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Siting restrictions and proximity of Concentrated Animal Feeding Operations to surface water

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ABSTRACT

Proximity and connections to surface waters may play significant roles in determining impacts of manure spills. As occurred in many U.S. states, Minnesota adopted in 2000 more stringent regulations on Concentrated Animal Feeding Operations (CAFOs) including restrictions on siting new facilities near surface waters. The objectives of this study were to determine whether CAFO proximity to surface waters decreased following the siting restrictions and to evaluate implications of siting restrictions. Permit dates, locations, and distances to nearest surface water bodies for 111 west central Minnesota CAFOs were determined based on satellite imagery, historical records, and correspondence with regulatory officials. Average distance between surface waters and facilities permitted after 2000 was greater than for facilities permitted before 2000. The increase in average distance between CAFOs and public surface waters was significant for open water (1790 m, $p = 0.03$), but not for streams (280 m, $p = 0.47$). Decreased CAFO proximity to surface waters should benefit water quality, but after 2000 facilities continued to be permitted close to hydraulic connections not covered by the siting restriction. Comprehensive manure spill tracking and long term targeted water quality monitoring are needed to evaluate effectiveness of siting restrictions and other strategies for protecting surface waters from manure spills.

1. Introduction

Over the past several decades, animal feeding operations in many nations have become increasingly consolidated and concentrated into fewer, larger operations. This trend is evident in European nations including France, Denmark, and the Netherlands, as well as North American nations of Canada, Mexico, and the United States (Dourmad et al., 1999; Fernández et al., 1999; Van der Peet-Schwering et al., 1999; CPI, 2007; Ponette-González and Fry, 2010). In the U.S., the largest animal operations are termed Concentrated Animal Feeding Operations (CAFOs), which are defined as animal feeding operations that meet minimum thresholds for number of animals (e.g. 700 mature dairy cows, 2500 swine weighing 25 kg or more, 55,000 turkeys), discharge to surface water, or are otherwise determined to be a significant contributor to water pollution (US CFR, 2009).

Agriculture was listed in 2010 by the US Environmental Protection Agency (US EPA) as the most common probable source of stream impairments. Within the agriculture category, five of the top ten leading stream impairment sources were related to animal agriculture and included grazing in riparian zones, grazing or feeding operations, and permitted runoff from Concentrated Animal Feeding Operations (CAFOs) (US EPA, 2010). Regulation of CAFOs has been a point of contention for several decades as evidenced by prolonged debates over and legal challenges to the recent US Environmental Protection Agency rules regarding CAFOs (Becker and Howard, 2010–2011). Animal agriculture is of unquestionable

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value to the food system as well as many states' economies. However, the question is how to balance this type of activity with the need to prevent negative impacts such as surface water quality degradation. This study focused on siting restrictions implemented to prevent manure spills from reaching surface waters and had the following objectives: (1) determine whether CAFO proximity to surface waters decreased following siting restrictions implemented in 2000 and (2) discuss the water quality implications and means for determining the effectiveness of siting restrictions.

1.1. *Recent trends in U.S. animal agriculture*

Consolidation and concentration in animal agriculture in the United States (U.S.) is perhaps most apparent in the swine industry: between 1974 and 2007 there was a more than 8 fold increase in the average number of swine per farm, and the percentage of swine inventory on farms with 1000 head or more increased from 16% in 1974 to 93% in 2007 (USDA, 1974a, 2007a). Significant consolidation of the bovine industry (including both beef and dairy operations) also occurred: the percentage of cattle and calf inventory on farms with 1000 head or more increased from 16% to 34% (USDA, 1974a, 2007a). Continuous, concentrated production of poultry, especially broiler chickens, began in the 1930s, much earlier than swine or bovines (USDA, 2009). Turkey production in 1974 already was focused in large operations, but became still more concentrated by 2007: the percentage of turkeys sold in the U.S. that were raised on farms with more than 60,000 turkeys increased from 61% in 1974 to 85% in 2007 (USDA, 1974a, 2007a).

Animal agriculture has also become more concentrated in Minnesota: the percentage of swine inventory on farms with 500 head or more increased from 27% in 1974 to 97% in 2007. The percentage of turkeys sold on farms with 60,000 or more turkeys increased from 87% to 96%. There was also an increase from 6% in 1974 to 30% in 2007 in the percentage of bovine inventory on farms with 500 head or more; dairy operations with 500 head or more increased from 0% in 1974 to nearly 20% of total dairy inventory in 2007, while beef operations with 500 head or more increased only from 2.3% to 2.9% of total beef inventory (USDA, 1974b, 2007b). In 2011, Minnesota ranked #1 in the U.S. in turkey production and #3 in pork production (USDA, 2012; MDA, 2012). The proportion of Minnesota-raised pork exported doubled from 7% in 1997 to 14% in 2007; more than 10% of turkeys raised in Minnesota were exported in 2008 (Ye, 2009; Minnesota Turkey Growers Association, 2011).

1.2. *Manure spill impacts on water resources*

The increase in size and geographic concentration of CAFOs has been associated with numerous environmental problems, including water quality degradation (Burkholder et al., 2007). Modern swine and dairy CAFOs may store millions of liters of liquid manure onsite in lagoons, tanks, or pits and must transfer the manure through hoses or tankers for application to nearby fields; whereas beef and poultry operations often stockpile hundreds or thousands of tons of solid manure (Spellman and Whiting, 2007). Water quality impacts from animal manure may be largely driven by surface runoff and tile drainage from manure-applied fields, but major manure releases or spills from storage lagoons, transport vessels, or hoses are also of concern (Armstrong et al., 2010).

Manure spills and direct releases to surface waters have been reported in several states, but there do not appear to be national or statewide mechanisms for tracking spills. Even within state government agencies, there may be several different programs to which spills are reported, and counties may also have their own spill reporting via local 911 systems (Ronk and Erb, 2010). Manure spills may occur at the CAFO production site, in transporting manure from production site to field, during field application, or following application. Causes of reported incidents vary and include over application of manure, heavy rains following manure application, equipment or lagoon failure, manure storage or lagoon overflows, and the use of spray irrigation. Because facility CAFO siting restrictions are relevant only to those spills that occur at the production site, the review of manure spills below focuses only on spills that occur at the production site.

The Upper Thames River Conservation Authority (2003) identified 278 manure spills in southwestern Ontario between 1988 and 2001. The majority of these spills were related to application and transport issues; however, approximately 10% were caused by storage related issues and 10% by equipment failures. Ronk and Erb (2010) reported 300 manure incidents in Wisconsin from 2005 to 2009, with 40% occurring at farmstead sites; of the farmstead site incidents, storage overtopping (37%) and runoff from livestock production areas (18%) were the most frequently cited factors. Osterberg and Wallinga (2004) indicated that of 304 reported spills in Iowa (1992–2002) nearly half of the spills were due to manure storage overflow and equipment failure, and 18% from runoff at open feedlots. The Iowa Environmental Council (2012) reported that 262 spills reached surface waters in Iowa between 2001 and 2011; 30% of these spills occurred at CAFO production sites and 24 spills killed 10,000 or more fish. No recent study of manure spills in Minnesota has been published, but a 3.8 million liter spill was recently reported in Southeastern Minnesota (Marcotty, 2013).

There is an extensive literature on the fate, transport and management of nutrients and pathogens associated with manure from CAFOs (see for example Bicudo and Goyal, 2003; Mishra et al., 2006; Soupir et al., 2006; Sharpley et al., 1999; Sistani et al., 2010; Cardoso et al., 2012). Sudden releases of manure into water bodies result in elevated concentrations of nutrients and pathogens in the water column, with immediate toxic impacts on fish populations from ammonia (Armstrong et al., 2010). Major blooms of algae (eventually leading to anoxic conditions) and *Pfiesteria piscicida* in coastal waters are also associated with fish kills and in the latter case neurotoxic impacts in humans (Armstrong et al., 2010; Burkholder and Marshall, 2012). Armstrong et al. (2009) found that manure spills can have lasting impacts on nutrient balances in streams as sediment-bound phosphorus may persist and be re-released to water for weeks or months following a spill. Other contaminants such as antibiotics and hormones have also been associated with CAFOs. For example, in their national reconnaissance of organic wastewater contaminants, Kolpin et al. (2002) found the exclusively veterinary antibiotic tylosin in 13.5% of stream samples. Shore (2009) asserts "both