Public Policy and Agricultural Air Quality

History of Conflicts Between Swine Farmers and Neighbors in North Carolina: The Response of the Law to Conflict

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Abstract

Conflicts between swine farmers and their neighbors have been documented in North Carolina since the early 1840s. Early disputes were caused by livestock ranging through city streets. Later 19th century disputes pitted planters against stock owners over whose duty it was to protect crops from livestock. In the early 20th century, conflicts were usually framed as zoning issues, odor and nuisance complaints. By the end of the 20th century, swine raising practices had undergone a revolution and a new set of environmental concerns came to the foreground. These recent conflicts were framed as environmental issues and challenges to agricultural exemptions from environmental and other laws. North Carolina's three branches of government were all engaged to solve these conflicts through the 1990's. Peace, but not resolution of these conflicts, was achieved through enactment of more stringent environmental laws and a moratorium on lagoon construction for swine farms. The moratorium slowed further development until technological solutions could be found to the problems identified.

Swine in North Carolina's History

During several points in American history, pork production has produced conflicts in land use and these conflicts have influenced the development of law. Prior to the introduction of swine by Spanish explorers, there were no swine in North America. Early colonial settlers in the Southern colonies of Virginia and the Carolinas kept hogs primarily on open range in swamps and forested land. This exposed the swine to predation from wolves and foxes when young and bears when older.[2] Pork was fattened by allowing them to forage on tree mast, tuberous roots and green canes found in the forests and swamps.[3]

Writing in the late 1700s, Johann David Shoepf[4] observed of North Carolina's swine raising practices:

"Their hogs likewise range throughout the year in the woods. Towards the coast in the pine forests, the cones of the pitch-pine, larger than those of the other sorts, are their favorite food; also they root up the young sprouts of these pines and eat off the bark, for which reason the pitch-pine does not spring up so readily where it has once been taken off. Farther up the country the hogs find better mast beneath the numerous oaks, chestnuts, beech-trees, and chinquapins. In winter the sows make themselves beds of pine-twigs where they litter; the owner seeks them out, brings them in nearer the house, gives them a better bed of straw, and marks the pigs. Later, to accustom them to the plantation, they are called up several times a day and fed on corn-stalks. In the autumn, after the maize-harvest, a number of hogs are brought in from the woods and placed on feed. A bushel of corn a week is allowed each head, for 5-6 weeks. The amount of corn made determines the number of hogs to be fed. Fattened hogs reach 3 to 500 pounds' weight. Live hogs sell at 3-3½ Spanish dollars the hundred. Nowhere on the whole continent is the breeding of swine so considerable or so profitable as in North Carolina. Besides what is consumed in the country, salted, exported, and lost in the woods, there are annually 10-12000 head driven to South Carolina or to Virginia.

[1] This is an educational manuscript only and expresses the views of the author. It has neither been reviewed nor approved in accordance with the policy for issuing Attorney General's Opinions.
[2] Records of the Moravians in North Carolina, I, 131-140. (1755), available on Internet, at: http://www.ah.dcr.state.nc.us/sections/hp/colonial/Bookshelf/Moravian/extracts.htm (February 15, 2006)
[3] Byrd, William and Ruffin, Edmund, "The Westover Manuscripts: Containing the History of the Dividing Line Betwixt Virginia and North Carolina; A Journey to the Land of Eden, A. D. 1733; and A Progress to the Mines." Written from 1728 to 1736, available on Internet, at: http://docsouth.unc.edu/nc/byrd/byrd.html. (Feb. 15, 2006)
[4] Schoepf, Johann David , "Travels in the Confederation [1783-1784]" (Translated from the German and Edited by Alfred J. Morrison, Philadelphia, William J. Campbell, 1911), available on Internet, at: http://www.ah.dcr.state.nc.us/sections/hp/colonial/Bookshelf/Travels/Default.htm (February 15, 2006)

The North Carolinians therefore should not look a-skance, if their neighbors rally them for being pork-makers, for when the talk gets on their swine-breeding they themselves use the expression, 'We make pork.' But in these circumstances, a hog costing them next to nothing except for what goes into the fattening, the North Carolinians can send their salted hog-meat to market at a third or a half cheaper than their neighbors in the northern states where harder winters and more restricted pasturage make the maintenance dearer."

Colonists of the eighteenth century were mostly subsistence farmers, who relied on hominy, cornbread, and pork for staple foods.[5] Ninety-five percent of North Carolina's colonists were engaged in agriculture or related industries.[6] Since the colonists lacked paper money, gold and silver, commodities were the chief means of commercial exchange. Sixteen commodities were rated as money within the North Carolina colony in 1715, including pork.[7] About one-eighth of the pork and beef shipments from the English continental colonies were from North Carolina.[8] These statistics likely understate North Carolina's contribution to colonial swine production, since swine were frequently raised in North Carolina and driven north to Virginia or South Carolina for sale, as these colonies had the advantage in ports and commerce. Conflicts between livestock owners and others have been occupying our courts and legislative assemblies ever since.

Towns began to pass ordinances restricting the free roaming of livestock inside their boundaries. Beaufort's ordinance prohibiting swine running loose in the town was challenged by two swine owners, one of whom sued on the basis that the ordinance could not be enforced against him because he was not a town resident.[9] In ruling that the ordinance did apply, the North Carolina Supreme Court held that the farmer was liable under the ordinance, but noted that he had done "as every other farmer does, turned out his stock to range upon the unenclosed land around him."[10] Absent a valid town ordinance such as Beaufort's, such practice was legal in North Carolina.

Indeed, the University of North Carolina's neighboring village, Chapel Hill, was not immune from this trouble. "A serious trouble to pedestrians arose from the presence of numerous bovines and hogs on the streets. There was so little traffic that there was an abundance of good pasturage in the village and every family kept at least one cow, and many raised their own pork. Ladies and gentlemen were often compelled to drive animals from the sidewalks in order to pass. The more timid sometimes yielded precedence to the intruders and made a wide circuit to avoid them."[11]

Hogs in town were not a North Carolina oddity. New York's Central Park was established in the mid nineteenth century on land that had also housed hog lots.[12] In North Carolina, the highest swine populations were present in more densely settled areas in the nineteenth century. Duplin County was behind eight other North Carolina Counties in pork production in 1869.[13] Higher populations of swine were present in the

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[5] Lefler, Hugh Talmadge & Newsome, Albert Ray, "The History of a Southern State: North Carolina"124 (3d ed. 1973)

[6] *Ibid*. at 89.

[7] *Ibid*. at 157–58.

[8] *Id*.

[9] *See* Whitfield v. Longest, 28 N.C. 268 (1846)(Please note that this is the first of a number of citations to North Carolina appellate cases which are reported in a series of bound volumes, where the first number indicates the volume, the "N.C." in the citation abbreviation refers to the official court reporter and the third number is the page number upon which the case begins.)

[10] *Ibid*. at 273.

[11] Battle, Kemp P. "History of the University of North Carolina:Volume I: From its Beginning to the Death of President Swain, 1789-1868" (Kemp Plummer 1919).

[12] Taylor, Dorceta E., Central Park as a Model for Social Control: Urban Parks, Social Class and Leisure Behavior in Nineteenth-Century America; Statistical Data Included, *National Recreation and Park Association Journal of Leisure Research* (September 22, 1999).

[13] North Carolina Land Co., "A Guide to Capitalists and Emigrants: Being a Statistical and Descriptive Account of the Several Counties of the State of North Carolina, United States of America; Together with Letters of Prominent Citizens of the State in Relation to the Soil, Climate, Productions, Minerals, &C., and an Account of the Swamp Lands of the State" (From the N.C. Land Company, 1869)

county of Wake where the state capital was located as well as the important industrial and commercial center of Guilford County than in Duplin County.

English common law placed responsibility on livestock owners to keep them under control and keep them away from mischief. This rule was abrogated by statute and custom early in history of North Carolina, putting it in a free range state. In 1860, the N.C. Supreme Court held that a corn and pea crop farmer whose crop was damaged by horses and cattle of his neighbor across the Yadkin River had no claim. While the Court held that the cattle were trespassing, it further held that the offended crop owner had no recourse but to erect a lawful fence. The Court observed, “Thus the keeping under inclosure domestic animals, which is regarded as the rule of the common law of England, if it were ever recognised in our waste and thinly populated country, has been long since abrogated by various legislative acts and by constant usage to the contrary.”[14]

This abrogation by the legislature of the common law rule and its acceptance by the courts arose from the recognition that England was densely settled, while North Carolina was thinly settled. As populations of people grew and land deemed waste became valuable property, the basis for the rule of law became questionable. Because livestock interests were accustomed to the older practice, they demanded free range as of right. Increasingly, row crop farmers and town residents attacked these laws and these struggles resulted in considerable legislative fine tuning.

Livestock grazing on unfenced land brought with it conflicts between row crop farmers and livestock growers throughout the state. During the end of the nineteenth century, a series of livestock fencing requirements — referred to as “fence law” or “stock law” — were passed, covering larger and larger portions of North Carolina, county by county or even swamp by swamp.[15]

The law cited in the Burgwyn case shows the extreme precision with which the legislature endeavored to carve out stock law territory. The Burgwyn Court cites the following pertinent provision within the statute: “the Legislature, at the session of 1876, Chap. 60, passed a private law for their benefit, wherein it was enacted that the river, a rail fence running from Faison's corner on the river to Mud Castle, and thence to Wheeler's Swamp, at the head of Bull Hill mill-pond, and the run of said swamp from the head of said mill-pond to the river, should be sufficient as a fence, with a declaration in the sixth section of the act that the act should not apply to stock kept north of the rail fence constituting part of the boundary, unless the fence was kept in good and lawful condition, nor to stock kept east of Wheeler's Swamp, provided a gate was kept.” Such description reads more like a zoning ordinance than a piece of legislation.

As more legislators sought to protect their citizens from wandering livestock, the stock law was gradually extended to cover the entire state. Towns and counties were given the option to add the coverage of the Stock Law to their borders; where the law existed, it was a misdemeanor for the owner of livestock to allow them to run at large.[16] Cases involving the application of the Stock Law demonstrate that hogs and other livestock were getting loose and causing conflicts with row crop farmers and town residents for many years.[17] North Carolina’s Stock Law produced a number of reported appellate decisions over a single animal or its monetary value. These decisions show a steady development away from English common law principles, and a form of statewide zoning engaged in directly by the legislature.

All sides agreed that livestock at large were capable of damaging crops. The row crop farmers disagreed with the livestock owners about who should have to pay for the fence construction and maintenance. Initially the law aided the livestock owners in this regard. Trespassing livestock who were injured or killed were protected by law. A hog farmer obtained compensation from a railroad company because spilled molasses on the railroad tracks lured his trespassing swine there to feed wherein they were run over.[18] A

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[14] Jones v. Witherspoon, 52 N.C. 555 (1860).
[15] See Burgwyn v. Whitfield, 81 N.C. 261 (1879)
[16] N.C. Gen. Stat. § 68-16 (2003).
[17] *See* State v. Tweedy, 115 N.C. 704 (1894) (indictment of town resident for shooting hog running at large in town overturned because indictment did not charge that hog was running loose unlawfully); Broadfoot v. Fayetteville, 121 N.C. 418 (1897) (challenges to ordinance and stock law under state and federal constitutions rejected by court) ; Bowen v. Town of Williamston, 171 N.C. 57 (1916).
[18] Page v. N.C. Railroad Company, 71 N.C. 222 (1874).

hog trespassing on a chicken farmer's land was protected from harm, despite having previously killed a chicken.[19] A trespassing boar which had rooted up a lawful fence several times, eluded pursuit by men and dogs and crashed down the fence altogether could not be shot by the landowner, because the boar was a public service to the community at large and was protected by statute.[20]

But the tide turned around the turn of the century as more and more people sought changes to the stock law. By 1896, it was a misdemeanor to allow stock to run at large in Wake County.[21] By 1908, mountainous counties such as McDowell were under the stock law as well.[22] The North Carolina Supreme Court recognized in the Mathis case that conditions had changed and that the law had changed with it. Justice Connor wrote:

"If the condition, in respect to the agricultural system of the people so changes as to make it conducive to their interest to require all stock to be "fenced in" and relieve the land owner of the duty to "fence it out," we can see no good reason why the Legislature may not by appropriate legislation do so, either in respect to the whole State or political divisions thereof. For the past twenty-five years, such has been the policy of the State, as evidenced by our legislation. This being true, we do not see why the Legislature, or when power is conferred upon them, the county commissioners, may not forbid stock running at large in the county, or any township thereof, and declare a mountain range, a creek or other natural political boundary a lawful fence, or the limit within which the law shall operate."[23]

By 1913, the stock law was in force over nine-tenths of the territory of the state.[24] The territories had gradually spread under the general principal that every man has a right to use his own provided he does not do so to the injury of the rights of others. In 1918, the Chief Justice observed the stock law situation and its costs as follows:

"Besides these and other arguments which have caused the extension of the "no-fence law," the "Commission for the Conservation of Food" have recently called attention to the fact that in this State last year $ 60,000 worth of stock were killed by railroad locomotives, a very small per cent of which loss occurred in the no-fence law counties, but almost entirely in that small part of the State in which the free range still obtains. At the same ratio, if stock had been allowed to run at large throughout the State, the destruction of stock and the loss of food thereby would amount annually to far over a half million dollars, for less than one-tenth of the State is now outside of the stock-law territory.

Our Legislature, in deference to the wishes of the people of any locality, have given them opportunity to declare whether they shall adopt the policy of each man fencing up his stock or of every man fencing out the stock of others. The result has been the growth of the stock law in North Carolina, until now it prevails over nine-tenths of the State; in fact, in all the State except in parts of half a dozen townships in the mountain sections where the cultivated fields are a negligible quantity and in a few counties along the Atlantic Coast, in most of which there are large areas of land not yet under cultivation, though even in this fringe of counties there are considerable areas in which the stock law prevails."[25]

Two of the last counties to be covered were Duplin and Pender County.[26] Conflicts in those counties arose over how a fence would be paid for in order to keep the open range throughout these counties. By the 1940's the entire state was under the stock law, and owners of livestock were under duty to keep them fenced upon penalty of law and liability.[27] Within a span of one hundred years, the complete reversal of the open range rule had occurred. From there on out, owners of stock were legally bound to keep them confined. This they did, with increasing density.

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[19] Morse v. Nixon, 51 N.C. 293 (1859)
[20] Bost v. Mingues, 64 N.C. 44 (1870)
[21] State v. Hunter, 118 N.C. 1196 (1896).
[22] State v. Mathis, 149 N.C. 546 (1908).
[23] *Ibid.* at 548.
[24] Marshburn v. Jones, 176 N.C. 516; 517 (1918).
[25] Marshburn v. Jones, 176 N.C. 516; 522 (1918).
[26] *See* Keith v. Lockhart, 171 N.C. 451 (1916), Marshburn v. Jones, 176 N.C. 516 (1918), *and* Faison v. Commissioners of Duplin, 171 N.C. 411 (1916).
[27] McKoy v. Tillman, 224 N.C. 201 (1944).

North Carolina's Swine Population Boom

The legal conflicts were plentiful even as the amount of livestock raised in North Carolina was declining. North Carolina was always a top tobacco producing state but gradually became an insignificant producer of livestock. In 1920, the value of all livestock in North Carolina per farm was $442, one dollar above Alabama as the lowest ranking state.[28] In 1925, North Carolina's tobacco crop was worth $87,438,000, ranking North Carolina second in tobacco production to Kentucky.[29] The agricultural landscape changed dramatically in the latter half of the twentieth century. In 1940, $5,747,918 of North Carolina's $328,695,232 in farm income came from hogs;[30] in 1969, $118,614,000 of North Carolina's $1,406,161,000 in farm income came from hogs,[31] an increase of from two to more than eight percent of total farm income in less than thirty years. The biggest jump was yet to come as new swine production techniques were developed and introduced. By 1993, North Carolina had become the third largest pork producing state; instead of allowing their pigs to forage or feeding them garbage, swine producers copied the success of poultry producers and learned to efficiently produce pigs by formulating diets and constructing confinement structures.[32]

Modern hog production depends upon three carefully controlled factors: genetic selection, feed formulation, and climate control. A geneticist selects which strain will go on each farm. Nutritionists formulate feed with vitamin supplementation to control costs and to meet specific nutritional needs of the genetic strain being raised. Automatic feeders provide pigs with a steady stream of the specially formulated meal. Hogs are confined inside a building with electrical light and heat and cooling systems. Workers remove their clothes, take a shower, and put on coveralls before entering the hog house to prevent the transmission of diseases. Hogs are given water from wells specially dug for their house. Under these conditions, swine grow quickly to market weight and once they do so, they are shipped out and the house is cleaned to be ready for the next group or "turn."

Floors inside hog houses are slatted, some partially and some fully. The slats allow manure and urine to fall through to pits beneath the houses. It is as if the entire house sat over a giant toilet bowl. There are four different types of systems for this toilet bowl to use for removing the waste from the house: deep pit, pull plug, pit recharge, and flush. Deep pits are not used much in North Carolina, but the other three types are common. In North Carolina, once these systems are activated, wastewater is sent from under the house to a lagoon.

A lagoon is an open air primary waste treatment structure. Most lagoons in North Carolina are designed for anaerobic operation, meaning that the bottom portion of the lagoon has extremely low dissolved oxygen. Anaerobic bacteria, which do not tolerate oxygen, thrive in this environment and work to break down the manure that sinks to the bottom of the lagoon. This breakdown produces gases and sludge, which accumulate in the lagoon until released or removed. Gases leave by complicated biological and chemical processes linked to life cycles of the bacteria, manure loading, and the pH of the wastewater. Sludge stays and accumulates until removed mechanically. The Natural Resources Conservation Service of the U.S. Department of Agriculture recommends that the accumulated sludge be removed every five years if it has encroached upon the treatment volume of the lagoon.[33]

Lagoons vary in design parameters such as shape, depth, and liner material. These differences are primarily correlated with lagoon age in North Carolina as lagoon designs have been modified over the years. A few farms have more than one stage in their lagoons to provide further storage and treatment. All farms need to have sufficient volume to treat the wastewater loaded into them and to store that wastewater until it can be disposed of through land application. An average sized pig of 135 pounds produces 1.37 gallons per day of urine and feces, compared to an 800 pound beef cow's production of 5.53 gallons per day. In addition to

[28] Lefler, Hugh Talmadge & Newsome, Albert Ray, "The History of a Southern State: North Carolina" 578 (3d ed. 1973).
[29] *Id*.
[30] *Ibid*. at 647.
[31] *Id.*
[32] *Id.*
[33] Natural Resources Conservation Service Practice Standard for Waste Treatment Lagoon, CPS 359, Rev. 4, p. 15 (NRCS-NC, January 1998)

this waste volume, lagoons must also hold the fresh water added to the housing for cooling and the rainfall which flows into the lagoon. Lagoons in North Carolina are now supposed to be designed to accommodate heavy rainfall and a twenty-five year twenty-four hour storm event without encroaching into a twelve inch zone called the structural freeboard.[34]

Some wastewater from lagoons is recycled to serve as the flush water for the houses. Excess wastewater from the lagoon is applied to cropland primarily by spray irrigation for disposal. This disposal is limited by two primary factors: the nutrient requirements of crops and the ability of the soil to accept the hydrologic load. If too much wastewater is applied, it may pond up and run off the fields faster than the soil can absorb it. If too much waste is applied, the roots of the crops cannot absorb the nutrients and they may be lost to groundwater, the soil, or the atmosphere. Sprayfield crops generally include grasses for grazing and grains, which can be marketed or used by the producers. North Carolina's sprayfields do not currently produce enough crops to feed the number of livestock raised. North Carolina is still a net importer of grain for feed.

The North Carolina experience with growth was in number of swine, not in the number of swine farms. This was a national trend in pork production, but more pronounced in North Carolina. [35] Nationwide, the number of farms with swine fell from 317,087 to 103,965 between 1982 and 1997.[36] During the same period, the number of swine produced rose from 7,730,637 to 8,522,082 nationwide for a net increase nationwide of 1,191,445 measured as animal units (AU). North Carolina's growth accounted for 1,160,152 AU of that increase, or more than ninety-five percent of the net national increase. During the same period, the number of North Carolina swine farms decreased from 8,691 to 2,673.[37]

In 2002, hogs were still the number one cash receipts farm product in North Carolina, as they had been since the mid 1990s.[38] Out of the top seven crops in cash receipts for 2002, only two row crops are listed: greenhouse/nursery production was third and tobacco was fourth. Hogs almost accounted for more receipts than tobacco and greenhouse nursery combined. Within a single decade, pork had eclipsed tobacco in North Carolina's agricultural economy.

North Carolina's pork production is now significant to the economy of the nation. On December 1, 2004, North Carolina was estimated to have 9.8 million hogs out of the whole U.S. herd of 60.5 million.[39] The total number of hogs owned by operations with over 5,000 head total inventory, but reared under production contracts, accounted for thirty-eight percent of the total U.S. hog inventory, up three percent over the previous year.[40] The top ten swine producing counties in North Carolina have combined inventories of more than seven million hogs.[41] North Carolina's top ten counties account for more than eighty percent of the state's swine inventory and more than ten percent of the national swine inventory.

Many of these animals are sent for slaughter to one of the two large slaughterhouses in North Carolina. They are often also sent to other grain-rich states to be fattened prior to slaughtering.[42] In 2001, 3.8 million

[34] *Id.*
[35] Economic Research Service, U.S. Department of Agriculture, information available on the Internet at: http://www.ers.usda.gov/data/Manure/spreadsheets/prk82.xls and http://www.ers.usda.gov/data/Manure/spreadsheets/prk97.xls (February 15, 2006)
[36] *Id.*
[37] *Id.*
[38] Agricultural Statistics Division, N.C. Department of Agriculture, Cash Receipts, information available on Internet, at http://www.ncagr.com/stats/cashrcpt/commrank.htm (Feb. 6, 2004).
[39] Agricultural Statistics Division, N.C. Department of Agriculture, Livestock, information available on Internet, at http://www.ncagr.com/stats/livestoc/anihgi12.htm (May 10, 2005) Units are hogs, not animal units.
[40] *Id.*
[41] Agricultural Statistics Division, N.C. Department of Agriculture, Livestock, information available on Internet, at http://www.ncagr.com/stats/cnty_est/ctyhogtt.htm (May 10, 2005).
[42] *Id.*

hogs left North Carolina to be finished in other states.[43] In contrast, North Carolina only had 158,000 hogs shipped into this state from other states. It is therefore true that North Carolina weans far more pigs than it slaughters.

North Carolina hog slaughter is also nationally significant. In the 1950s, Burrows Lundy moved from Pennsylvania to Clinton, North Carolina, to open the Lundy Packing Company. With the help of Lew Fetterman, Mr. Lundy moved up processing capacity from 1,000 hogs per week in the 1950s to 8,000 hogs per day in the 1980s. North Carolina is now home to the largest hog slaughterhouse in the United States (and perhaps the world) with a capacity of 32,000 hogs per day. This plant is owned by Smithfield Packing Company and is located in Bladen County near the town of Tar Heel. Smithfield Packing's parent company, Smithfield Foods, is the largest pork processor in the world.[44] Nevertheless, the star jewel in its processing crown is the Bladen County plant. The Lundy plant is also still in operation and was significantly updated after Lundy Packing was acquired by Premium Standard Farms of Missouri, a national leader in vertical integration.

Federal Water Pollution Control Act

While North Carolina was increasing its ranking in animal agriculture, the federal government began to regulate operations where large numbers of animals are confined. The Federal Water Pollution Control Act Amendments of 1972 (CWA) began a planning process for states to deal with water pollution from manure, called areawide waste treatment management plans, often referred to as the Section 208 process.[45] A few years later, this was amended to add an incentive program for agricultural polluters that used a cost sharing arrangement.[46] The Rural Clean Water Program offered financial incentives to landowners to implement best management practices (BMPs) to control nonpoint source pollution. This program was later expanded and funded under future farm bills to an alphabet soup of conservation incentive programs administered by the U.S. Department of Agriculture.[47]

Congress also took action to require states to report on their progress in water quality improvement on a watershed by watershed basis.[48] These requirements reinforced the notion that the primary role for developing plans for controlling pollution lay with states. At the same time, the states worked to implement these plans with a variety of legal mechanisms. Each state is required to "identify those waters within its boundaries for which the effluent limitations required …are not stringent enough to implement any water quality standard."[49] These waters are usually those which receive pollution from sources not regulated as point sources under the CWA. Potential sources of these pollution problems are numerous, but include runoffs and discharges from agricultural and livestock sources.

North Carolina's Incentives and Nonpoint Source Regulations

In the 1980s, North Carolina had adopted its own program to offer financial incentives to agricultural operations to undertake conservation measures. The primary program created was called the Agricultural Cost Share Program for Nonpoint Source Pollution Control. This program was created in 1986 and provides for the supervision of the program by the North Carolina Soil and Water Conservation

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[43] Shields, Dennis A. and Matthews, Kenneth H. Jr., *Interstate Livestock Movements*, USDA Economic Research Service, available on Internet, at: http://www.ers.usda.gov/publications/ldp/jun03/ldpm10801/ldpm10801.pdf .

[44] Annual Report, Smithfield Foods, Fiscal Year 2004.

[45] 33 U.S.C.A. § 1288 (2005).

[46] 33 U.S.C.A. § 1288(i), (j) (2005).

[47] The Farm Security and Rural Investment Act of 2002 authorized federal funding for the following cost share conservation programs: Agriculture Management Assistance (AMA), Conservation of Private Grazing Land (CPGL), Conservation Reserve Program (CRP), Conservation Security Program (CSP), Environmental Quality Incentives Program (EQIP), Farmland Protection Program (FPP), Grasslands Reserve Program (GRP), Wetlands Reserve Program (WRP) and Wildlife Habitat Incentives Program (WHIP). U.S. Pub. L. No. 107–171 (May 13, 2002).

[48] 33 U.S.C.A. § 1329 (2005).

[49] 33 U.S.C.A § 1313(d)(1)(a)(2005).

Commission.[50] The program is used to fund a wide variety of conservation practices, including animal waste management systems.[51] Regulation of these sources beyond incentives has proven quite difficult scientifically, logistically, and politically. Nowhere has that proved more true than in North Carolina's Neuse River.

Environmental conditions in the Neuse River are driven by complex interactions between salinity, rainfall, wind, atmospheric deposition, shallow groundwater flows, water temperatures, biology, and chemistry. The Neuse is a relatively shallow river that drains into the Albemarle-Pamlico Sound complex, the second largest estuarine system in the United States, second only to the Chesapeake Bay. The Sound's 30,000 square miles of watershed are significant habitat for a variety of birds, reptiles, turtles, fish, and shellfish. Situated at the northern range of southern species and the southern range of many northern species, it is the home for both alligators and tundra swans. Sea turtles nest on the beaches and swim in the inlets of the sound each summer and diving ducks feed in the sound each winter

While pollution and fish kills in the Neuse have been problems for many decades, recent kills have become more worrisome to state planners. Even as discharges to the Neuse from point sources have been increasingly restricted, excess reactive nitrogen in the river has led to nuisance algae blooms. Researchers spent increasing time and energy focusing on the causes of these problems in the 1980s and 1990s.

In the early 1990s, North Carolina controlled animal waste management systems through state level administrative rules on nondischarge waste treatment.[52] These rules were referred to as the 0.200 rules due to their regulatory citation number. The 0.200 rules required farms with more than 250 swine to obtain certified animal waste management plans.[53] These rules also provided that compliant nondischarge facilities would be considered "deemed permitted" and would not have to obtain individual permits unless they broke the rules.

Meanwhile, one of North Carolina's largest newspapers, the Raleigh News and Observer, ran a series of articles on the growth of the swine industry and the state of its regulation. These articles ran February 19, 21, 22, 24 and 26 of 1995.[54] This series of articles was referred to as the "Boss Hog" series and won the reporters a Pulitzer Prize in 1996 for public service. The Boss Hog articles were generally critical of the state's hog regulation. The articles contended that enforcement of environmental rules against hog farms was too lax and that the 0.0200 rules were not protective enough by themselves. Many swine farmers contended that the articles were unfair. Legislative action to expedite implementation of new rules on hog farms was killed in April of 1995 in favor of a study commission.

Oceanview Farms Case

A couple of months after legislative actions were killed, a serious new conflict arose. On June 21, 1995, the eight-acre manure lagoon at Oceanview Farms in Onslow County burst its dike, sending a tide of wastewater across neighboring roads, fields, and streams and into the New River near Jacksonville, North Carolina.

While the Oceanview facility had a certified animal waste management plan, it had not followed that plan. The farm had not been applying the waste to land as required and the lagoon was filled far beyond its specified capacity, which required that there be a minimum of one foot of freeboard to protect the physical structure from breach.[55] Larval casings for insects were found within a few inches of the dike crest, indicating that the lagoon had reached the top of the dike before rupturing. Additionally, investigators found that less than half of the land required for land application had been cleared by Oceanview. Also, the

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[50] N.C. Gen. Stat. § 143-215.74(a) (2005).
[51] *Ibid*. at (b)(5).
[52] 15A N.C.Admin.Code § 2H 0.0200 *et seq*. (1993).
[53] *Ibid.*at § 2H 0.0217.
[54] *News and Observer*. The articles were published on February 19, 21, 22, 24 and 26, 1995. Electronic copies are available online at:
http://www.pulitzer.org/year/1996/public-service/works/
[55] Plaintiff's Preliminary Injunction Brief, pp. 5-11, State of North Carolina ex rel. Michael F. Easley v. Oceanview Farms Limited Partnership, 95 CVS 1993, (Onslow County Superior Court, Sept. 12, 1995).

dike walls had been weakened by installation of piping and pumps in the walls. These factors contributed to the lagoon's massive rupture, which spilled about twenty-five million gallons of wastewater.

The Oceanview Farms case resulted in an injunction being issued against the facility, requiring significant remedial and repair actions. The North Carolina Division of Water Quality levied a $92,000 fine against Oceanview Farms in 1995, the largest ever. After the company appealed, an Administrative Law Judge reduced the fine to $75,000. Later the North Carolina Department of Environment and Natural Resources (DENR) settled the appeal and further reduced the fine to $50,000, payable over six years. The enforcement costs were not reduced and were collected for $11,820.49. While the case was closed in 2001, its repercussions still linger.

Legislative Responses to Oceanview Farms and Subsequent Spills

The spill provoked national media coverage accompanied by a swift legislative response. Other spills occurred around the same time, with a one million gallon swine waste spill on a different farm the same day as Oceanview's and an eight million gallon spill of chicken wastewater from a lagoon on July 3, 1995. On July 10, 1995, North Carolina Governor Jim Hunt ordered state water quality inspectors to do a blitz of inspections on the state's lagoons.

On July 11, 1995, the North Carolina General Assembly enacted the Swine Farm Siting Act.[56] The Swine Farm Siting Act required a 1,500 foot setback for lagoons from residences, with a farther setback from schools and a smaller one from property boundaries.[57] The Swine Farm Siting Act had a delayed effective date of October 1, 1995, which prompted a flurry of lagoon site evaluation activity between July and October of 1995.

Meanwhile, work began in earnest by a Blue Ribbon Study Commission.[58] The commission consisted of members appointed by the legislative leadership and the Governor. Based in part upon the commission's report, the General Assembly acted to strengthen permitting requirements beyond the minimum federal requirements.[59] This piece of legislation was the most comprehensive to date in North Carolina on the subject and is still referred to by its bill number, Senate Bill 1217. Senate Bill 1217 required that all operations with more than 250 swine obtain permits.[60]

Under these permits, the swine farms were required to follow a nutrient management plan with nitrogen acting as the limiting nutrient.[61] The farms are also required to use a certified applicator for waste application.[62] Senate Bill 1217 required DENR to conduct annual inspections of swine farms. It also increased setback distances, enhanced enforcement of the Swine Farm Siting Act, and increased the maximum daily civil penalty assessable against animal operations from $5,000 to $10,000 per day per violation.[63] The effects of Senate Bill 1217 were significant in North Carolina. Due to the requirements for waste management plan certification, many operations had to undertake significant upgrades of their waste management systems. The North Carolina Supreme Court has held these statutory changes to constitute complete regulation of the field.[64]

In addition to these measures, North Carolina adopted a set of operator certification requirements for those who operated animal waste management systems. These requirements included licensing upon a written

[56] 1995 N.C. Sess. Laws, Chapter 420.
[57] *Id*.
[58] 1995 N.C. Sess. Laws Ch. 542, Sec. 4.1 through 4.7.
[59] *Ibid.* at Ch. 626.
[60] *Ibid* at Sec. 1.
[61] *Id*.
[62] *Ibid* at Section 5.
[63] *Ibid* at Section 4.
[64] "We conclude from the foregoing specifications that North Carolina's swine farm regulations, the Swine Farm Siting Act and the Animal Waste Management Systems statutes are so comprehensive in scope that the General Assembly must have intended that they comprise "complete and integrated regulatory scheme" on a statewide basis, thus leaving no room for further local regulation." Craig v. County of Chatham, 356 N.C. 40, 50, 565 S.E.2d 172, 179 (2002)

examination, a disciplinary process, and continuing education requirements.[65] Since all animal waste management systems are required to have a certified operator, the threat of disciplinary sanctions has a significant salutary effect on waste handling practices. Lastly, North Carolina required that swine farm owners register the name of the owner of their livestock, or "integrator."[66] The registered integrator is to be informed of all violations observed at the owner's farm.[67] Each facility is mandated to have a compliance inspection annually.[68]

More Fish Kills and Moratorium Building Boom

During July, September, and October, 1995, extensive fish kills occurred in the Neuse River itself, a much larger water body than the New River affected by Oceanview Farms. Millions of menhaden, as well as many flounder, croaker, and striped bass, were killed. DENR collected copious water quality samples in the areas of the fish kills. The samples showed that the water lacked oxygen only 1 to 2 meters below the surface and contained a prevalence of algal blooms. During June of 1995, record rainfalls delivered a tremendous load of nonpoint source nutrients into the Neuse River. DENR took action.

On February 8, 1996, the North Carolina Environmental Management Commission (EMC) approved a draft conceptual Neuse River Nutrient Sensitive Waters (NSW) Management Strategy. The draft contained alternative language to further discussion at public workshops. Some initial changes were incorporated into the proposed rules as a result of comments received at the workshops and written comments. The Neuse River NSW Management Strategy's action plans called for the establishment of a Neuse River Basin Coordinator to coordinate activities of agricultural agencies involved in implementing the strategy, and to ensure progress toward successful installation of BMPs. The NSW management strategy proposal required a thirty percent reduction in nitrogen input to the Neuse River by all major contributors. A final set of rules was adopted by the EMC December 11, 1997.

For agriculture, these rules provide flexibility for implementing locally determined and appropriate site specific BMPs, rather than imposing identical requirements on all agricultural land throughout the basin. Farmers collectively achieved the thirty percent reduction goal by signing on with a Local Advisory Committee (LAC). Each LAC developed the local strategy and farm plans. Farmers who did not wish to work with an LAC were required to implement the default BMP option provided under the rules. This default option combined riparian buffers and water control structures with nutrient management planning. The LACs had a more extensive matrix of options available allowing for some operations to avoid costly changes by using the average reduction of all operations. The reduction goal was thirty percent below the level determined as the average for 1991-1995. The reduction goal was met in the plans developed.

These regulatory changes were quickly followed by even more stringent legislative measures. In 1997, the Clean Water Responsibility and Environmentally Sound Policy Act was passed. This bill established a moratorium on swine farm construction and expansion, expanded county zoning power over large swine farms, directed that odor control rules be developed, strengthened the Swine Farm Siting Act, and made sweeping changes to the nutrient regulations for other dischargers. This moratorium has been amended in 1998, 1999, 2001 and 2003, with the last amendment extending the moratorium to September 1, 2007.

Like the Swine Farm Siting Act, the initial moratorium had a delayed effective date. The delayed effective date triggered a new rush of applications and building activity to beat the deadline. Some in the industry have argued that the industry's response in building in anticipation of the moratorium contributed to a pork supply glut, which led to swine price drops of 1998 and later.[69] These price drops have also contributed to the exit of many smaller producers.

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[65] N.C. Gen. Stat. §§ 90A-47 *et seq*. (2003).
[66] N.C. Gen. Stat § 143-215.10H (2003).
[67] *Ibid*. at (d).
[68] N.C. Gen. Stat. § 143-215.10F (2003).
[69] *Industry Pacesetters: Interview with Bill Prestage*, NATIONAL HOG FARMER (June 15, 2001).

Conclusion

Conflicts between swine owners and others is nothing new in North Carolina. Legislators, mayors, courts, governors and other public officials have made many adjustments in the law to accommodate the distinct problems of their age. In the 18th century, the problem with pork was viewed as a problem of waste land, what we now think of as wilderness. In the 19th Century, the problems were conflicts between swine in the streets and pedestrians in towns. Towards the end of the 19th century, legislators responded to concerns of constituents by changing the law from open range to requiring livestock owners to enclose their livestock. In the 20th century, the enclosed livestock have undergone a boom in population and created a new set of conflicts. At each stage, these conflicts have evoked a response from North Carolina's government. While North Carolina has been challenged by the pork production boom it has enjoyed, the State's response has been to do more than talk about it. North Carolina's laws have responded to the challenges as they arose, albeit with all deliberate speed.

Ecological Indicators of Air Quality: Plans and Progress

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Abstract

The H. John Heinz III Center for Science, Economics and the Environment has initiated a multi-stakeholder, technically-based process to determine indicators and analyses that can be used to monitor and report ecological responses to changes in air quality. This process builds upon the success of the Heinz Center's 2002 report, The State of the Nation's Ecosystems , in reporting indicators of ecosystem condition but will expand on it by considering ecosystem responses specific to changes in air quality. Three related areas are addressed: appropriate indicators of condition and functioning in terrestrial and aquatic ecosystems, indicators quantifying exposure to air pollutants, and analyses of the potential for observed ecosystem changes to result from air pollutant exposure. Interim results include a review of candidate indicators for both ecosystem condition and pollutant exposure as well as potential methods of analysis using statistical and process-based models. Initial review has indicated the potential importance of considering agricultural emissions in assessing ecological changes in neighboring terrestrial ecosystems. The project is anticipated to result in a major publication by the Heinz Center at the end of the third year, with recommendations for both national level indicators, analyses of available data, and a regional case study. Support for this project comes from a cooperative agreement with the EPA's Clean Air Markets Division.

Agricultural Air Quality Policy in Iowa

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Abstract

Iowa is one of the leading producers of agricultural livestock in the United States, especially with respect to pork and egg production. Air qualilty near livestock operations in Iowa remains a primary concern to rural residents. It is the responsibility of the Air Quality Bureau of the Iowa Department of Natural Resources to work closely with the general public, elected officials, and affected stakeholders to develop policy that both protects and maintains the quality of air in rural Iowa and allows the agricultural industry to continue to thrive. An example of this effort is the establishment of a health based standard for hydrogen sulfide applicable during an on-going field study of air qualilty in rural Iowa, that was developed over a four-year period.

Introduction

Iowa is one of the leading producers of agricultural livestock in the United States. According to the most recent census by USDA (USDA, 2004), Iowa is the number one producer of pork and the number one producer of eggs in the country. As such, air quality in the vicinity of animal feeding operations has remained a prominent issue in the state. Citizens living near livestock operations are concerned about odors and potential health effects from invisible gases like ammonia and hydrogen sulfide. The Iowa Department of Natural Resources, specifically the Air Quality Bureau, has the responsibility of maintaining the quality of air in rural Iowa. Developing public policy to accomplish this task has been difficult.

Historical Overview and Timeline

The issue of potential health effects due to emissions from animal feeding operations was first brought to the attention of the department in January of 2001 by a grassroots organization called the Iowa Citizens for Community Improvement (Iowa CCI). The group filed a petition for rulemaking before the Iowa Environmental Protection Commission (EPC), a panel of nine citizens who provide policy oversight over Iowa's environmental protection efforts. The petition requested that the department adopt specific fence line and ambient air quality standards for hydrogen sulfide, ammonia and odor applicable to animal feeding operations. Although the petition was eventually denied, it prompted the Governor of Iowa and the Director of the Department of Natural Resources to call upon the expertise of the University of Iowa and Iowa State University to weigh in on the issue. Specifically, the Universities were asked to provide a joint recommendation on how the department should address the impacts of air quality surrounding animal feeding operations on Iowans (Iowa State University and The University of Iowa Study Group, 2002). In February of 2002, the Universities co-authored a report entitled the Iowa Concentrated Animal Feeding Operations Air Quality Study (hereafter referred to as the University Report), which included several recommendations on how to proceed with public policy. One recommendation from the University Report was for statewide ambient air quality standards for ammonia and hydrogen sulfide:

> *Hydrogen Sulfide*
> *It is recommended that hydrogen sulfide, measured at the CAFO property line, not exceed 70 parts per billion (ppb) for a 1-hour time-weighted average (TWA) period. In addition, the concentration at a residence or public use area shall not exceed 15 ppb, measured in the same manner as the property line. It is recommended that each CAFO have up to seven days (with 48 hour notice) each calendar year when they are allowed to exceed the concentration for hydrogen sulfide.*
>
> *Ammonia*
> *It is recommended that ammonia, measured at the CAFO property line, not exceed 500 ppb for a 1-hour TWA period. In addition, the concentration at a residence or public use area shall not exceed 150 ppb, measured in the same manner as the property line measurement. It is recommended that each*

CAFO have up to seven days (with 48 hour notice) each calendar year when they are allowed to exceed the concentration for ammonia.

Two months after the release of the University Report, the Iowa General Assembly adopted Senate File 2293, which instructed the department to complete a comprehensive field study measuring emissions of ammonia, hydrogen sulfide, and odors to determine if these gases were present at levels that could cause material and verifiable adverse health effects in areas where people live and spend time, such as residences, commercial, educational, or religious establishments, or public use areas (Iowa Code section 459.207). In response to the new law, the department began monitoring ammonia and hydrogen sulfide using continuous monitoring techniques at ten locations throughout the state near some of Iowa's largest livestock operations. In addition, the department implemented an odor study, where field staff were trained to gauge odor levels using an instrument called a scentometer.

In July, 2002, the department moved forward with a rule recommending the adoption of the ambient air quality standards as recommended in the University Report. After extensive public comment, the EPC approved a final version of the rule in April, 2003. Specifically, hydrogen sulfide was set at 15 parts per billion (ppb), daily maximum 1-hour average, and ammonia at 150 ppb, daily maximum 1-hour average. The standards were formulated as a three-year average of the annual eighth-highest daily maximum hourly average concentration.

This initial attempt by the department to implement the recommendations of the University Report by the establishment of statewide ambient air quality standards for ammonia and hydrogen sulfide was deemed too broad and was overturned by the Iowa General Assembly.

The department modified its approach and in December, 2003 brought forth recommendations to the EPC to establish a hydrogen sulfide health effects value (HEV) and health effects standard (HES). The rule proposed an HEV of 15 ppb 1-hour daily maximum, and an HES at 15 ppb 1-hour daily maximum not to be exceeded more than 7 times a year. Recommendations to establish similar standards for ammonia and odors were not brought forth.

The Iowa General Assembly adopted House File 2523 in April 2004, providing for the regulation of air quality by establishing minimal risk levels, creating an odor panel, and making penalties applicable. However, this law was eventually vetoed by the Governor.

In September, 2004, the final version of the HEV/HES rulemaking was approved by the EPC. Based on public comments and recommendations by the Iowa Department of Public Health, the levels of the HEV and HES were changed from 15 ppb to 30 ppb, respectively. The rule became effective in September 2004.

The Regulatory Bar

The HEV represents a level commonly known to cause a material and verifiable adverse health effect. The HEV is 30 parts per billion (ppb) averaged over one hour.

The HES represents a level to determine if the baseline data from an ongoing field study indicates a need to develop regulatory plans and programs to mitigate hydrogen sulfide emissions from animal feeding operations. The HES is 30 parts per billion (ppb) daily maximum one–hour average, not to be exceeded more than seven days in one year.

The health effects standard is used primarily as a regulatory bar in order to determine if harmful concentrations of hydrogen sulfide are present near animal operations. The HES acts as a regulatory trigger that if exceeded, requires the department to take action to reduce emissions. All data obtained during the course of the on-going field study are compared to the HES. Should the HES be exceeded during the field study, the department will develop plans and programs to mitigate hydrogen sulfide emissions from animal feeding operations.

These values are applicable to animal feeding operations only, and apply only to "separated locations". These are areas where people live and spend time, such as residences, commercial, educational, or religious establishments, or public use areas. By law, monitoring sites for the field study are to be located in close proximity to these separated locations and not at the fenceline of the animal feeding operation, as would typically be done for monitoring of ambient air (Iowa Code section 459.207).

Outcome

Monitoring of ammonia and hydrogen sulfide concentrations continues to be collected at ten locations throughout Iowa near large livestock facilities, with data being compared to the hydrogen sulfide health effects standard. 2005 data indicates that the HES was not exceeded during the calendar year, therefore comprehensive plans and programs to mitigate emissions of hydrogen sulfide from animal feeding operations have not been established at this time. The Air Quality Bureau's website at www.iowacleanair.com provides links to interim data from the field study and to real-time monitoring data, as well as reports that provide more detailed graphical analyses.

The odor portion of the field study concluded in December, 2005. Tables with results and a final report detailing the methodology of the study and measurement data will be available at the Bureau's website in March 2006.

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A Life Cycle Approach to Policy Decisions on Swine Waste Management Alternatives

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The comparison of swine waste management technologies can be done in a number of ways, e.g. economics, emissions of a single chemical such as ammonia, in terms of total environmental impact, etc. The latter is referred to as the net environmental benefit or life cycle approach. Use of a life cycle concept attempts to understand the transfer or shifts in pollution that often occur in complex systems such as the swine production industry.

The Water Resources Research Institute of the University of North Carolina has funded a parallel study to the large Attorney General/Smithfield Agreement research effort. The goal of the WRRI project is to determine for a small number of swine waste management alternatives, what life cycle results would occur and compare that to the results from decision-making for ammonia emissions. Four swine waste management technologies were investigated:

1. conventional lagoon and spray irrigation (with lagoon solids removal and land application when full)
2. covered lagoon with spray irrigation, utilization of methane production for electricity, and lagoon solids removal and land application when full
3. biological aerated filter process with land application of effluents and solids, and
4. Harvestore collection and land application of raw waste.

An engineering and science approach was used to assess the energy (usually electricity) and emissions from each of these technologies. Because a life cycle approach was used, all related supply chain emissions and energy requirements were also added. Thus when electricity is used, the emissions from electrical power generation are included. When swine waste NPK are land applied, emissions and energy requirements from industrial plants for NPK are correspondingly reduced creating an environmental benefit.

Analysis of these technology comparisons was done for a number of environmental parameters, but in this summary, two are highlighted. The first is the ammonia emissions to the air and the second is the impact on global climate change potential (a combined effect of CO_2, methane, and nitrous oxides, using scientific rules for combining these emissions and expressing the effect as equivalent CO_2. These results are provided in Figures 1 and 2.

Figure 1: Ammonia emissions from life cycle evaluation of swine waste management technologies

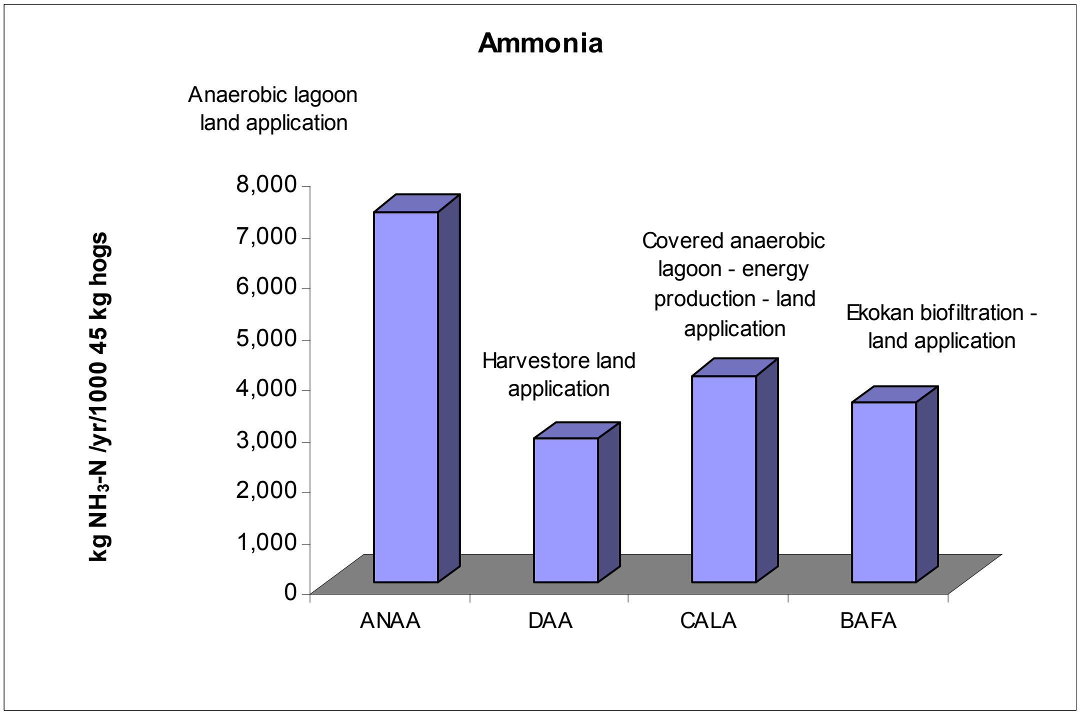
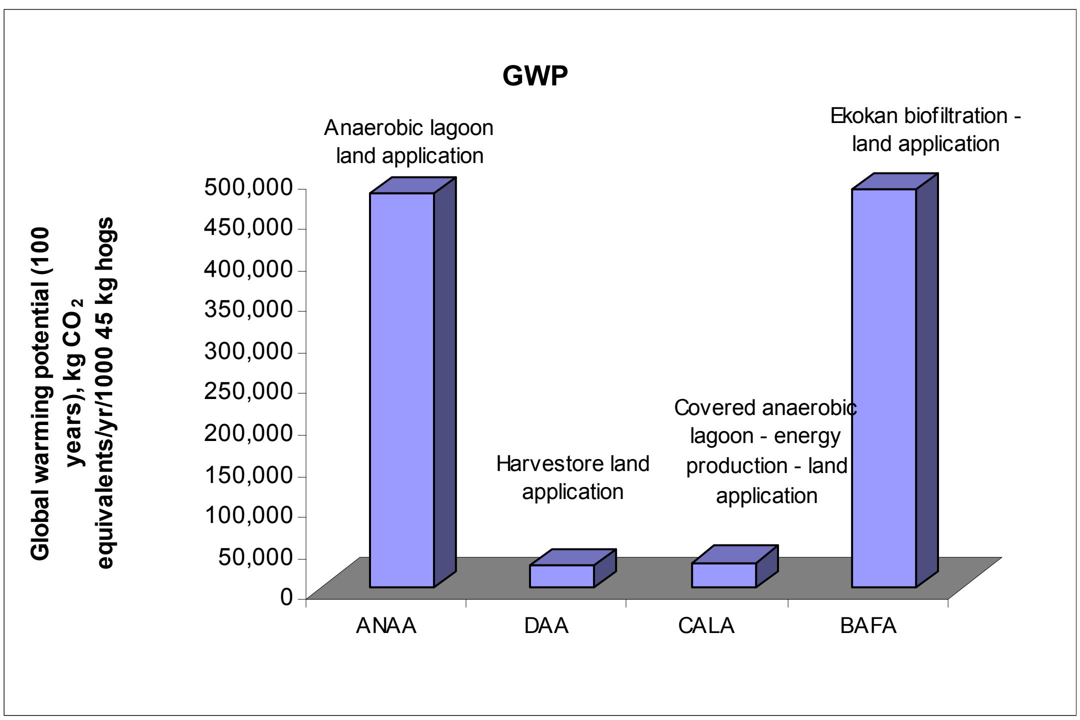


Figure 2: Global warming emissions (CO_2 equivalents) from life cycle evaluation of swine waste management technologies



The life cycle approach shows that changing swine waste management technologies results in two clear geographic transfers of pollution. First, using ammonia emissions as the criterion for technology choice (Fig. 1), the Ekokan biofiltration is slightly better than the covered lagoon and significantly better than the current lagoon-land application system. However when one looks at global warming emissions, the Ekokan system has a substantially higher impact than the new technologies of the covered lagoon or the direct land application. Thus there is a geographic shift from ammonia emissions at the swine site, to larger emissions at the power generation facilities.

The second shift is from one form of emissions to another. In this case, the shift is from ammonia in air to the constituents comprising global warming potential. This is referred to as chemical or pollution shift. In the report, other environmental shifts are documented for these four swine waste management alternatives.

Conclusions

1) A life cycle approach to swine waste management technologies selection provides the most comprehensive assessment of environmental impact.
2) Mass balance approaches provide more independent measures and lowest cost technique for determining ammonia emissions from most swine waste management technologies.
3) There are shifts in geographic impact and chemical emissions that occur when selections are made between swine waste management technologies. These shifts should be better understood when industry-wide decisions are made.

Regulation of Ammonia from Agriculture in Denmark: Concept and Methodology

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Abstract

Emissions of ammonia from Danish livestock farms are strongly regulated. Manure applications to the fields are restricted to take place in the growth seasons and within certain limits for the total load per hectare on annual basis. Farmers need to document access to fields for application of the manure. Finally the farmers need to apply to the local authorities when they intend to increase the animal production. These applications for increasing the production are treated using an official Guideline for Environmental Impact Assessment (EIA) of ammonia loads of the local nature. A structural change taking place in Denmark by 2007 will move the obligation of carrying out this assessment from the counties to the municipalities. The current Guideline for making the assessment is under review. One of the aims is to make the assessment simple to perform and updated with respect to the latest knowledge about dispersion and deposition. The present paper outlines the planned methodology behind the suggested future Guideline for EIA on local nature of ammonia emissions from livestock farming in Denmark.

Introduction

The anthropogenic emission of nitrogen compounds to the atmosphere is of great concern due to its impact on both human health and environment. The Dobris assessment showed that in the beginning of the 1990'ties the critical loads and levels for atmospheric nitrogen compounds were exceeded over large parts of Europe (EEA, 1995). The Third Assessment in 2000 showed that despite considerable improvements concerning the pressures on nature, the critical loads were still exceeded for more than half of European ecosystems (EEA, 2003). In Denmark the impact of atmospheric nitrogen on terrestrial and marine ecosystems is know to be very significant (Bach et al., 2005). Episodes of oxygen decificts in bottom waters, in worst case situations followed by death of fish and bentic fauna, are frequent phenomena in the inner Danish waters. These episode are strongly linked to the anthropogenic nitrogen loads, of which current estimates have shown that about 30% of the bioavailable nitrogen arise from atmospheric loadings (Spokes et al., 2006). It has furthermore been shown that critical loads are exceeded for more than 70% of Danish terrestrial ecosystems (Bach et al., 2005). For the most sentitive Danish terrestrial ecosystems calculations have shown that even the atmospheric background deposition exceeds critical loads (Hertel et al., 2003). Calculations also show that Danish sources contribute to 40 - 45% of the background deposition over land (Ellermann et al., 2005).

Figure 1 shows the background atmospheric nitrogen deposition to Danish land areas for 2004 and forcasted for 2020. The calculations show that a signifant part of the country has loads in the range pf 14 to 16 kg N/ha in 2004. The projection for 2020 shows that loads will still be in the range 12-15 kg N/ha over large parts of especially the western part of the country. However, close to local livestock farms this contribution may be significantly higher both in the present and future situation and lead to significant exceedances of critical loads even for the less sensitive ecosystems. Calculations with NERI's local scale plume model OML-DEP have shown that for a typical Danish livestock farm, a little more than 20% of the annual emission from barns and storages will deposited within a radius of 2km from the farm.

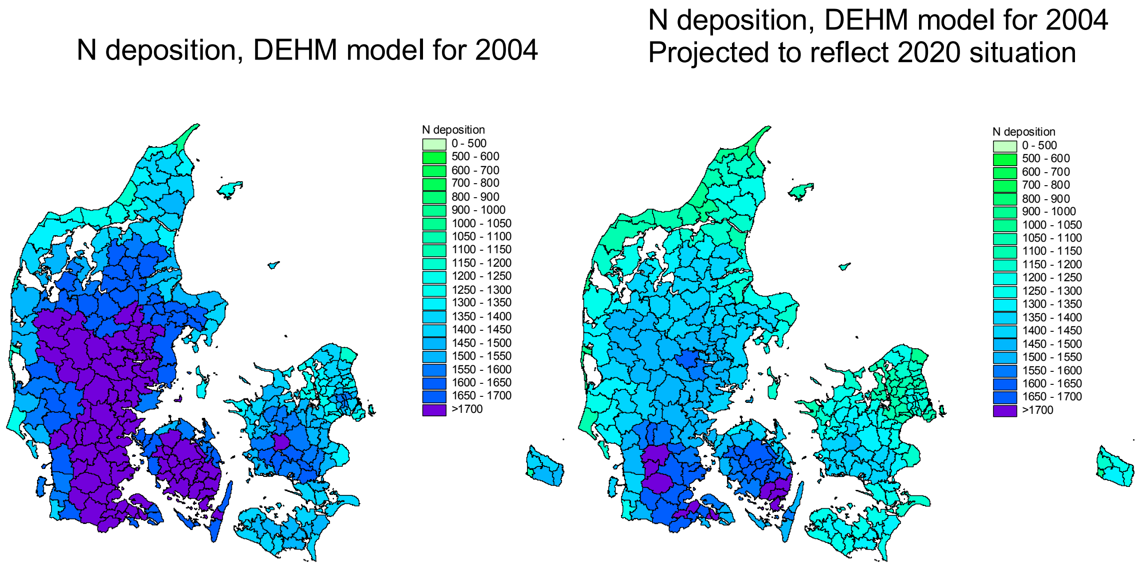

Figure 1 Computed atmospheric nitrogen loads on municipality level. The left figure is for 2004 and the right figure a projection for 2020. The projection is based on simple scaling of Danish and international contributions based on EMEP expert emissions in 2003 and 2020. Depositions are in kg/km^2 (divided by 10 this equals kg/ha).

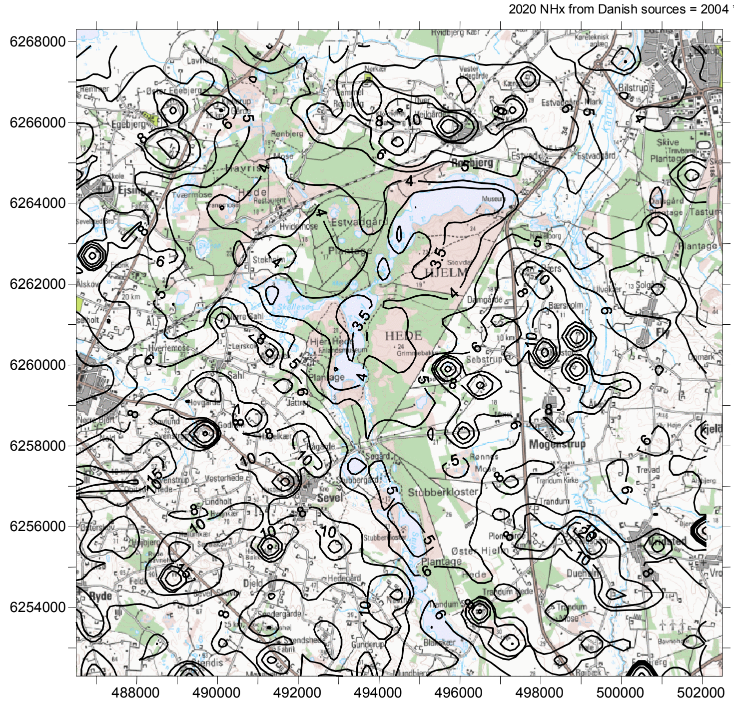

Figure 2 Atmospheric nitrogen loads (kg N/ha) from local ammonia emissions to Hjelm Heath in Jutland in the western part of Denmark. Coordinates along the axis represent UTM-32N. Calculated with the OML-DEP model within the Danish Background Monitoring Programme (Ellermann et al., 2005). The background deposition is about 11 kg N/ha for this area.

The annual emissions from barns and storages may be in the range of 20 - 40 kg N and up to even 2000 kg N. Therefore the average annual deposition in the 2km radius around the farm is espected to be in the range of 0.1 kg N/ha and up to 4 kg N/ha. Although a relatively steep gradient will be present away from the farm (see Figure 3). Similarly depositions will depend on the frequency of wind directions – in this context the prevailing wind direction in Denmark is from south-west. Similarly to the contribution from emissions arising from barns and storages, there is a significant contribution from the emissions from fields related mainly related to manure application and to a smaller extend also arising from evaporation of ammonia from crops. This contribution from the fields has also been estimated to be in the range of 2 to 4 kg N/ha as average in a 2km zone around the fields – again with a realtively steep gradient away from edge of the field. This is demonstrated in Figure 2, which shows OML-DEP calculations performed in connection with the Danish background monitoring programme (Ellermann et al., 2005) for a heath area in the western part of the country. It is evident that depositions in this area arising from local livestock farming may contribute to 3 to 10 kg N/ha on annual basis. The impact on nature areas will be governed totalle by the specific situation of livestock farms in the vicinity of nature areas. A recent study has shown that depositions of atmospheric nitrogen to Danish nature areas would typically be reduced by 1 to 2 kg N/ha/year by establishing 200m buffer zones around Danish nature areas (Schou et al., 2006).

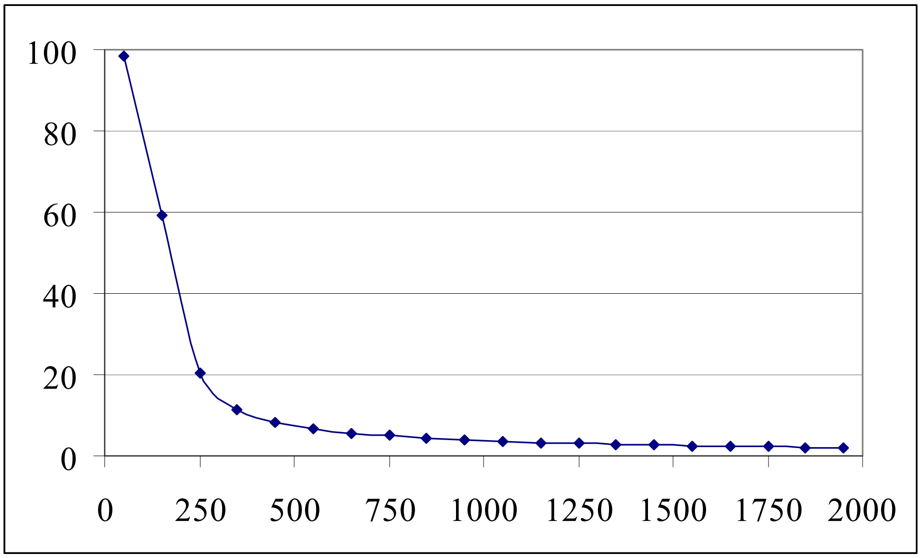

Figure 3 Ammonia deposition (kg N/ha/year) from a livestock farm with 100 animal units of cattle (68 mature cows and 69 calves), which yields an ammonia emission of 1114kg N (895 kg N from barn and 219 kg N from storage. Depositions are shown as function of the distance from the source. Calculations with NERI's local scale plume model OML-DEP.

The negative impact on the environment of anthropogenic nitrogen has been the background for three large Danish National Aquatic Action Plans in 1987, 1998 and 2004 aiming at reducing the nitrogen (and phosphorous) input into the aquatic ecosystems (Anonymous, 2004). The first two Danish national actions plans have lead to vast investments in waste water treatment plants, establishing and improving storage tanks for manure etc, and have thereby succesfully reduced the nitrogen loads of the environment. The third action plan (2005-2015) aims at reducing ammonia and odour emissions. These action plans have influenced also the atmospheric emissions in amount as well as seasonal distribution through a change in agricultural praxis (Skjøth et al., 2004).

However, beside the regulation associated to the aquatic actions plans, the emissions from livestock farms are also regulated directly. The farmers are obligished to make an application to the local authorities in connection with establishing new or increasing animal production of existing livestock farms. In connection with such an application, the local authorties perform an EIA of ammonia emissions on the local nature in the vicinity of the livestock farm. This is currently carried out by following a Guideline from the Danish Forest and Nature Agency (Bak, 2003). The applications have until now been handled by the counties, but by 2007 Danish local authorities will be restructured and the existing 9 counties in Denmark will closed down. The current obligations of the counties will be distributed between state, municipalities and three new regional centres. However, the regulation of livestock farms will in the future be handled solely by the municipalities that therefore will have to build up expertise in this field. Currently Denmark has 270 municipalities, but after the structural change, a number of these will be merged and there will remain approximately 98 municipalities. These 98 municipalities will then perform the regulation of livestock farms, and it is anticipated that this will be carried out using the suggested new Guideline.

The Danish municipalities have claimed that the current Guideline for assessment of the impact of ammonia emissions from livestock farms is too complex. At the same time new model tools have become available since the current Guideline was made. The counties have constructed a spreadsheet that has eased the used of the Guideline, but still a revision is strongly requsted in order to improve the operationality and update with state-of-the-art. The Danish Forest and Nature Agency has therefore initiated a project to form the basis for a revised version of the guideline. The present paper describes the basic methodology of this new Guideline suggested to be the tool for the municipalities in their furture handling of applications from Danish farmers for establising or increasing livestock production on their farms.

Concept for the suggested calculations procedure

The concept behind the calculation procedure in the suggested new Guideline for ammonia from animal production includes three steps with increasing complexity (see also the sketch presented in Figure 4):

A. Simple screening – a method for quick assessment of potential environmental impact as a result of airborne ammonia emitted from smaller livestock farms. This method will be used for smaller livestock farms (<75 animal units) and is solely intended for a first crude screening of farms with insignificant impact on the local nature. The screening is not carried out for cases when manure is brought to a biogas plant.
B. Standard method – the basic method for assessment of environmental impact based on nomograms and tables. This method is intended to be used for all cases that cannot be close after step A, except for situations when the applicant or others ask for more detailed treatment after step C.
C. Detailed model calculations – a detailed mapping of nitrogen loads based on model calculations and similarly detailed critical load estimates for the local nature in the nearby region of the livestock farm. This method is intended to be used only when the applicant or others may wish so on basis of a number of predefined guidelines for when such a possibility should be open.

STEP A: SIMPLE SCREENING

The annual emissions from barns, storages and manure application are calculated for a "standard" livestock farm. The emissions are based on the current animal production and using standard emission factors according to a Danish norm system. Emissions from manure application to fields are calculated as a fixed fraction of the applied nitrogen.

Influence zones around the farm and the associated fields are computed. These zones cover the area in which there is a potential risk for significant impact on the ecosystems. In the calculation of the extent of the influence zone, the frequency of various wind directions is taken into account. The radius of zone in a given direction is calculated so that it represents the distance in which the deposition is below a certain predefined level; a level at which the contribution to eutrophication is considered insignificant.

The influence zones around the sources are drawn on a map where the local nature areas are shown. Especially in cases of overlap between influence zones there is a potential risk for negative impacts of ammonia from livestock farms on the sensitive local ecosystems. In such cases the application from the farmer for establishing or increasing the animal production will subsequently be treated after the standard method in step B.

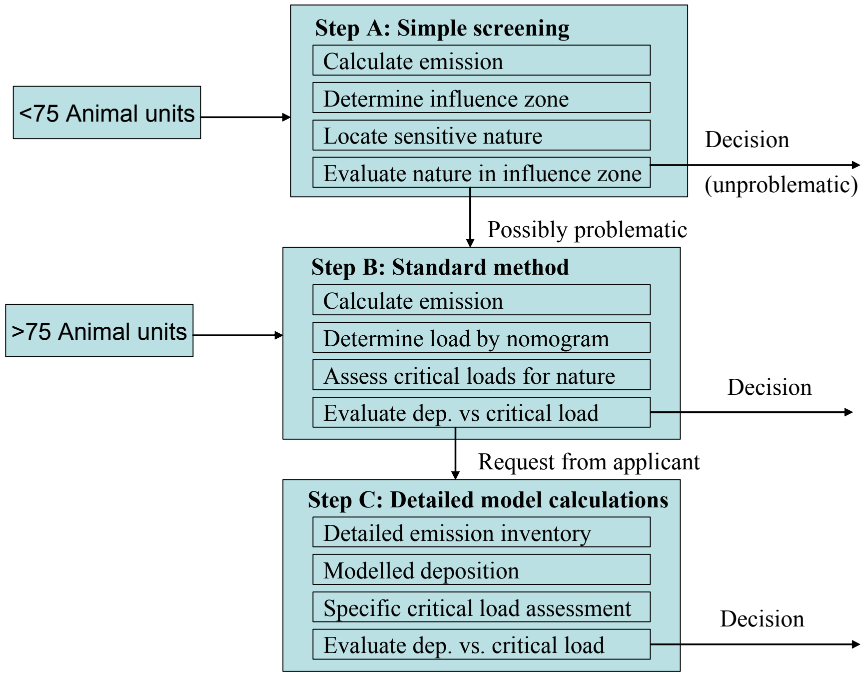

Figure 4 Sketch to illustrate the overall calculation procedure in the suggested new Guideline for assessment of environmental impact of ammonia emissions from livestock production in Denmark (Geels et al., 2006).

STEP B: THE STANDARD METHOD

Just as for the screening method the emissions from barns, storages and manure application are calculated, but in this case the emissions may deviate from the defined standard livestock farm concerning the following points: the nitrogen separation (feeding practise, production level and the time the animals spend outdoors in the fields); surface area and cover of the storage tank; time and method for application of manure on the fields, application of air scrubbers, acidification of manure or other documented ways to reduce the ammonia emission.

The annual background atmospheric nitrogen load as an average over five years is provided from standard model calculations with DEHM-REGINA at NERI on a 16.67km by 16.67km grid. An online routine on a central server selects background data on basis of user defined coordinates for the location of the farm, and the selection of background depositions is taking into account the specific land use of the area. These data will be updated on regular basis.

The deposition of nitrogen from the local sources is determined on basis of a set of standard nomograms. These nomograms are computed using the OML-DEP; a plume model with a deposition module included. A simple scaling based on the emissions from the specific livestock farm is applied, since the relationship between emission and ambient concentrations to a good approximation may be considered as linear. The calculation is performed out to the distance from the source in which the deposition is below a certain predefined level; a level where at which the contribution to the overall load is considered insignificant. This procedure is repeated for all point and area sources to account for possible overlap of influence zones.

A standard table has been compiled for the determination of typical intervals for the critical loads of the local nature areas. However, in the assessment more specific empirical or semi-empirical critical loads for the actual nature are of high importance. Such critical loads may be determined from observations of relationships between loads and impact from research or surveillance projects, but may also be based on extrapolation from laboratory studies. Another way to determine the critical load is to apply models that are based on chemical criteria for a scientifically shown relationship between loads exceeding a given critical value and unwanted effects.

The computed nitrogen depositions are drawn on maps using wind direction frequency corrected influence zones for each source. The total deposition is determined with and without the increase in animal production that the farmer has applied for permission to have. The total deposition is compared to critical loads for the nature areas in the area nearby.

STEP C: DETAILED MODEL CALCULATIONS

The emissions are determined in similar way as for step B, but in this case a detailed seasonal variation is applied. The emission variation handles separately the variation in releases from barns, storages, application of manure and fertilizer, grazing animals, evaporation from crops as well as other minor sources. This seasonal variation is computed using a procedure based on a simple growth model and primarily driven by the temperature (Ambelas Skjøth et al., 2004; Gyldenkærne et al., 2005).

The model calculations are performed with the DAMOS (Danish Ammonia Modelling System), which is based on a combination of the OML-DEP and the regional model DEHM-REGINA. OML-DEP receives initial concentrations from DEHM-REGINA and performs calculations hour by hour for a grid of receptor points in a suitable zone around the farm. The initial concentrations for each hourly calculation are taken from the up-wind direction and meteorological data are provided from a meteorological model (either Eta or MM5).

As a starting point, calculations will be performed for one year and based on the latest available data – typically this will mean from the previous year.

The OML-DEP model

The OML-DEP is developed on basis of the OML models at NERI, which are Gaussian plume models handling dispersion of pollutants from point and area sources within a distance of about 20km from the sources (Olesen, 1994; 1995; Berkowicz et al., 1986). The new feature of the OML-DEP compared with the previous versions of the OML model is that it contains a deposition description. The model is set up to perform calculations for a regular receptor net of e.g. 400m x 400m for an area of e.g. 16km x 16km. OML-DEP is a part of the DAMOS (Danish Ammonia Modelling system), which consists of the OML-DEP coupled to the regional scale model DEHM-REGINA (Figure 5).

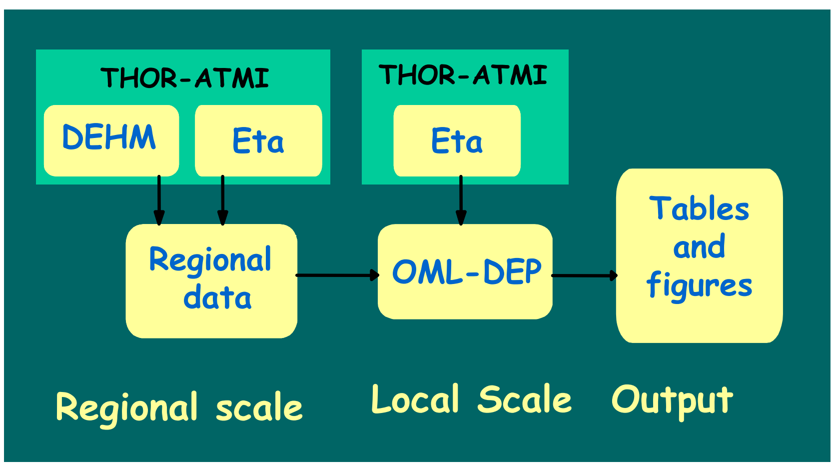

Figure 5 Sketch to illustrate the DAMOS (Danish Ammonia Modelling System) for assessment of atmospheric ammonia loads from livestock farms.

In the DAMOS system, the OML-DEP generates an initial concentration field based on upstream background concentrations from DEHM-REGINA. Calculations are based on local meteorological date from either a local mast or generated by a meteorological forecast model (at NERI the Eta and MM5 models are applied). Emission data for ammonia are obtained on basis of the Central Livestock Registry and the Basic Agricultural Registry, the farmers manure budgets reported to the National Crop Directorate and maps of the agricultural fields in the country (Gyldenkærne et al., 2004; 2005). The land use data, which are important for the deposition velocity, are obtained from national Area Information System AIS (Nielsen et al., 2001). OML-DEP was applied within the Danish national monitoring programme (Ellermann et al., 2005).

Conclusions

Ammonia emissions from Danish farms are regulated by local authorities. A structural change of the local authorities will take place by January 1st 2007. One of the consequences of this structural change is that applications from farmers for establishing or increasing animal production on livestock farms will be handled by municipalities that currently have no expertise in this field. The current Guideline is furthermore complex and new model tools have recently become available. A new Guideline for assessment of the environmental impact of ammonia emissions from livestock farms in Denmark is therefore suggested. The basic methodology of proposed calculation procedure consists of three steps with increasing complexity. First step is a simple screening based on calculation of influence zones around the sources, and comparing these with the situation of nature areas in the surroundings of the farms. Second step is the standard method that is expected to be used on the main part of the applications. In this step the load estimates are based on a nomogram method, where the curves have been produced from calculations with NERI's local scale model OML-DEP. The third step is planned only to be used only on special request by either applicant or authority. This method consists of detailed model calculations with DAMOS – the combination of the local scale plume model OML-DEP and NERI's regional scale model DEHM-REGINA for calculation of the background loads.

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Evidence of Enhanced Atmospheric Ammoniacal Nitrogen in Hell's Canyon National Recreation Area: Implications for Natural and Cultural Resources

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Abstract

Regional agricultural operations release large amounts of fertilizing pollutants to air sheds and waterways of the northwest US. To evaluate air pollution threats to historic rock paintings and natural resources along the Snake River in Hells Canyon National Recreation Area, Oregon and Idaho, USA, we monitored ambient ammonia, nitrogen oxides, sulfur dioxide, and hydrogen sulfide at five stations along 60 km of the Snake River valley floor from July 2002-June 2003 and obtained ozone and fine particulates concentration data from the Hells Canyon IMPROVE station. Ammonia concentrations were high, peaking in spring and summer; the nutrient-laden Snake River is the most likely source. Ammonium nitrate concentrations in fine particulates peaked in winter with drainage of stagnant air masses from the Snake River Basin, a national center of livestock and crop production. Other pollutant concentrations were within background ranges for remote locations. Ammoniacal nitrogen in Hells Canyon is at levels known to adversely affect western biotic communities and ecosystem processes and is potentially corrosive to clay-based pictographs. Better controls on agricultural emissions and enforcement of state water quality standards would help protect these precious resources.

Introduction

Hell's Canyon National Recreation Area (HCNRA), including the Class 1 Hells Canyon Wilderness, encompasses 71 miles of the Snake River along the northern Oregon and central Idaho border and contains one of the best-preserved collections of riverine archaeology in North America (Keyser 1992). Over 200 pictographs and carved petroglyphs ranging in age from 200 to 7,100 years are recorded in the National Register of Historic Places. In the1990's, US Forest Service career archeologists expressed concern that pictographs in HCRNA along the Snake River had deteriorated in recent decades (Schaff & Szymoniak 1996). Because air pollutants can dissolve rock and clay minerals (Van Grieken et al. 1998) and enhance the growth of biological weathering agents (Mansch & Beck 1998) of culturally modified stone, they postulated that air pollution in the Snake River corridor could be a cause of rock art weathering in Hells Canyon.

In 2000, the Forest Service sponsored a lichen study of the Snake River valley, its primary tributaries, and the adjacent Imnaha watershed, all within HCNRA (Geiser et al. 2006). Extensive bark cover of nitrophytic lichens and high nitrogen concentrations in lichen tissues indicated that nitrogen deposition was high throughout the study area but especially on the Snake River valley floor where most of the rock art is located. Higher bark pH at sites with higher lichen cover pointed to an ammoniacal as opposed to acidic deposition source. The authors concluded that despite HCNRA's remote location, deposition of nitrogen-containing pollutants was enhanced relative to other remote sites in the northwestern United States.

The present study was limited to the Snake River valley floor where the greatest threat is perceived. The objectives were to 1), measure levels of fertilizing and oxidizing pollutants that could volatilize from the Snake River or be transported in the air from local or regional sources, 2) identify which pollutants, if any, could adversely effect HCNRA cultural or natural resources at observed levels and 3), identify the most likely sources and peak transport times of these pollutants.

Methods

Sampling occurred from July 2002 – June, 2003 at 6 stations along 80 km of the Snake River valley floor in and near Hell's Canyon National Recreation Area. At five monitoring stations inside HCNRA, Ogawa passive air samplers (Ogawa & Co., 1230 S.E. 7th Ave., Pompano Beach, FL 33060, USA) for NO_x/NO,

NO_2/SO_2, and NH_3 and Maxaam samplers for H_2S (Maxaam Analytics, Inc., Centre for Passive Sampling Technology, 9331 48th Street, Edmonton, ABT6B 2R4, Canada) were placed on PVC posts about 2 m above the ground level. There were two replicate removable collection pads for each gas. Collection pads for NO_x, NO_2, SO_2, NH_3, and H_2S were replaced with clean, unexposed pads every two weeks to four weeks. Sampler components, pollutant extraction procedures and calculations of ambient concentrations followed by the analytical laboratories (USDA Forest Service Pacific Southwest Research Station, Riverside, CA 92507 and Maxaam Analytics) are described by Ogawa & Co. (1999) and Tang (2001). At the sixth station, HECA in Oxbow, OR we obtained 2001-2003 IMPROVE mean daily concentrations of ammonium nitrate and ammonium sulfate in fine particulate matter and July 2002-September 2003 hourly mean ambient ozone concentrations from a co-located portable ozone monitor (Model No. 202, 2B Technologies, Inc., PO Box 288, Golden, CO 80401, USA). Ammonium nitrate and ammonium sulfate concentrations at HECA and all other Oregon, Washington and Idaho IMPROVE stations were obtained from the Visibility Information Exchange Web System (VIEWS) (http://vista.cira.colostate.edu/views)for comparison. Frequencies and seasonality of pollution transport to HCNRA from different geographic source areas during days of peak NH_4NO_3 and $(NH_4)_2SO_4$ concentrations were estimated using 4-24 hour back trajectories at HECA available from VIEWS.

Results and Discussion

We found that ozone, sulfur dioxide, hydrogen sulfide, and nitrogen oxide concentrations in ambient air, and ammonium sulfate in fine particulates along the Snake River valley floor of Hells Canyon National Recreation Area were within background ranges expected for remote areas in the western US. In contrast, ambient ammonia and ammonium nitrate in fine particulates were seasonally enhanced. The Snake River is the most likely cause of elevated atmospheric ammonia levels detected in HCNRA, which peak in spring and summer and are most elevated close to the river, while regional atmospheric transport, especially from the Snake River Basin in winter, is the most likely source of elevated depositional ammonium nitrate detected throughout the study area by the lichen study.

Compared to other parts of the US, ammonia emissions in southeastern WA, northeast OR and the Snake River Basin of Idaho are high with total regional emissions estimated at 43,000 tons in 1998 (EPA 2005). The reaction of nitric acid with ammonia gas emitted from agricultural operations results in the formation of ammonium nitrate particles that can be transported to remote parks and wilderness, depending on the pattern of local ammonia emissions relative to the supply of nitric acid vapor (Schoettle et al. 1999). Surface winds are most likely to channel regional pollutants into HCNRA via the Canyon (Schaaf & Szymoniak 1996); gravity would drain winter time Snake River Basin inversions through the Canyon.

Local surface waters are also an important anthropogenic source of nitrogen. The Snake and Boise Rivers, which join up-river from HCNRA, are straddled by Boise, Twin Falls and Idaho Falls, many minor urban and industrial areas, and drain a major national agricultural region. The lakes above Brownslee and Oxbow dams experience severe algal blooms each summer and chlorophyll a concentrations and phosphate levels do not meet state standards for these water quality indicators nearly 100% of the time (IDEQ 2004). Anearobic microbial activity in the deep, hypoxic lake waters produce high levels of ammonia, released from the bottom of the dams into Hells Canyon reach (Meyers et al., 2003). Volatilization of ammonia from dissolved ammonium is greatly favored under high pH conditions created when algal blooms consume large amounts of CO_2, (Brady 1984); the pH of the lower Snake River ranges between 6 and 9 (IDEQ 2004). Deposition of ammoniacal nitrogen to vegetation and soils normally occurs close to the source but may be especially enhanced by humidity along the Snake River and concentration of solutes in low hanging fog.

We conclude that ammoniacal nitrogen in HCNRA is well above natural background ranges for the western US, and poses a threat to the integrity of natural and cultural resources, especially along the valley floor. Better controls on agricultural emissions and enforcement of existing water quality standards are needed to protect these precious resources.

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