



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search  
<http://ageconsearch.umn.edu>  
[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

# Perceptions of Rural Air Quality: What Will the Neighbors Think?

Luanne Lohr

---

***Abstract:** Individuals exposed to odors from livestock facilities do not report annoyance uniformly. The reaction to a detectable odor depends on perceptions of the odor and its source which are mediated by odor attributes and personal factors. Correlations among these factors were tested in a rural context using data from a pilot study of seventeen households neighboring two swine operations in Michigan. Annoyance was measured as the impact of the neighboring facility on enjoyment of property. Characterization of odor as a problem was positively correlated with offensiveness, frequency and duration of exposure. Annoyance was negatively correlated with term of residence, current employment on a farm, and acquaintance with the facility owner. Annoyance was positively correlated with suburban characterization of the residence, unacceptability of the facility's appearance and perception of odor as a problem. Strategies to minimize exposure augmented by increasing familiarity with the operation and owner can reduce annoyance.*

***Key Words and Phrases:** Correlation analysis, Environmental annoyance, Manure management, Odor nuisance.*

---

Rural environments have characteristic odors that many perceive as pleasant and beneficial to air quality, such as mown hayfields, freshly turned soil and blossoming wildflowers, or unpleasant and detrimental to air quality, such as animal wastes, sprayed chemicals and diesel tractor exhaust. Relationships between perceptions of odors and experience with, or knowledge about, odor sources have not been tested in a rural context. A pilot study was initiated to determine if such relationships found in the urban context warrant further study in the rural setting.

The primary object of complaints about rural odors is livestock waste. Livestock operators increasing facility size or adding animal enterprises are increasingly in conflict with neighbors over odors. These conflicts may result in regulatory responses or litigation against farm operators. The conventional wisdom is that suburbanites unfamiliar with farming practices

are making the complaints (Graham; Thelen). This would be consistent with research on correlations between familiarity or economic dependence and odor perceptions in urban settings (De Boer et al.; Winneke and Kastka). If this relationship holds, conflicts between livestock farmers and neighbors may be averted by education or negotiation. Thus, escalation to regulatory or legal resolution may be avoided for this subset of potential conflicts. This research explores these relationships for households located near livestock operations.

In this paper, the effect on enjoyment of property measures the degree of annoyance expressed by a sample of households neighboring two swine operations in southern Michigan. Correlation analysis is used to identify factors in neighbors' experience and knowledge sets that are related to the perceptions of the animal enterprises. Perceived visual and odor nuisances are also compared to each other and to factors that describe odor characteristics. Several hypotheses presented in research on odor annoyance in urban settings are explained and tested. Recommendations are made for modifying neighbors' negative perceptions of animal agriculture under conditions in which it is possible to forestall confrontation.

### *Responses to Odors in a Rural Context*

Two main categories of odor responses are defensive avoidance and confrontive coping (De Boer et al.). Defensive avoidance includes ignoring odors, continuing activities interrupted by odors, and trying to find ways to minimize annoyance. Confrontive coping includes identifying the source of the odor, discussing the problem with others, and demanding immediate action. The means of coping with odors depends on available options and respondents' knowledge, skill and monetary resources.

Concentrated animal feeding operations (CAFOs) place high densities of animals in feedlots. When these animals generate waste, the associated odors may be detectable at neighboring residences. The odors often are perceived as unpleasant and may cause annoyance. Reported responses to perceived odor nuisances from CAFOs have included complaining informally, filing formal complaints or lawsuits against operators, curbing outdoor activities during periods when odors are worst, and even changing residences. These responses are analogous to reactions to industrial odors by urban residents (De Boer et al.).

Evidence of neighbors' reactions to livestock odor exposure is mostly anecdotal, but data are available for Michigan, where the state Department of Agriculture processes formal complaints. In the first six months of

1989, thirty-nine odor complaints were filed in Michigan (Abeles-Allison and Connor). Slightly more than 50 percent of the complaints were filed against hog operations ranging in size from one to more than 10,000 head. In 1990, 133 complaints of all types were received, compared with 120 complaints received in 1991 when government response procedures were modified (Thelen). Of these, 42 percent were about air quality and 30 percent were for swine operations. In most cases, these were not multiple complaints against individual operations.

Poor relations with neighbors about odors take their toll politically. In Michigan, zoning variances for residential construction in agricultural areas were instrumental in bringing urban and suburban residents into contact with farms (Lohr and Harvey). Residents trying to limit their exposure to nuisances have attempted to create zoning ordinances restricting animal agriculture. As a voting minority in many places, farmers cannot generate sufficient influence to stem these actions. By supporting these restrictions, neighbors are expressing annoyance. Observed responses to odor exposures are not uniformly confrontive. In the rural environment, defensive avoidance strategies may be used for several reasons. Agriculture's protected status under right-to-farm laws constrains nuisance torts, limiting an option used by urban residents. Benefits derived from farms, such as open space preservation, educational value, and multiplier effects in the local economy contribute to a desirable rural lifestyle and may weigh against taking confrontive actions.

Predicting responses to odor in the rural context is complicated by institutional, social and personal factors and expectations. Exposure alone is not an accurate predictor of annoyance (Winneke and Kastka; Cavalini et al.). Different degrees of annoyance are expressed despite comparable patterns of exposure to odor from the same source. In some cases, any level of odor from livestock operations has generated complaints, while in others only extreme intensity, sometimes enough to violate air quality standards, has stimulated formal action (Graham). Whether an odor stimulates a confrontive or a defensive response, annoyance damages the relationship between the farmer and neighbors.

### *Odor Perceptions*

Characterization of an odor as pleasant or unpleasant is a fundamental factor in whether exposed individuals are bothered by the odor. Exposure factors affect this characterization, but do not completely explain it. Emotional reactions also play a role. In a study of odors from industrial

sources, Winneke and Kastka found that even though odor concentrations were highest near a chocolate plant, reported annoyance levels nearby were much lower than for an insulation plant, a tar-oil refinery or a brewery.

Almagor (1990a, 1990b) recognized that odor is context dependent and that perceptions of the quality of a particular odor vary across individuals and groups. Odors may not be universally classified because perception is directly connected with emotions and memory. Almagor's theory of context dependence implies there is a relative appropriateness of the odor for the time and location in which it is experienced. This concept is consistent with the disagreement over whether animal waste smells are pleasant or unpleasant. If they are consistent with the individual's perception of the rural landscape, animal waste odors may be tolerable or even pleasant. If the odors are at odds with expectations about rural air quality, the reaction may be one of annoyance.

Odor perceptions also may be influenced by visual perceptions and visual-aesthetic context variables (Koelega). CAFOs may appear unsanitary because animal manures accumulate in the facility between cleanings. Detectable odor is more likely to be evaluated negatively if there is disapproval of the visual attributes of the CAFO, even if the odor itself is not objectionable. For example, 44 percent of investigations in Michigan in 1991 resulted in findings that the complaints were not verifiable, attributed in part to the lack of knowledge of farm practices among rural nonfarm residents (Thelen). Badly managed farms often generate both odor and visual impacts and typically elicit a negative response even among farm neighbors.

The interaction of cognitive and emotional factors in qualifying odors as pleasant or unpleasant makes comparison of perceptions across individuals difficult. Annoyance is not necessarily correlated with the characterization of an odor. Individuals who classify an odor as unpleasant may not express high levels of annoyance. Campbell suggested there are factors that mediate the impact of nuisances on annoyance ratings. Socioeconomic characteristics, attitudes, knowledge and temporal attributes influence whether an unpleasant odor is perceived as annoying. Both the concept of annoyance and the effects of mediating factors are basic to understanding neighbors' perceptions.

### *Relationships Between Odor and Annoyance*

Annoyance is a general feeling of displeasure or aversion toward a source, perhaps involving mild anger or fear, which results from interfer-

ence with reaching a goal or with an important ongoing activity (De Boer *et al.*, Evans and Tafalla). Annoyance may be considered a welfare loss to the individual who experiences it. An odor externality imposes a cost to the affected (annoyed) individual in the form of interference with activities which is not accounted for in the cost of livestock production. The welfare loss may not be equal across individuals, and some may take action that compensates for the loss. Those who object to odors but choose to live in an exposed location anyway make a conscious decision to trade off suboptimal environmental conditions for other amenities that compensate for the loss. Individuals who are constrained to living in an exposed area have a smaller response choice set in compensating for welfare losses. Often, these residents develop a passive resignation to the externality and adapt their expectation set to a lower welfare level. Newer residents, who thought that moving to the site would improve their welfare, may find instead they experience a net loss even if they choose a confrontive coping strategy. In either case, the cost is borne by individuals who did not generate the externality. From a social standpoint, this loss should be accounted for, if not compensated.

Greater annoyance is correlated with more confrontive reactions. In a study of more than 500 users and nonusers of an environmental telephone complaint service in three industrial districts in the Netherlands, De Boer *et al.* found users of the complaint service significantly more likely to report greater frequency of exposure and greater annoyance with odors, even though physical exposure to the odor was the same for both groups. This study also showed that anxiety and anger were higher among the complaint service users. The reaction to a detectable odor depends on perceptions of the odor and its source, which are mediated by odor attributes and personal factors. This suggests that altering the exposure-perception response could reduce complaints, even though odor characteristics remain constant.

Temporal attributes of an odor include frequency, duration, intensity and abruptness of change in conditions. These determine not only the nature of exposure episodes, but also adaptation to ambient odor levels (Evans and Tafalla). In general, annoyance increases with odor concentration (Cavalini *et al.*). Cavalini *et al.* showed that annoyance must be treated as an intertemporal experiential factor, based on previous experience at the site and elsewhere. Among long-time residents, greater intensity and continuity of ambient odors are associated with lower levels of reported annoyance, possibly due to a continuous adjustment to background odor (De Boer *et al.*; Cavalini *et al.*). Evans and Tafalla reported that long-term residents in an affected area may become passively resigned to ambient odors, while

newer residents are more likely to take direct action to alter an environment not matching their expectations.

Cavalini et al. surveyed residents in the Netherlands about annoyance with odors from sugarbeet refineries and a tobacco factory. They found that age and length of residence were significantly negatively correlated with annoyance. Time spent at home, where exposure occurred, was a positive predictor of annoyance. Evans and Tafalla reported annoyance was negatively correlated with economic dependence on the source of the pollutant and length of residence, and was positively correlated with belief that generators could control odor but chose not to. Perrin found that economic dependence reduced reported annoyance in the vicinity of a paper mill and an organic waste processing plant in France, even though 88 percent of respondents noticed the existence of odors. Perrin's results indicated rural residents were less likely to be annoyed than urban residents, and those who spent more time at home were more likely to be annoyed due to higher rates of exposure.

A factor that has not been tested is experience or familiarity with the activities that generate the odor. Expectations of rural lifestyle are formed by prior residence, visits to the countryside, and media images. Dissonance between positive expectations and negative aspects of rural life, such as the potential for odor exposures, may generate greater annoyance. Previous experience with livestock farming, familiarity with farming practices, and knowledge of existing operations in the vicinity of the residence should produce more realistic perceptions that could result in acceptance or adaptation to odors, and lower reported annoyance. This relationship was tested in this study.

### *Method of Analysis*

In this pilot study, a small sample of livestock operations was selected to test for relationships found for urban odor annoyance. For the results to be meaningful for assessing the value of expanded research on this topic, the trial sample had to be representative of situations for which nonconfrontive solutions are possible. This is most likely in situations in which neighbors are close enough to be affected by visual or odor impacts, but where the farm is not operated in such a manner as to elicit strong, uniformly negative reactions that result in confrontive responses. In addition, to represent the land use situation in Michigan, the farms selected had to have suburban and rural nonfarm neighbors, not be in violation of existing environmental regulations relating to odor or water quality, nor be

the object of multiple complaints to regulatory agencies. For the typical CAFO in Michigan, the operator uses some, but not all, of the Michigan Agriculture Commission's recommended manure management practices and attempts to limit problem situations. However, the operator may be unaware of neighbors' concerns or disagree with the assessment of the condition as a problem.

This study focused on two swine operations in southern Michigan that typify the conditions described. For the CAFOs in this study, there was no consensus in characterizing the odors as pleasant or offensive, nor in describing the degree of annoyance felt. The selected farms were both surrounded by suburban and rural residential development, mixed with farm neighbors. The farms had fewer than 300 sows, and had never had a complaint filed against them. Abeles-Allison and Connor reported that 0.03 percent of hog operations smaller than 500 head in Michigan elicited complaints in the first six months of 1989. In the same time period, hog operations accounted for 46 percent of the total number of odor complaints in the state. Thus, for the farms in the pilot study, there was the potential for neighbors to file complaints, but the likelihood they would not. This seems to be another favorable condition for negotiated solutions to odor conflicts.

Lenawee County, where the pilot study was conducted, borders the Ann Arbor-Detroit metro area, and is experiencing the mixed residential, service and retail growth typical of the region, with an 8 percent decline in farmland between 1982 and 1987. In 1987, there were 1,387 farms in the county, and farmland accounted for 72 percent of the county's total acreage (Michigan Department of Agriculture). Most of the 91,000 residents in 1988 did not work on farms, but were likely to be living near farmland. Seventeen households, each within one mile of one of the operations, were interviewed in summer 1989. An attempt was made to interview all neighbors, but a few chose not to participate or could not be reached. The sample was distributed around each farm to capture directional differences, such as wind or visual screens. The distance reflected the farm sizes and the distance at which neighbors might be expected to experience visual and odor impacts. Respondents answered questions about household characteristics and general familiarity with livestock farming. Multiple choice and rank response questions were used to elicit respondents' knowledge of and perceptions about the nearby farms, the neighboring swine operation and its owner. Respondents who indicated odors were a problem were asked to characterize the offensiveness, frequency and duration of the odor and to identify actions they had taken or would be willing to take to resolve the situation.



Table 1.

*Explanation of Variables Measured*

Variable	Description	Values Assigned
ENJOY	Effect of neighboring swine operation on enjoyment of residence	1 if enhances, 2 if compatible with, 3 if occasionally hinders, 4 if often hinders, 5 if usually hinders
FARM	Works full- or part-time on farm or lives on a farm currently	1 if yes, 0 if no
RURAL	Residence is in rural subdivision or town	1 if yes, 0 if no
FAMILIAR	Has lived on or worked with a livestock operation previously	1 if yes, 0 if no
METOWNER	Has met owner of neighboring operation	1 if yes, 0 if no
INVOLVE	Neighboring farmer is involved with community in a positive way	1 if yes, 0 if no
SWINE	Primary activity on neighboring farm is swine production	1 if yes, 0 if no
BEEF	Beef operation within mile of residence	1 if yes, 0 if no
DAIRY	Dairy operation within mile of residence	1 if yes, 0 if no
NUMOPS	Number of agricultural operations within one-mile of residence	Open-ended
LIVEAT	Number of years at current residence	2.5 if at least five; 8 if six to ten; 13 if 11 to 15; 18 if 16 to 20; 23 if 21 to 25; 28.5 if more than 25
KIDS	Number of children no older than 18 living in residence	Open-ended
ATHOME	Homemaker, retired or unemployed	1 if yes, 0 if no
VISUAL	Visual appearance of neighboring livestock operation	1 if very attractive, 2 if attractive, 3 if acceptable, 4 if undesirable, 5 if very undesirable

ODOR	Odor from neighboring livestock operation is a problem	1 if yes, 0 if no
OFFSPRG	Offensiveness of odor in Spring (May 1 - May 31)	1 if pleasing, 2 if neutral, 3 if slightly offensive, 4 if offensive, 5 if very offensive
OFFSUMM	Offensiveness of odor in summer (June 1 - August 31)	same as for OFFSPRG
OFFFALL	Offensiveness of odor in fall (September 1 - November 30)	same as for OFFSPRG
OFFWINT	Offensiveness of odor in winter (December 1 - February 28)	same as for OFFSPRG
FREQSPRG	Frequency of odors noticed in spring	1 if monthly, 2 if semimonthly, 4 if weekly, 30 if daily
FREQSUMM	Frequency of odors noticed in summer	same as for FREQSPRG
FREQFALL	Frequency of odors noticed in fall	same as for FREQSPRG
FREQWINT	Frequency of odors noticed in winter	same as for FREQSPRG
DURSPRG	Duration of odors noticed in spring	6 if less than 12 hours; 18 if 12 to 24 hours, 36 if one to two days; 120 if three to seven days; 336 if weeks
DURSUMM	Duration of odors noticed in summer	same as for DURSPRG
DURFALL	Duration of odors noticed in fall	same as for DURSPRG
DURWINT	Duration of odors noticed in winter	same as for DURSPRG
NOREAST	Residence is located North to East of farm	1 if yes, 0 if no
SOUEAST	Residence is located East to South of farm	1 if yes, 0 if no
SOUWEST	Residence is located South to West of farm	1 if yes, 0 if no
NORWEST	Residence is located West to North of farm	1 if yes, 0 if no

The linear relationships between paired variables of interest were analyzed using correlation coefficients, as has been done in urban odor studies (Cavalini et al.; Evans and Tafalla; Winneke and Kastka). Correlation analysis permits comparison of multiple sets of two variables even when sample sizes are relatively small. Thus, the number of comparisons is not bound by the number of observations as it is in regression analysis, and all possible pairwise comparisons may be made. Significance tests were performed using standardized z-scores, rather than t-statistics, since several of the variables were binary and therefore not normally distributed. The z-score was calculated for each pair of variables of interest and compared with critical values for one-tailed tests of significance.

Two key perceptions were explored. Odor perception was the individual's characterization of odors from the neighboring swine operation. Annoyance perception was the subjective evaluation of the degree to which odors hindered enjoyment of property. Table 1 lists the variables used in the correlation analyses, describes the variables and enumerates the values assigned in their measurement.

Finding a way to describe annoyance to survey respondents was difficult, since the stronger the term used to describe annoyance, the fewer people express this feeling (Koelega). A metric of odor quality was needed to elicit similar interpretations of annoyance by all individuals. A suggestion was provided by Evans and Tafalla, who reported moderately high correlations between activity disturbance and annoyance rating scales. Since odors from CAFOs may interfere with the enjoyment of household activities during exposure, a rating of this impairment represents a measure of annoyance that directly reflects the welfare loss to the exposed individual. The variable ENJOY describes respondent annoyance with the neighboring swine operation. Assigned values are 1 if the facility enhances enjoyment of the residence, 2 if the facility is compatible with enjoyment, 3 if it occasionally hinders enjoyment, 4 if it often hinders enjoyment and 5 if the operation usually hinders enjoyment.

Annoyance perception correlations were tested for fourteen variables. Positive values for FARM and FAMILIAR suggest economic dependence on and experience with farming. The factor RURAL implies expectations about the nature of the environment, with a positive value indicating expectations consistent with a suburb or small town rather than with farm life. Positive responses for METOWNER and INVOLVE reflect information about and favorable perceptions of the farm operator. Respondent perceptions of agricultural activities in the surrounding area are given by SWINE, BEEF, DAIRY and NUMOPS. Perceptions of contextual

appropriateness of odors should be related to beliefs about agricultural intensity.

The variable LIVEAT corresponds to term of residence, for which longer tenure may reflect more realistic expectations or greater acceptance of the local rural environment. Positive values for KIDS and ATHOME indicate the potential for greater exposure to odors, since most manure management activities, such as land application, take place during the day and often during the summer months.

Two variables, VISUAL and ODOR, were used to indicate the acceptability of the livestock operation. Negative visual and olfactory impressions should be correlated with reported annoyance. Also, there could be interaction between sensory impressions, so that visual undesirability is correlated with reported odor problems. VISUAL is an integer variable, ranging from 1 if very attractive to 5 if very undesirable. ODOR is a binary variable, taking the value 1 if odor from the neighboring operation is a problem and 0 if it is not.

Odor perception, represented by ODOR, is tested with respondents' assessments of odor offensiveness, frequency and duration. These three factors were evaluated for each of four seasons—spring (May 1 through May 31), summer (June 1 through August 31), fall (September 1 through November 30) and winter (December 1 through February 28). Offensiveness is rated 1 if the odor is pleasing, 2 if neutral, 3 if slightly offensive, 4 if offensive and 5 if very offensive. Frequency is measured as number of times the odor is noticed per month, with 1 if monthly, 2 if semimonthly, 4 if weekly and 30 if daily. Duration is enumerated as the length of time the odor is noticed, with 6 if less than 12 hours, 18 if 12 to 24 hours, 36 if one to two days, 120 if three to seven days and 336 if for weeks. Respondents reported their perceptions of average exposures. The variables OFFSPRG, OFFSUMM, OFFFALL, OFFWINT, FREQSPRG, FREQSUMM, FREQFALL, FREQWINT, DURSPPRG, DURSUMM, DURFALL, DURWINT represent these perceptions.

Factors such as wind direction and proximity to the farm affect measurable exposure. Since this information was not available, four directional indicators were created to describe the locations of residences relative to the neighboring swine operations. NOREAST, SOUEAST, SOUWEST and NORWEST represent compass points from 0° to 90°, 91° to 180°, 181° to 270° and 271° to 360° from north, measured on an arc around the farm. Correlations between location and odor perceptions would suggest a correspondence between objective and subjective indicators of exposure, so that measures taken to reduce exposure should also reduce negative odor perceptions, and perhaps reduce reported annoyance.

## Results of Analysis

The results of the pilot study are suggestive, but not conclusive, of the statistical relationships between odor and annoyance perceptions and other factors that may exist among neighbors of CAFOs. Table 2 gives the mean values of the variables analyzed. The two columns list the variables evaluated in the annoyance perception and odor perception correlations. The mean reported annoyance (ENJOY) was 2.47, midway between "compatible with" and "occasionally hinders" enjoyment of the residence. There was no statistical difference between means of this variable for the two sites, so the responses were combined for the analysis. Although there were respondents at both sites that indicated the operation "usually hinders" enjoyment, the average reflects a positive attitude toward these CAFOs.

Twenty-nine percent of respondents currently farmed or lived on a farm (FARM), while 65 percent described their homes as suburban or small town residences (RURAL). A slight majority of 53 percent had lived or worked on a livestock operation (FAMILIAR). Relationships with the neighboring farmer were characterized by 65 percent who had met the owner of the livestock facility (METOWNER) and 47 percent who reported the owner was positively involved in the community (INVOLVE). The majority of respondents, 88 percent, knew the neighboring operation was a swine facility (SWINE). An average of 6.65 agricultural operations were believed to be within a one-mile radius of the respondents' residences (NUMOPS). Eighteen percent reported at least one beef operation (BEEF) and 41 percent reported at least one dairy facility (DAIRY) within a mile of their residences.

The average length of residence was slightly more than fifteen years (LIVEAT). Respondents had an average of 1.24 children no older than eighteen in their homes, and 29 percent of respondents were likely to be home most of the day (ATHOME). The average rating of the neighboring CAFO's visual appearance was 2.29, between "attractive" and "very attractive" (VISUAL). None of the respondents rated the facilities as less than "acceptable" in appearance. Odor was a problem for 47 percent of respondents (ODOR), including some who reported little negative impact on property enjoyment.

Perceived offensiveness of odors ranged from "pleasing" to "very offensive" across seasons. Odor was worst on average in summer, when it was characterized as "slightly offensive" to "offensive" (OFFSUMM). In all other seasons, odor averaged ratings of "neutral" to "slightly offensive" (OFFSPRG, OFFFALL and OFFWINT). Frequency of exposures was highest in summer, with FREQSUMM averaging 3.24

Table 2.  
*Means of Variables in Correlation Analyses*

Annoyance Perception		Odor Perception	
Variable	Mean	Variable	Mean
ENJOY	2.47	OFFSPRG	2.94
FARM	0.29	OFFSUMM	3.53
RURAL	0.65	OFFFALL	2.41
FAMILIAR	0.53	OFFWINT	2.35
METOWNER	0.65	FREQSPRG	1.18
INVOLVE	0.47	FREQSUMM	3.24
SWINE	0.88	FREQFALL	0.71
BEEF	0.18	FREQWINT	0.12
DAIRY	0.41	DURSPRG	12.00
NUMOPS	6.65	DURSUMM	16.59
LIVEAT	14.47	DURFALL	10.59
KIDS	1.24	DURWINT	2.47
ATHOME	0.29	NOREAST	0.35
VISUAL	2.29	SOUEAST	0.12
ODOR	0.47	SOUWEST	0.41
		NORWEST	0.12

occurrences. In order of declining mean frequency were spring (FREQSPRG at 1.18), fall (FREQFALL at 0.71) and winter (FREQWINT at 0.12). Duration of exposure was also highest in summer, with DURSUMM averaging 16.59, indicating about twelve to twenty-four hours per episode. Average duration was somewhat more than twelve hours in spring and fall (DURSPRG and DURFALL), and substantially less than twelve hours in winter (DURWINT). Relative to the neighboring swine operations, 35 percent of respondents' residences were located to the northeast, 12 percent to the southeast, 41 percent to the southwest and 12 percent to the northwest.

Table 3.

*Statistically Significant Correlations in Odor Perception*

Variable	Negative Correlations		Positive Correlations	
ODOR	NORWEST	-0.34 <sup>c</sup>	OFFSPRG	0.78 <sup>a</sup>
			OFFSUMM	0.80 <sup>a</sup>
			OFFFALL	0.51 <sup>b</sup>
			OFFWINT	0.39 <sup>c</sup>
			FREQSPRG	0.61 <sup>a</sup>
			FREQSUM	0.38 <sup>c</sup>
			FREQFALL	0.38 <sup>c</sup>
			FREQWINT	0.39 <sup>c</sup>
			DURSPRG	0.38 <sup>c</sup>
			DURSUMM	0.47 <sup>b</sup>
			SOUEAST	0.39 <sup>c</sup>
OFFSPRG		FREQSPRG	0.72 <sup>a</sup>	
		DURSPRG	0.48 <sup>b</sup>	
		OFFSUMM	0.68 <sup>a</sup>	
		OFFFALL	0.62 <sup>a</sup>	
		OFFWINT	0.52 <sup>b</sup>	
OFFSUMM		FREQSUM	0.25 <sup>d</sup>	
		DURSUMM	0.46 <sup>b</sup>	
		OFFFALL	0.47 <sup>b</sup>	
		OFFWINT	0.42 <sup>b</sup>	
OFFFALL		FREQFALL	0.76 <sup>a</sup>	
		DURFALL	0.67 <sup>a</sup>	
		OFFWINT	0.36 <sup>c</sup>	
OFFWINT		FREQWINT	1.00 <sup>a</sup>	
		DURWINT	0.80 <sup>a</sup>	

<sup>a</sup>p < 0.01, one-tailed test.<sup>b</sup>p < 0.05, one-tailed test.<sup>c</sup>p < 0.10, one-tailed test.<sup>d</sup>p > 0.10, one-tailed test.

Tables 3 and 4 show statistically significant correlations in odor perception and annoyance perception. Correlations do not indicate causal direction, so a listed variable cannot be said to affect another. Correlations describe which variables are positively associated (move in the same direction) or negatively associated (move in opposite directions).

As shown in Table 3, the perception that odor was a problem was positively correlated with offensiveness and frequency of odors in all seasons, and with duration of odors in the spring and summer. Identification of an odor problem was most highly correlated with negative perceptions of spring and summer odors. This suggests that, unlike urban odor problems, which vary with cycles in industrial activity, rural odor is most noticeable when households are spending more time outdoors. Offensiveness and frequency of exposures in winter was positively correlated with negative odor perceptions, but this relationship was the weakest for the four seasons. The Michigan Agriculture Commission recommends spreading and incorporation of animal manures in the fall, rather than spring or summer, but suggests avoiding land application altogether in winter. Based on reported perceptions of odor problems and environmental considerations, the fall recommendation appears to be a good strategy.

Two locational variables had significant correlations with other factors. A respondent from a southeastern location relative to these CAFOs was likely to report negative odor perception, while a respondent in a northwestern location was likely to indicate that odor was not a problem. This result may be due to prevailing wind direction during exposures, so that odors from the farm are directed away from the northwest and toward the southeast. Attention to local wind patterns may assist in targeting strategies to reduce exposure.

Reported offensiveness of odor in each season was positively correlated with perceived frequency and duration of episodes, except for frequency of episodes in the summer. Similarly, reported offensiveness was positively correlated across all seasons. This implies that individuals who consider odors offensive are likely to characterize the odors as unpleasant whenever they are exposed. Also, offensive odors were believed to occur more frequently and with greater duration than odors characterized as pleasant or neutral. These results suggest that actions taken to reduce perceived odor offensiveness also are likely to result in reports of fewer and shorter noticeable odor exposures. Thus, technical solutions to odor quality could alter neighbors' adverse reactions to odors.

Results in Table 4 show that length of residence, economic dependence on farming, previous contact with CAFO owner, and number of beef operations located nearby were negatively correlated with odor annoyance. Correlations of annoyance with the term of residence and economic dependence are consistent with hypotheses tested in urban studies. Contact with the CAFO owner may create a sense of neighborliness that makes individuals more reluctant to attribute negative characteristics to odors from



Table 4.

*Statistically Significant Correlations in Annoyance Perception*

Variable	Negative Correlations		Positive Correlations	
ENJOY	LIVEAT	-42 <sup>b</sup>	RURAL	0.43 <sup>b</sup>
	FARM	-52 <sup>b</sup>	VISUAL	0.52 <sup>b</sup>
	METOWNER	-47 <sup>b</sup>	ODOR	0.67 <sup>a</sup>
	BEEF	-48 <sup>b</sup>		
VISUAL	LIVEAT	-60 <sup>a</sup>	ODOR	0.35 <sup>c</sup>
	FAMILIAR	-48 <sup>b</sup>		
	BEEF	-50 <sup>b</sup>		
	NUMOPS	-61 <sup>a</sup>		
	ATHOME	-36 <sup>c</sup>		
ODOR	FARM	-61 <sup>a</sup>	RURAL	0.45 <sup>b</sup>
	SWINE	-39 <sup>c</sup>		
	DAIRY	-55 <sup>b</sup>		
ATHOME	KIDS	-63	LIVEAT	0.54
			FAMILIAR	0.35
			NUMOPS	0.56

<sup>a</sup>p < 0.01, one-tailed test.<sup>b</sup>p < 0.05, one-tailed test.<sup>c</sup>p < 0.10, one-tailed test.

the CAFO. Or contact may generate confidence that the owner is attempting to act responsibly toward the neighbors. Not listed in Table 4 was a significant positive correlation found between owner contact and belief that the owner has positive involvement with community, suggesting that contact and perceptions of responsible behavior are related.

Certain factors may be related to expectations and contextual correctness of CAFOs that influence annoyance ratings. With more local beef operations, there is an opportunity for greater awareness of an agricultural context with which the neighboring swine operation may be compared. Characterization of residence as a suburban or small town home was positively correlated with annoyance and with negative odor perceptions. Context expectations based on suburban perceptions of housing are likely to conflict with the reality of the mixed agricultural-residential context. Disappointment of expectations might be reduced with attention to creating realistic perceptions of rural life and farming.

Table 4 indicates that undesirable visual appearance and perception of odor as a problem were positively correlated with annoyance. These attributes were also positively correlated with each other, so altering one aesthetic impression may also alter the other. If a CAFO can be made more visually appealing or screened from view by trees, odor perceptions and annoyance perceptions might be positively influenced as well.

Undesirable rating of visual appearance was negatively correlated with term of residence, familiarity with livestock practices, number of beef operations and farms nearby and likelihood of being at home during the day. Perception of odor as a problem was negatively correlated with farming occupations, correct identification of swine as the primary activity on the neighboring farm, and number of dairy operations in the area.

The negative correlation between undesirable visual appearance and likelihood of being at home is counter to the expectation that the more time spent at home, the greater the exposure to unpleasant sights and smells. The relationship may be partially explained by the positive correlations with term of residence, familiarity with livestock farming, and number of nearby farms and by the negative correlation with number of children. In this sample, residents who stayed home tended to be longer-term residents familiar with livestock farming and local agriculture, and to spend less time with children, so exposures probably were not as likely to evoke negative reactions.

### *Summary and Conclusions*

The results of the correlation analyses on the pilot study data indicate that personal knowledge of the neighbor-operator, longer-term residence, economic dependence on farming, familiarity with livestock farming and awareness of the agricultural-residential context are factors correlated with lower reported annoyance. Those who characterize odors as offensive are also likely to describe them as more frequent and of longer duration than those who do not identify the odors as a problem. These findings are consistent with similar studies of responses to urban odors, although the results are not definitive because of the small sample size.

Although nine possible actions ranging from "complain to friends of the owner" to "file a lawsuit" were identified in the questionnaire, all respondents indicated having done nothing to alter the odor situation and none planned any future action. This result highlights the inappropriateness of using annoyance measures to predict exposure responses without consideration of mediating factors. Yet, the welfare loss from annoyance should

not be ignored simply because it does not motivate action against the CAFO.

This welfare loss may be prevented by either altering expectations about the rural environment or altering the rural environment to match expectations. Perception of rural air quality is a context-dependent judgment, based on expectations of odors appropriate for the rural landscape. Annoyance about odors from livestock operations may be reduced by encouraging residents and CAFO owners to meet and educate each other about their expectations. Positive interaction and education about the agricultural-residential context can generate greater tolerance for occasional odor exposure episodes. Overt efforts to comply with generally accepted manure management practices and to work with neighbors to reduce exposure periods demonstrate responsiveness of CAFO owners to neighbors' concerns. These strategies may reduce reported annoyance.

Some threshold ratio of residential density to animal density exists for which odor and annoyance perceptions cannot be improved. In these cases, changing expectations is not a realistic approach to reducing conflict. The rural environment may be altered by limiting either farm activities or residential expansion. Zoning approaches in Michigan include designation of exclusive agricultural districts, quarter/quarter zoning that restricts residential development to one lot per forty acres of farmland, sliding scale lot sizes according to total parcel size, and establishment of buffer districts with mixed low density residential and less industrial agricultural land uses to separate zones of heavy agricultural from high density residential uses (American Farmland Trust). The threshold ratio may vary by location, but these situations cannot be avoided as livestock and residential intensity increase in rural areas. However, to the extent that efforts to alter this ratio are effective, they are likely to pay off for both farmers and their neighbors.

Future research should extend the analysis of factors related to annoyance perceptions. Comparison of expectations with reality for farmers and their neighbors could identify behavioral and educational activities to reduce welfare losses. By expanding the sample size in future surveys, results could be made more generalizable. Regression analysis could be used to test causal effects of factors on annoyance and odor perceptions. This would suggest policies to reduce conflicts over odor annoyance.

## Notes

Luanne Lohr is Assistant Professor in the Department of Agricultural and Applied Economics University of Georgia, Athens. The author acknowledges Howard Person, Michigan State University, for supplying data for this study. Comments by three anonymous reviewers improved the quality of this article.

## References

- Abeles-Allison, M., and L.J. Connor. *An Analysis of Local Benefits and Costs of Michigan Hog Operations Experiencing Environmental Conflicts*. Dept. of Agr. Econ. Rep. 536. Michigan State University, East Lansing, June, 1990.
- Almagor, U. "Some Thoughts on Common Scents." *J. Theory Soc. Behav.* 20(1990a):181-195.
- \_\_\_\_\_. "Odors and Private Language: Observations on the Phenomenology of Scent." *Human Studies* 13(1990b):253-274.
- American Farmland Trust. *Planning and Zoning for Farmland Protection: A Community Based Approach*. East Lansing, MI, Jan. 1987.
- Cavalini, P. M., L. G. Koeter-Kemmerling, and M. P. J. Pulles. "Coping With Odour Annoyance and Odour Concentrations: Three Field Studies." *J. Env. Psych.* 11(1991):123-142.
- Campbell, J. M. "Ambient Stressors." *Env. and Behav.* 15(1983):355-380.
- DeBoer, J., J. Van Der Linden, and J. Van Der Pligt. "Air Pollution, Annoyance and Coping." *Environmental Annoyance: Characterization, Measurement and Control*, ed. H.S. Koelega, pp. 165-174. Amsterdam, The Netherlands: Elsevier Science Publishing, B.V., 1987.
- Evans, G. W., and R. Tafalla. "Measurement of Environmental Annoyance." *Environmental Annoyance: Characterization, Measurement and Control*, ed. H.S. Koelega, pp. 11-27. Amsterdam, The Netherlands: Elsevier Science Publishing, B.V., 1987.
- Graham, M. "Intensive Livestock Operations: Regulatory Problems and Prospects." *Planning and Zoning News* 12(1986):6-11.
- Koelega, H. S. "Introduction: Environmental Annoyance." *Environmental Annoyance: Characterization, Measurement and Control*, ed. H.S. Koelega, pp. 1-7. Amsterdam, The Netherlands: Elsevier Science Publishing, B.V., 1987.
- Lohr, L., and L.R. Harvey. "Emerging Rural Farm-Nonfarm Conflicts: Whose Preferences Count?" *Increasing Understanding of Public*

- Problems and Policies*, ed. S.A. Halbrook and T.E. Grace, pp. 91-98. Oak Brook, IL: Farm Foundation, 1992.
- Michigan Agriculture Commission. *Generally Accepted Agricultural Practices for Manure Management and Utilization*. Lansing, MI, 1991.
- Michigan Department of Agriculture. *1990 County Food and Agricultural Development Statistics*. MASS 90-02. Lansing, MI, 1990.
- Perrin, M.L. "Annoyance Felt by Populations Living Near Odour-Emitting Industries." *Environmental Annoyance: Characterization, Measurement and Control*, ed. H.S. Koelega, pp. 141-144. Amsterdam, The Netherlands: Elsevier Science Publishing, B.V., 1987.
- Thelen, K.D. "Right To Farm—Environmental Complaint Response." Unpublished paper. Lansing, MI: Michigan Department of Agriculture, 1991.
- Winneke, G., and J. Kastka. "Comparison of Odour-Annoyance Data from Different Industrial Sources: Problems and Implications." *Environmental Annoyance: Characterization, Measurement and Control*, ed. H.S. Koelega, pp. 129-137. Amsterdam, The Netherlands: Elsevier Science Publishing, B.V., 1987.