

Animal Operations and Residential Property Values

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Animal operations (AOs) may be broadly defined as facilities in which animals are raised or brought for slaughter. The common denominator is a large perpetual inventory and density of animals.¹

Although livestock and poultry production has more than doubled in the United States since the 1950s, the number of animal operations has decreased by 80%.² Food animal production in the United States has shifted to concentrated facilities where animals usually are raised in confinement. This concentration of animals brings environmental concerns related to air and water quality as well as animal and human health. As a result, animal operations are subject to regulation by the US Environmental Protection Agency (EPA), the US Department of Agriculture (USDA), and a variety of state entities. Laws and government regulations related to animal operations include specific definitions based on the function and size of the operations. For example, the EPA defines *animal feeding operations* (AFOs) as

agricultural enterprises where animals are kept and raised in confined situations. AFOs congregate animals, feed, manure and urine, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures, fields, or on rangeland.³

To qualify as an AFO, an animal operation must confine animals for at least 45 days in a twelve-month period.⁴ According to the EPA, there are approximately 450,000 AFOs in the United States.⁵ The EPA also designates certain AFOs as *concentrated animal feeding operations* (CAFOs) based on the confinement of large numbers of animals and the pollutant discharge. At CAFOs, there is a higher concentration of waste that increases the potential impact on air, water, and land quality.⁶ CAFOs are regulated by the EPA under the Clean Water Act,

ABSTRACT

Animal feeding and processing operations have grown more concentrated, with each facility handling much larger numbers of animals than traditional farms. The larger concentration of animals impacts the quality of surrounding air and water. In addition, the facilities impact the economic conditions of the communities where they are located. All of these factors can potentially affect the value of nearby houses. This article summarizes the current literature on how animal operations may affect the value of residential properties located near such facilities; this information will be useful to practicing appraisers faced with valuing houses in these communities.

1. Quite a few documents were reviewed to develop this discussion; see subsequent footnotes and Drew L. Kershen and Chuck Barlow, "Concentrated Animal Feeding Operations and Water, Air, Land, and Welfare," report on the American Bar Association (ABA) Special Committee on Agricultural Management Roundtable II on Environmental Challenges in Animal Feeding Operations (September 23, 1999).
2. EPA, *Literature Review of Contaminants in Livestock and Poultry Manure and Implications for Water Quality* (EPA 820-R-13-002, July 2013), 3; <http://water.epa.gov/scitech/cec/upload/Literature-Review-of-Contaminants-in-Livestock-and-Poultry-Manure-and-Implications-for-Water-Quality.pdf>.
3. EPA, "What is a CAFO?," <http://www.epa.gov/region07/water/cafo/>.
4. Ibid.
5. EPA, "Animal Operations," <http://www.epa.gov/agriculture/anafoidx.html>.
6. http://www.epa.gov/region07/water/cafo/cafo_impact_environment.htm.

as environmental concerns arise when waste runoff is discharged onto adjacent landscapes and waterways.⁷

As the structure of the livestock industry has trended toward concentration of more animals in fewer operations, state and local governments also have acknowledged the problems associated with large operations by enacting legislation imposing stricter regulations on CAFOs and increasing separation distances.⁸ For example, in North Carolina the following mandatory setbacks are imposed on new or expanded farms with 250 or more hogs: 1,500 feet from occupied residences, 500 feet from any residential property boundary to swine houses and lagoons, and 75 feet from any residential property boundary to sprayfield boundaries.

Overall, the empirical evidence indicates that residences near AOs are significantly affected, and data seems to suggest a valuation impact of up to 26% for nearby properties, depending on distance, wind direction, and other factors. Further, there has been some suggestion that properties immediately abutting an AO can be diminished as much as 88%. One study estimates the total negative impact to property values in the United States at \$26 billion.⁹ Mitigation makes a marginal impact. Not only are residences affected, but nearby small farms can be impacted by such factors as water degradation and insects.

Environmental Impacts and Regulation of Animal Operations

AOs are generally recognized to affect the surrounding environment in several key ways: air quality and

odors (ammonia, hydrogen sulfide, methane, and particulate matter), greenhouse gas and climate change, insect vectors (often carrying resistant strains of pathogens), groundwater and surface water contamination, and a variety of pathogens.¹⁰

Data from the USDA and the EPA estimate that livestock in the United States produce 130 times the total amount of manure as the entire human population of the country. For example, one hog excretes nearly three gallons of waste per day or 2.5 times the average human's daily total. A 3,000-sow AO will produce about 25 tons of manure a day.¹¹ A similar number of chickens will produce about 700 pounds of manure per day (plus or minus 30%), containing about 9 pounds of nitrogen gas, 7.5 pounds of phosphorus pentoxide (a powerful irritant and corrosive) and over 4 pounds of potassium oxide, a highly reactive deliquescent that reacts violently with water to produce potassium hydroxide.¹² Manure from livestock production can contain bacteria (salmonella, E. Coli 0157:H7), parasites, viruses, and antimicrobials (antibiotics and vaccines).¹³ Excessive levels of phosphorus in land and water have been correlated with livestock density; and manure has caused eutrophication and degradation of US waterways.¹⁴

AOs are regarded as potential sources for contamination because of the large amounts of manure that they produce, and because the proximity in which the animals are confined allows for disease to be easily transferred.¹⁵ A 2006 outbreak of E. coli 0157:H7 was associated with the consumption of fresh spinach that had been in contact with water contaminated with animal feces.¹⁶ One of the

7. The USDA and EPA first regulated animal operations under the 1999 "Unified National Strategy for Animal Feeding Operations," see <http://water.epa.gov/polwaste/npdes/afo/Animal-Feeding-Operations-Regulations.cfm>. The USDA Economic Research Service presents a discussion of regulatory issues related to animal waste at <http://www.ers.usda.gov/topics/animal-products/animal-production-marketing-issues/policy-regulatory-issues.aspx#regulatory>. Up-to-date information on the Clean Water Act is available at <http://www2.epa.gov/laws-regulations>.

8. Joseph Herriges, Silvia Secchi, and Bruce A. Babcock, "Living with Hogs in Iowa: The Impact of Livestock Facilities on Rural Residential Property Values" (Iowa State University Center for Agricultural and Rural Development working paper, August 2003).

9. Doug Gurian-Sherman, *CAFOs Uncovered: The Untold Cost of Confined Animal Feeding Operations* (Cambridge, MA: Union of Concerned Scientists, 2008).

10. Carrie Hribar, *Understanding Concentrated Animal Feeding Operations and Their Impact on Communities* (National Association of Local Boards of Health, 2010), available at http://www.cdc.gov/nceh/ehs/docs/understanding_cafos_nalboh.pdf.

11. Don Hopey, "Study Finds Large Hog Farms Lower Property Values," *Post-Gazette* (June 7, 2003).

12. Jing Tao and Karen Mancel, "Estimating Manure Production, Storage Size, and Land Application Area," Ohio State University, 2008 Agricultural Fact Sheet. According to a study by the University of Wisconsin-Madison, the average chicken farm has 14,500 birds, with farm sizes ranging up to 50,000 birds; see UW-Madison College of Agricultural and Life Sciences, Center for Integrated Agricultural Systems, Research Brief 63, January 2003.

13. EPA, *Literature Review of Contaminants in Livestock and Poultry Manure*.

14. Stephen Jann, "Recent Developments in Water Pollution Control Strategies and Regulations," presentation at ABA Special Committee on Agricultural Management Roundtable II on Environmental Challenges in Animal Feeding Operations, Minneapolis, MN (May 12, 1999).

15. "National Pollutant Discharge Elimination System Permit Regulation and Effluent Limitation Guidelines and Standards for Concentrated Animal Feeding Operations (CAFOs); Final Rule" *Federal Register* 68 (February 12, 2003). Note that portions of this were subsequently overturned in *Waterkeeper Alliance v. EPA*, 399 F.3d 486.

16. "FDA Finalizes Report on 2006 Spinach Outbreak," FDA (March 24, 2007), <http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/2007/ucm108873.htm>.

leading causes of food and waterborne illness in the United States is this *E. coli* 0157:H7 organism, which is a specific strain of the *Escherichia coli* bacteria commonly found in the intestines of healthy cattle. One means of transfer of *E. coli* to humans occurs when untreated manure is able to enter water sources or used for fertilization.¹⁷ The EPA acting under the Clean Water Act has designated AFOs as point sources of pollution and requires that they have zero discharge or apply for a permit that requires an extensive waste management plan. Despite regulatory efforts to segregate manure-related contaminants from the water supply, contaminants still may enter the supply because of flooding, leeching into the soil, or through disregard of regulations.

In addition to water quality issues related to manure and waste run-off, animal operations facilities attract flies and other insects and parasites.¹⁸

As noted in Kilpatrick, state entities began regulating AFOs in the late 1990s.¹⁹ In 2000–2001, the EPA began levying fines against concentrated beef production facilities in the Northwestern United States that met two criteria: the facility confined animals for at least 45 non-consecutive days per year and the confinement area was devoid of vegetation. The rules generally applied to any operation with 300 head of cattle or more. At the time of the regulations, the EPA estimated that this would affect between 26,000 and 39,000 AFOs in the United States.²⁰

On December 11, 2002, the EPA issued its final revised regulations.²¹ The regulations affirmed the prior definitions of AFOs and CAFOs, provided for an explicit duty to apply for a permit, established required performance standards and best management practices, and explicitly required nutrient management plans.²²

Overview of AO Impacts on Property Values

An AO can affect the value of proximate properties in two ways. First, AOs have a substantial indirect negative economic impact on surrounding communities, including property values in those communities, via shifts in sources of purchases and other inputs in the factors of production. An early study by Chism and Levins reports that smaller farms make nearly 95% of their expenditures locally, while larger operations spend less than 20% locally.²³ Gomez and Zhang study 1,106 rural communities and conclude that economic growth rates in communities with conventional farming are 55% higher than in those with AOs.²⁴ They document the negative impact of AOs on the economy of the surrounding community, as revealed by sales tax receipts and reduced local purchases. They note that conventional farmers buy most or all of their supplies locally, thus stimulating the local community and, by extension, stimulating the local real estate market. On the other hand, AOs bypass local retailers and import the factors of production. Gomez and Zhang state that AOs exacerbate the economic negative impact by “importing” large quantities of pollution and the attendant costs; they also find AOs cause “disruption of local social and economic systems, pollution problems resulting from intensive agriculture, and negative impacts on the quality of life in rural communities.” This finding replicates those of an earlier study by Abeles-Allison and Connor, which showed AOs have the effect of crowding out more traditional farmers and decreasing purchases in local stores.²⁵

Hence, local communities suffer the negative economic byproducts without the attendant economic benefits.

17. “Disease Listing, *Escherichia Coli* 0157:H7, Gen Info,” Centers for Disease Control and Prevention, <http://www.cdc.gov/ecoli/>.

18. Stuart A. Smith, “Concentrated Animal Feeding Operations—Resources for Environmental Responsibility” (working paper prepared by Smith-Comeskey Ground Water Sciences, April 1, 2000); for additional information see <http://www.groundwaterscience.com/resources/tech-article-library/100-concentrated-animal-feeding-facilities-resources-for-environmental-responsibility-.html>.

19. John A. Kilpatrick, “Concentrated Animal Feeding Operations and Proximate Property Values,” *The Appraisal Journal* (July 2001): 301–306.

20. Peggy Steward, “Cattlemen Find CAFO Rules Confusing,” *Capital Press Agricultural Weekly* (March 9, 2001): 9.

21. Claudia Copeland, “Animal Waste and Water Quality: EPA Regulation of Concentrated Animal Feeding Operations (CAFOs),” Congressional Research Service Report for Congress No 7-5700, February 16, 2010. The regulations were published in the *Federal Register* on February 12, 2003 and went into effect on April 14, 2003.

22. <http://water.epa.gov/polwaste/npdes/af/>. Permitting is under the EPA’s National Pollutant Discharge Elimination System (NPDES) program, which regulates the discharge of pollutants from point sources; CAFOs are defined as point sources by the Clean Water Act.

23. John W. Chism and Richard A. Levins, “Farm Spending and Local Selling: How Do They Match Up?” *Minnesota Agricultural Economist* 676 (1994): 1–4.

24. Miguel Gomez and Liying Zhang, “Impacts of Concentration in Hog Production on Economic Growth in Rural Illinois” (Illinois State U. working paper presented at annual meeting of American Agricultural Economics Association, July 30–August 2, 2000).

25. M. Abeles-Allison and L. Connor, *An Analysis of Local Benefits and Costs of Michigan Hog Operations Experiencing Environmental Conflicts* (Agricultural Economic Report 536, Department of Agricultural Economics, Michigan State University monograph, 1990).

Second, AOs impact values at the individual residential value level. Property values are impacted as market participants view the AO as a negative externality. As an externality, it is not typically considered economically curable under generally accepted appraisal theory and practice. Hence, the value diminution attributable to proximate location of an AO can be attributed to stigma. The next section discusses case studies regarding the effects of AOs.

Proximity Case Studies

Kilpatrick presented a series of case studies from the 1990s that document the impacts of AOs.²⁶ For example, a Minnesota homeowner lived near two swine AOs when her family reportedly became ill and testing found that the level of hydrogen sulfide was well above the danger levels.²⁷ An early study in North Carolina by Schiffman et al. reports emotional impacts (tension, depression, anger, reduced vigor, fatigue, and confusion) linked to airborne contamination emanating from an AO.²⁸ A later North Carolina study by Wing and Wolf reports increased incidences of headache, runny nose, sore throat, excessive coughing, diarrhea, burning eyes, and “reduced quality of life.”²⁹ An early study in Iowa by Thu et al. finds increases in eye and upper-respiratory problems among those living within 2 miles of an AO.³⁰ A later Iowa study³¹ finds extensive literature documenting acute and chronic respiratory disease and dysfunction among CAFO workers from exposures to complex mixtures of particulates, gases, and vapors; it concludes that CAFO air emissions may constitute a public health hazard.

Ables-Allison and Connor were among the first to examine property value impacts resulting from

airborne contamination and odors.³² Examining 288 sales between 1986 and 1989, they find that for every thousand animals added within a 5-mile area, there is an average sale price drop of \$450 per property, with the most significant losses within 1.6 miles. Notably, they find that during the first half of 1989 an AO with greater than 500 animals was 50 times more likely to have an odor complaint lodged with the state than one with fewer than 500 animals.³³

Taff, Tiffany, and Weisberg perform a hedonic price analysis on 292 rural residences in Minnesota and find a statistically significant pricing impact related both to the existence of an AO as well as the distance to the AO.³⁴ A 1996 study by Padgett and Johnson finds that homes within 0.5 mile of a CAFO decrease in value by 40%, and homes within 1.0 mile decrease in value by 30%, within 1.5 miles by 20%, and within 2.0 miles by 10%.³⁵ Palmquist, Roka, and Vukina quantitatively determine that AOs depress nearby home values. They develop a model to measure the spatial impacts of AOs and, like Padgett and Johnson, find differential value impacts at 0.5, 1.0, and 2.0 miles.³⁶

Hamed, Johnson, and Miller, quantify both the average value impact of an AO as well as the impact by distance with a study of 99 rural, non-family real estate transactions of more than one acre near an AO. Thirty-nine of the properties in the study included a residence. An average residential parcel within 3 miles of an AO experienced a loss of about 6.6%. However, if that parcel was located within 0.10 mile of the AO (the minimum unit of measure in the study), then the loss in value was estimated at about 88.3%.³⁷

26. Kilpatrick, “Concentrated Animal Feeding Operations.”

27. Presentation at ABA Special Committee on Agricultural Management Roundtable II.

28. Susan S. Schiffman, Elizabeth A. Miller, Mark S. Suggs, and Breck G. Graham, “The Effect of Environmental Odors Emanating from Commercial Swine Operations on the Mood of Nearby Residents,” *Brain Research Bulletin* 37, no. 4 (1995): 369–375.

29. S. Wing and S. Wolf, “Intensive Livestock Operations, Health, and Quality of Life Among North Carolina Residents,” *Environmental Health Perspectives* 108, no. 3 (March 2000): 233–238.

30. K. Thu, K. Donham, R. Ziegenhorn, S. Reynolds, P. Thorne, P. Subramanian, P. Whitten, and J. Stookesberry, “A Control Study of the Physical and Mental Health of Residents Living Near a Large-Scale Swine Operation,” *Journal of Agricultural Safety and Health* 3, no. 1 (1997): 13–26.

31. *Iowa Concentrated Animal Feeding Operations Air Quality Study—Final Report* [End Ital], Iowa State University and the University of Iowa Study Group (February 2002), http://www.public-health.uiowa.edu/ehsr/CAFOstudy/CAFO_final2-14.pdf.

32. Abeles-Allison and Connor, *Analysis of Local Benefits and Costs of Michigan Hog Operations*.

33. As previously discussed, this study also reports that AOs affect the economics of local communities.

34. Steven J. Taff, Douglas G. Tiffany, and Sanford Weisberg, “Measured Effects of Feedlots on Residential Property Values in Minnesota: A Report to the Legislature” (U. Minnesota Staff Paper Series, July 1996), <http://ageconsearch.umn.edu/bitstream/14121/1/p96-12.pdf>.

35. Reported in William J. Weida, “The CAFO: Implications for Rural Economies in the US” (Colorado College working paper, February 24, 2004), <http://www.columbus.in.gov/planning/staff-reports/gelfius-materials-part-1/>.

36. R. Palmquist, F. Roka, and T. Vukina, “Hog Operations, Environmental Impacts, and Residential Property Values,” *Land Economics* 73, no. 1 (1997): 114–124.

37. Mubarek Hamed, Thomas Johnson, and Kathleen Miller, “The Impacts of Animal Feeding Operations on Rural Land Values,” University of Missouri-Columbia, Community Policy Analysis Center Report R-99-02 (May 1999).

Additional empirical studies have supplemented these findings. Kim and Goldsmith analyze property values of 2,155 homes located within 3 miles of an AO in North Carolina. The principle focus of their study is spatial hedonics, and within a 3-mile area they find the average impact to be negative 18%. At 1 mile, they find the impact is negative 23.5%.³⁸

Weida studies the economic and financial impact of CAFOs. While this study principally focuses on the diminished economic growth rates in communities surrounding CAFOs, it also notes the substantial decreases in property values in those areas, as evidenced by property tax reductions.³⁹

Kueth and Keeney find that the negative impacts of AOs are comparable to those generated by industrial waste, solid waste, and septic waste facilities.⁴⁰ They focus on airborne-related problems and note that odor is a particular source of nuisance, and higher-valued residences are more severely impacted.

The odor and airborne particulate issues also have been explored in a more recent study by Isakson and Ecker. They examine the impact of swine CAFOs on sale prices of 5,822 houses in Iowa. The study shows large adverse impacts for houses located within 3 miles and directly downwind from a CAFO—a loss of value of as much as 44.1%. Value loss diminished to 16.6% for houses not directly downwind, and loss in value decreased to 9.9% for houses directly downwind but 3 miles away. Isakson and Ecker also find a correlation between CAFO size and value loss; a 10% increase in CAFO size resulted in a 0.67 % decrease in house price as far as 7 miles from the nearest CAFO.⁴¹

Studies Using GIS

Increasingly, AO studies have relied on geographic information systems (GIS) technology and other spatial methods to investigate property value impacts.

Worley Rupert, and Risse use GIS to examine the efficacy of buffers to mitigate AO impacts.⁴² They find that adding buffers to animal operations reduces the amount of land available within an area for such operations.

Cajka, Deerhake, and Yao present a study technique using GIS and modeling software to investigate the dispersion of air pollution emanating from CAFOs. The advantage of this approach is it looks at cumulative emissions from multiple sources.⁴³

Milla, Thomas, and Ansine, study homes in Craven County, North Carolina, use a GIS-based hedonic pricing model to evaluate the impacts of CAFOs, particularly hog operations, on residential property values. Their results indicate a negative and significant impact on property value from hog operations and a relationship between distance to hog farms and property sale prices. They determine that a farm with 5,000 animals has a statistically significant impact on values of homes 1 mile away, with an impact on the average home of 3.1%.⁴⁴

Based on the results of the case studies, it is quite apparent that significant externalities are associated with animal feeding operations, that the relationship between externalities, farm characteristics, and community attributes can be quite complex, and that negative impacts of animal facilities, as reflected in lowered property values, can extend beyond established setbacks. The GIS-based studies suggest the externalities associated with AOs are a function of distance and that the GIS-based hedonic price modeling is a promising method for assessing property value damages associated with animal operations, for evaluating potential impacts when siting new operations, and for developing setback guidelines.

38. Jungik Kim and Peter Goldsmith, "A Spatial Hedonic Approach to Assess the Impact of Swine Production on Residential Property Values," *Environmental and Resource Economics* 42, no. 4 (April 2009): 509–534.

39. William J. Weida, "Potential Regional Economic Effects of CAFOs" (Colorado College working paper, August 24, 2001), available at <http://sraproject.org/wp-content/uploads/2007/12/commentsonthepotentialregionaleconomiceffectsoffeedlots.pdf>.

40. Todd H. Kueth and Roman Keeney, "Environmental Externalities and Residential Property Values: Externalized Costs Along the House Price Distribution," *Land Economics* 88, no. 2 (2002): 241–250, available at <http://naldc.nal.usda.gov/naldc/download.xhtml?id=54130&content=PDF>.

41. Hans R. Isakson and Mark D. Ecker, "An Analysis of the Impact of Swine CAFOs on the Value of Nearby Houses," *Agricultural Economics* 39, no. 3 (November 2008): 365–372.

42. J. W. Worley, C. Rupert, and L. M. Risse, "Use of GIS to Determine the Effect of Property Line and Water Buffers on Land Availability," *Applied Engineering in Agriculture* 17, no. 1 (September 2000): 49–54; available at <https://www.itos.uga.edu/library/buffers.pdf>.

43. Jamie Cajka, Marion Deerhake, and Chengwei Yao, "Modeling Ammonia Dispersion from Multiple CAFOs Using GIS," *Proceedings of the 24th ESRI Users Conference*, August 9–13, 2004, available at <http://proceedings.esri.com/library/userconf/proc04/docs/pap1381.pdf>.

44. Katherine Milla, Michael H. Thomas, and Winsbert Ansine, "Evaluating the Effect of Proximity to Hog Farms on Residential Property Values: A GIS-Based Hedonic Price Model Approach," *URISA Journal* 17, no. 1 (2005): 27–32.

Legal and Regulatory Actions

Legal and regulatory actions also can reveal the impacts of AOs on nearby properties. For example, in 2000, Central Industries operated a large-scale poultry rendering plant near Central, Mississippi. As part of the process, large quantities of poultry processing byproducts were brought to this facility for further processing. The plant had been subject to a number of flooding events, spreading bacteria-laced poultry byproducts into nearby creeks and downstream rivers. Poultry byproducts were discovered up to 50 miles away from the rendering plant. For violations of the Clean Water Act, company officers were fined varying amounts up to \$300,000 each, and the company was fined \$14 million.⁴⁵ Researchers found property value diminution of up to 60% for farms closest to the plant, and transaction prices impacted as far as 11 miles away.

In numerous counties across the country tax assessors have granted property value reductions as a result of proximity to AOs. For example, Beasley reports that Clark County, Illinois, established a property tax abatement for fifty homes around a swine AO. Homes within 0.5 mile were determined to have values diminished by 30%, ranging down to a 10% reduction in value for homes at 1.5 miles.⁴⁶

Aiken reports that the Nebraska Court of Appeals ruled that county board of equalization erred in not considering a rural residence's proximity to a swine facility in determining the residence's valuation. The owner of the facility also built a house 0.75 mile away and obtained an easement to spray the hog manure on the cropland across the road from the house. The court ordered the county to ignore the fact that the swine were also the property of the owner. The court cited Nebraska livestock nuisance decisions that show that hog odors would influence the home's value. Upon the ruling, the county accepted a determination by a local, independent appraiser that the value was diminished 30%.⁴⁷

Spears reports that in the summer of 2005, health officials declared about 40 kilometers of beaches on

Table 1 Property Tax Reductions in Areas Around AOs

Area	Amount of Reduction	Property Type
Grundy Co, MO	30%	
Mecosta Co, MI initially:	35%	Dwellings only
later changed to:	20%	Land and structures
Midland Co, MI	20%	
DeWitt Co, IL	30%	
McLean Co, IL	35%	
DeKalb Co, AL	Base reassessment, variable rates	
Renville Co, MN	Base reassessment, variable rates	Dwellings only
Humbolt Co, IA	20%-40%	Dwellings only
Frederick Co, MD	10%	
Muhlenberg Co, KY	18%	Dwellings only

Lake Huron permanently unsafe because of *E. coli* bacteria emanating from nearby AOs. This became the first new pollution hot spot on Canada's side of the Great Lakes in almost twenty years. Lab tests demonstrated that the *E. coli* levels in the streams feeding Lake Huron, and draining off nearby AOs, exceeded water quality standards by as much as 41,000 percent.⁴⁸

Ready and Abdalla expand upon the hedonic analyses of others and reviewed the amenity and disamenity impacts of agriculture in Berks County, Pennsylvania, including different types of open space (publicly owned, eased, vacant, pasture/crops), landfills, airports, mushroom production, and AOs. The study determines that "only landfills have a worse effect on adjacent property values,"⁴⁹ and further states, "a sewage treatment plant has less depressing effects on nearby housing prices

45. US Department of Justice Press Release, November 2, 2000.

46. Lee Beasley, "Cumberland Hog Facility May Affect Clark County Homeowners Property Values," *Guardian Publishing* (2001).

47. J. David Aiken, "Property Valuation May Be Reduced by Proximity of Livestock Operation" *Cornhusker Economics*, Department of Agricultural Economics, University of Nebraska-Lincoln (May 2002).

48. Tom Spears, "Ontario's West Coast Permanently Polluted," *The Ottawa Citizen* (November 15, 2003); also R. E. Dines, Deborah Henderson, and Louise Rock, "The Case Against Intensive Hog Operations" (working paper, February 2004).

49. Richard C. Ready and Charles W. Abdalla, "The Amenity and Disamenity Impacts of Agriculture: Estimates from a Hedonic Pricing Model," *American Journal of Agricultural Economics* 87, no. 2 (May 2005): 314-326.

than a factory farm operation.” The study also finds that the clustering of AOs within a certain area is the controlling factor, not the location of the nearest operation when considering proximity. The study reports a value impact of -4.1% from AOs within 800 meters, and at least -6.4% from within 500 meters, both of which were half the impact of a landfill at comparable distances. The study did not find any statistically significant difference in the effects based on AO size or species.

Herriges, Secchi, and Babcock expand upon previous work on AO price effects by using variables to quantify the effects in a hedonic analysis of proximity, size, and direction of nearest facility. Direction from site was included to determine the effect of being downwind, and the odor and pest issues associated with AOs. Results from this study indicate that a moderate-size facility has a value impact up to -6% within 1.5 miles and -26% within a 0.25 mile.⁵⁰

Finally, Keske documents ten lawsuits over AO nuisance in which the plaintiff prevailed, with jury awards ranging up to \$50 million (Table 2). The size of these awards suggests that preventive measures, even if expensive, might be cost effective.⁵¹

Summary of AO Empirical Findings

The establishment of an AO results in value diminution to nearby properties, both through a negative

externality as well as through indirect economic impacts. The amount of the value loss is an inverse function of distance (closer properties diminish more), a function of property type (newer, nicer residences lose more), and a function of property use (farms will lose value due to diminished productivity and comparative marketability to farm lands further away; residential use will no longer be a highest-and-best use). The empirical studies and case studies results indicate diminished marketability, loss of use and enjoyment, and loss of exclusivity that can range up to nearly 90% of otherwise unimpaired value for homes that are adjacent to the facility. Negative impacts are noted at distances exceeding 3 miles, and in the case of a flood or other weather event, waste from the facility can be spread over far greater areas, extending the area of negative impact (Table 3).

Mitigation of Impacts

There is surprisingly little empirical evidence of attempts to mitigate either the physical impacts or the perception of negative externality of AOs given the fairly consistent evidence of negative impacts on surrounding property values. The most significant and transcendent impacts are to surrounding community values and economics and to air quality. However, neither of these is well suited to mitigation efforts. Generally, mitigation fall into three categories: waste management plans, tree windbreaks, and anaerobic

Table 2 Damage Awards Related to AOs

Year/State	Jury Award	Case/Remarks
1991/NE	\$375,600	<i>Kopecky v. National Farms</i> , swine operation
1996/KS	\$12,100	Swine settlement – parties undisclosed in news article
1998/KS	> \$15,000	<i>Twietmeyer v. Blocker</i> , beef operations
1999/MO	\$5,200,000	<i>Hanes v. Continental Grain</i> , swine operation
2001/OH	\$19,182,483	<i>Seelke v. Buckey Egg Farm</i> , poultry
2002/IA	\$33,065,000	<i>Blass v. Iowa Select Farms</i> , swine operation
2004/OH	\$50,000,000	<i>Bear v. Buckey Egg Farm</i> , poultry
2006/AL	\$100,000	<i>Sierra Club v. Whitaker</i> , swine
2006/MO	\$4,500,000	<i>Turner v. Premium Standard Farms</i> , swine
2007/IL	\$27,000	State of Illinois (respondent unreported), swine

Source: Catherine M. H. Keske, “Determining the Economic Feasibility of Anaerobic Digestion in Colorado: Guidelines for Animal Farm Producers,” CSU Extension Fact Sheet 1.229 (2012).

50. Herriges, Secchi, and Babcock, “Living with Hogs in Iowa.”

51. Catherine M. H. Keske, “Determining the Economic Feasibility of Anaerobic Digestion in Colorado: Guidelines for Animal Farm Producers,” CSU Extension Fact Sheet 1.229 (2012), <http://www.ext.colostate.edu/pubs/livestk/01229.pdf>.

Table 3 Summary of Studies of AO Value Impacts

Case Study	Value Loss	Remarks
Ables-Allison and Connor (1990)	\$430 within 5 miles	Greatest impact within 1.6 miles
Taff, Tiffany, and Weisberg (1996)	N/A	AO sited near older, less-expensive homes
Palmquist, Roka, and Vukina (1997)	9%	Average up to 2 miles
Hamed Johnson, and Miller (1999)	6.6%–88%	Largest loss if within 0.10 mile
ABA Presentation (1999)	N/A	Confirmed respiratory problems
Central Industries (2000)	60% for farms closest to plant	USDOJ cases, values by appraisal
Beasley (2001)	Up to 30%	Impacts 10% at 1.5 miles
Aiken (2002)	30% @ 0.75 mile	Confirmed by court and local appraiser
Spears (2003)	N/A	40 km of beaches closed due to AO emissions
Herriges, Secchi, and Babcock (2003)	26% at 0.25 mile	Moderate-size AO, 6% at 1.5 miles
Weida (2004)	40% at 0.50 mile	10% at 2 miles
Ready and Abdalla (2005)	Residence at 0.25 mile > 6.4% Residence at 0.50 mile 4.1%	Roughly half the impact of a landfill
Kim and Goldsmith (2008)	23.5% at 1 mile	18% average within 3-mile radius
Isakson and Ecker (2008)	44%	Directly downwind and within 2 miles

Source: Catherine M. H. Keske, "Determining the Economic Feasibility of Anaerobic Digestion in Colorado: Guidelines for Animal Farm Producers," CSU Extension Fact Sheet 1.229 (2012).

digestion. Nonetheless, such mitigation does not appear to have an economically material impact on nearby property values.

Waste Management Plan

Laws or regulations typically require wastewater runoff treatment. However, some facilities go beyond that with actual waste management plans. There is some evidence that such plans will have marginal impact, as noted in the Ready and Abdalla study, which found a residential value differential of 4.2% versus 1.1%. Notably though, some of the most severe impacts have occurred near facilities with mandated waste management plans, particularly when and after those plans failed. For example, in one four-month period, the Central Industries facility studied by Ready and Abdalla committed approximately 1,114 permit violations, exceeding the pollutant limitations set forth in the company's permit by hundreds of percentage points and exceeding its permitted flow rate by millions of gallons. Hence, the efficacy of a waste management plan must be taken in the light of potential impacts of violations.⁵²

Planting Trees

The University of Delaware, College of Agriculture and Natural Resources, studied the planting of windbreaks around poultry houses to reduce odor, dust, feathers, and noises, and suggests that this approach can also ameliorate nitrogen in the groundwater.⁵³ However, several aspects regarding this mitigation study should be noted:

1. The study focus is on protecting the poultry houses themselves, not adjacent or nearby neighbors.
2. Establishment of an effective windbreak takes quite a few years and quite a few trees.
3. A windbreak may partially ameliorate view problems but does not seem to address the major issues of odor and other airborne contaminations (particles, insects, etc.).

Anaerobic Digestion Facility

The purpose of Keske's study was to provide guidance on the financial feasibility of a biogas-fueled cogeneration facility.⁵⁴ The study recognizes the significant production of flammable biogas by AOs and notes the feasibility of biogas-fueled cogeneration

52. Ready and Abdalla, "The Amenity and Disamenity Impacts of Agriculture."

53. George W. Malone, "Environmental and Production Benefits of Trees for Poultry Farms," U. Delaware Cooperative Extension Service (2001).

54. Keske, "Determining the Economic Feasibility of Anaerobic Digestion."

is limited by a number of factors. First, the up-front costs can be prohibitive—typically \$1.2 million, and up to \$5 million depending on the technology used. Also, annual operating costs are significant, and while these technologies are sold with the promise of offsetting electric bills, Keske notes that in the study area (Colorado) electricity rates are already lower than other parts of the United States. Hence, AO operators should be “particularly wary of relying on anaerobic digestion to generate revenues by selling electricity to the utility.” Finally, Keske notes that for a biogeneration facility to be feasible, at least two of the following criteria must be met:

1. The AO meets the definition of a confined AFO.
2. The waste stream can be combined with the waste stream of another operation or business (e.g., food manufacturing, municipal waste).
3. The AFO already receives frequent odor complaints.
4. The AFO produces swine or chickens (the two most egregious sources of biogas).
5. The AFO incurs more than \$5,000/month in average electricity or heating charges.

Keske notes that given the high threshold of cost of this mitigation approach, the approach is feasible only if it outweighs costs associated with not implementing a mitigation plan. As previously mentioned, to support this Keske documents ten lawsuits in which claimants were awarded as much as \$50 million for agricultural nuisance (Table 2). Notably, the two largest awards cited (\$50 million and \$19 million) were for poultry operations.⁵⁵

Summary and Conclusions

Since *The Appraisal Journal's* previous review of AO effects on proximate property values,⁵⁶ new study approaches have been identified. First, there has been an increased use of GIS by local governments, which has given researchers the ability to

conduct more thorough investigations. GIS provides researchers with more data—in abundance and in detail—and allows researchers to better locate which factors, and to what degree, have an effect on value.

Second, in conjunction with more data and use of GIS, there are substantial improvements in the hedonic analyses performed. Keske noted that early studies (such as the Taff, Tiffany and Weisberg study and the Palmquist, Roka, and Vukina study) were conducted on fewer than 300 sales transactions each, while the later study by Ready and Abdalla reviewed 8,090 sales, and the Herriges, Secchi, and Babcock study examined 1,145 sales transactions.

Third, because of the increased use of GIS and the results from the hedonic analysis in newer case studies, it has been shown that an AO's basic impact is related to proximity and size, but there are also other factors, such as the operations' waste management practices, that can reduce or exacerbate that impact. Overall, the new studies confirm the valuation impacts reported in earlier studies, as they range from 3.1% to 26% loss depending on multiple factors, and that properties immediately abutting an AO can be diminished as much as 88%. More importantly, however, is the discussion of the impact of other site-specific factors that were considered as part the hedonic analyses.

With respect to mitigation efforts, the Ready and Abdalla study of Berks County (Pennsylvania) shows that at 800 meters an operation with a waste management plan diminishes a house's value 1.1%, while an operation without such a plan would diminish the value 4.2%. Also related to this is the effect of operation size on property values. Both the Ready and Abdalla study and the Herriges, Secchi, and Babcock study show that a larger facility in close proximity would not necessarily decrease the value of a nearby property more than a smaller facility. Both of the studies concluded that this effect could be attributed to unmodeled characteristics such as waste management practices and other site-specific attributes.

55. Ibid.

56. Kilpatrick, “Concentrated Animal Feeding Operations.”

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Web Connections

Internet resources suggested by the Y. T. and Louise Lee Lum Library

eXtension Land-Grant University Cooperative Research Information

—Geospatial Technology

http://www.extension.org/geospatial_technology

—Animal Manure Management

http://www.extension.org/animal_manure_management

Food & Water Watch—Factory Farms

<http://www.foodandwaterwatch.org/food/factoryfarms/>

Texas A&M University, Texas Animal Management Issues Clearinghouse

<http://tammi.tamu.edu/index.html>

US Department of Agriculture, National Agricultural Library

<http://www.nal.usda.gov/topics>

US Environmental Protection Agency

—Agriculture Center

<http://www.epa.gov/agriculture>

—Drinking Water Regulations

<http://water.epa.gov/lawsregs/rulesregs/sdwa/currentregulations.cfm>

—Animal Feeding Operations Overview

<http://water.epa.gov/polwaste/npdes/afo/index.cfm>