Marathon	81800	2003	Outagamie	37000
1998	Juneau	10000	1988	Marathon	76500	2008	Outagamie	37500
2003	Juneau	8600	1993	Marathon	67400	1978	Ozaukee	10300
2008	Juneau	11000	1998	Marathon	63000	1983	Ozaukee	11400
1978	Kenosha	7200	2003	Marathon	60500	1988	Ozaukee	10400

1983	Kenosha	5900	2008	Marathon	62500	1993	Ozaukee	9400
1988	Kenosha	6000				1998	Ozaukee	8600
1993	Kenosha	4800				2003	Ozaukee	8800
1998	Kenosha	3700				2008	Ozaukee	8400
2003	Kenosha	3300						
2008	Kenosha	3300						

Year	County	Annual Average Milk Cows	Year	County	Annual Average Milk Cows	Year	County	Annual Average Milk Cows
1978	Pepin	10000	1978	Rock	27600	1978	Taylor	30100
1983	Pepin	10700	1983	Rock	24600	1983	Taylor	30500
1988	Pepin	10400	1988	Rock	23900	1988	Taylor	28500
1993	Pepin	9400	1993	Rock	18100	1993	Taylor	22400
1998	Pepin	8500	1998	Rock	14500	1998	Taylor	20500
2003	Pepin	9200	2003	Rock	12700	2003	Taylor	17100
2008	Pepin	8400	2008	Rock	12400	2008	Taylor	16300
1978	Pierce	25800	1978	Rusk	18600	1978	Trempealeau	35500
1983	Pierce	27400	1983	Rusk	18300	1983	Trempealeau	38900
1988	Pierce	24100	1988	Rusk	17800	1988	Trempealeau	35700
1993	Pierce	22200	1993	Rusk	14600	1993	Trempealeau	30300
1998	Pierce	19000	1998	Rusk	13500	1998	Trempealeau	26500
2003	Pierce	18000	2003	Rusk	11700	2003	Trempealeau	24000
2008	Pierce	16300	2008	Rusk	11200	2008	Trempealeau	22600
1978	Polk	33900	1978	Sauk	38300	1978	Vernon	44700
1983	Polk	33700	1983	Sauk	38500	1983	Vernon	44900
1988	Polk	31000	1988	Sauk	36500	1988	Vernon	44800
1993	Polk	25500	1993	Sauk	31400	1993	Vernon	39300
1998	Polk	21000	1998	Sauk	30500	1998	Vernon	33500
2003	Polk	17500	2003	Sauk	27400	2003	Vernon	24600
2008	Polk	16200	2008	Sauk	26400	2008	Vernon	25500
1978	Portage	17100	1978	Sawyer	3300	1978	Vilas	100
1983	Portage	17900	1983	Sawyer	3200	1983	Vilas	100
1988	Portage	17500	1988	Sawyer	3100	1993	Walworth	14800
1993	Portage	15700	1993	Sawyer	2700	1998	Walworth	12500
1998	Portage	15000	1998	Sawyer	2800	2003	Walworth	12500
2003	Portage	13300	2003	Sawyer	2900	2008	Walworth	12700
2008	Portage	12900	2008	Sawyer	2200	1978	Washburn	5800
1978	Price	9400	1978	Shawano	47700	1983	Washburn	6400
1983	Price	8300	1983	Shawano	51100	1988	Washburn	5300
1988	Price	6900	1988	Shawano	48200	1993	Washburn	4000
1993	Price	5000	1993	Shawano	43500	1998	Washburn	3300
1998	Price	4900	1998	Shawano	37500	2003	Washburn	3100
2003	Price	3900	2003	Shawano	35000	2008	Washburn	2800
2008	Price	3600	2008	Shawano	36500	1978	Washington	22600
1978	Racine	7200	1978	Sheboygan	32300	1983	Washington	23900
1983	Racine	8500	1983	Sheboygan	31500	1988	Washington	23800
1988	Racine	7200	1988	Sheboygan	30300	1993	Washington	20000
2008	Racine	3800	1993	Sheboygan	26000	1998	Washington	15500
1978	Richland	27500	1998	Sheboygan	26500	2003	Washington	14700
1983	Richland	26400	2003	Sheboygan	25500	2008	Washington	14800
1988	Richland	24900	2008	Sheboygan	27000	1978	Waukesha	10000

1993	Richland	22300
1998	Richland	19500
2003	Richland	13500
2008	Richland	14900

1978	St. Croix	35500
1983	St. Croix	36800
1988	St. Croix	34100
1993	St. Croix	28100
1998	St. Croix	24000
2003	St. Croix	23000
2008	St. Croix	21400

1983	Waukesha	10500
1988	Waukesha	9400
1993	Waukesha	7100
1998	Waukesha	5000
2003	Waukesha	3800

Year	County	Annual Average Milk Cows
1978	Waupaca	33800
1983	Waupaca	36300
1988	Waupaca	35200
1993	Waupaca	28700
1998	Waupaca	24500
2003	Waupaca	25000
2008	Waupaca	24400
1978	Waushara	12200
1983	Waushara	10500
1988	Waushara	9700
1993	Waushara	8400
1998	Waushara	6500
2003	Waushara	5800
2008	Waushara	5100
1978	Winnebago	24000
1983	Winnebago	23000
1988	Winnebago	21300
1993	Winnebago	18500
1998	Winnebago	16000
2003	Winnebago	14000
2008	Winnebago	16500
1978	Wood	25900
1983	Wood	26200
1988	Wood	26000
1993	Wood	23400
1998	Wood	22000
2003	Wood	24000
2008	Wood	20500

Year	County	Annual Average Milk Cows
1978	State Total	1811000
1983	State Total	1845000
1988	State Total	1758000
1993	State Total	1543000
1998	State Total	1369000
2003	State Total	1256000
2008	State Total	1252000