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Land Use and the Tank:
Land Use Impacts of Private Sewage Systems in Wisconsin

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I. INTRODUCTION

1. Background of the Research

In 1980 the State of Wisconsin initiated a program for the use of an experimental private on-site mound sewage system in its rural areas.¹ The implementation of this program was surrounded by controversy, partly because of the substantial growth in the state's rural areas and at its city's fringes. This growth, like rural and urban-fringe growth in other parts of the United States (Healy and Short 1979, Brown et al. 1981, Dubbink 1984, Doherty 1984), resulted in increased numbers of rural residents, pressures on public services, concern over the threat to rural land resources, such as agricultural and environmentally sensitive land, conflicts between traditional and new residents, and a flurry of state and local public policy responses to manage the growth.

The Wisconsin program for use of mound sewage systems grew out of nearly a decade of research on the technology. The research was intended to facilitate consumer choice in the selection of rural land sites while allowing for environmentally sound land development (Tyler et al. 1980). The program's implementation, after the preparation of an environmental impact statement (Wisconsin Department of Health and Social Services 1979), called for an interim permitting program for the period 1980 to 1985, involving both county and statewide quotas on the number of these systems. It was the intention of the drafters of this program that sometime during the latter part of the period, an assessment of the environmental, fiscal and social impacts of these systems would be conducted. Such an assessment was never undertaken. During the 1985 Wisconsin Legislative session, the interim program was extended for two years and the Legislature mandated the preparation of a study on private sewage systems and their impacts on Wisconsin's critical resources (Hanson,

Jacobs et al. 1986). This paper reports one aspect of the findings of that study; those relating to the land use impacts of private sewage system use in Wisconsin's rural areas.²

Substantively, the issues which prompted the study, and the initial EIS, had to do with the environmental, fiscal, and social impacts of mound and other types of private on-site sewage systems on the critical resources of Wisconsin. In the area of land use, opponents to mound system use asserted that (1) the use of these systems would lead to increased rural development, by 'opening' lands for rural residential use that are unavailable for such use with more conventional types of private, on-site systems, because of site based soil, slope or water-table limitations; (2) in particular, the use of mounds would lead to more rapid conversion of critical land resources, such as agricultural lands; (3) the availability of these technologies would facilitate an out-migration of persons from the state's urban areas, leaving an already substantial public investment in infrastructure to be supported by those with the least ability to pay; and (4) the land development associated with these new technology sewage systems would lead to increased demands and development of public services.

Supporters of system use held other assumptions about the land use impacts of this technology. They speculated that (1) it would lead to more compact rural land use patterns, by allowing for use of land currently 'skipped over' because of soil, slope, or water-table conditions unsuited to conventional on-site sewage system use; (2) system use would reduce pressures on the state's prime agricultural lands by facilitating development of more marginal lands; and (3) mound system use would, in fact, reduce infrastructure investment by eliminating the need for more expensive, urban based public sewage systems.³

The Legislative directive for the study called for examination of the impacts of a broad range of private sewage systems, not just mound systems; this was based on the understanding that the relative impact of one particular type of technology could be assessed only in comparison with other existing and proposed alternatives. This was particularly significant because the EIS had speculated that the marginal impact of mound systems could be insignificant since all types of land to which it could be applied could already be developed through the use of holding tanks, a common, permitted and less expensive private on-site sewage system alternative.

2. Existing Research

It is well established that public sewage systems and other development infrastructure have significant impacts on land development patterns, critical resources, and the capacity of local governments to provide public services (Tabors et al. 1976, Urban Systems Research and Engineering 1976, Real Estate Research Corporation 1974, American Society of Planning Officials 1976). These systems directly contribute to the conversion of urban and urban-fringe land for development by creating a cycle of change where high user charges for infrastructure investment together with increased market value for land act as an impetus for land conversion. However, as noted, much of this research focused on public sewage systems and urban and urban-fringe land use. A similar range of studies are not available on the impacts of private sewage systems, rural infrastructure and rural land use.

The notable exception to this is the study prepared and reported by Popper (1980, 1981). In this study, the sand filter and related alternative on-site sewage systems were examined for their impact on land development patterns. Like the debate in Wisconsin in the late 1970s, Popper notes that the use of

these technologies may have one of three impacts: (1) no impact, because of a downturn of rural residential development, (2) negative impact, because they will open up land previously undevelopable because of limitations of conventional sewage systems, or (3) beneficial impact, because they will allow for more efficient land use. Popper concluded that what appeared to be the determining factor among these possible outcomes is the degree to which local and state governments assertively engaged in land-use planning and regulation.

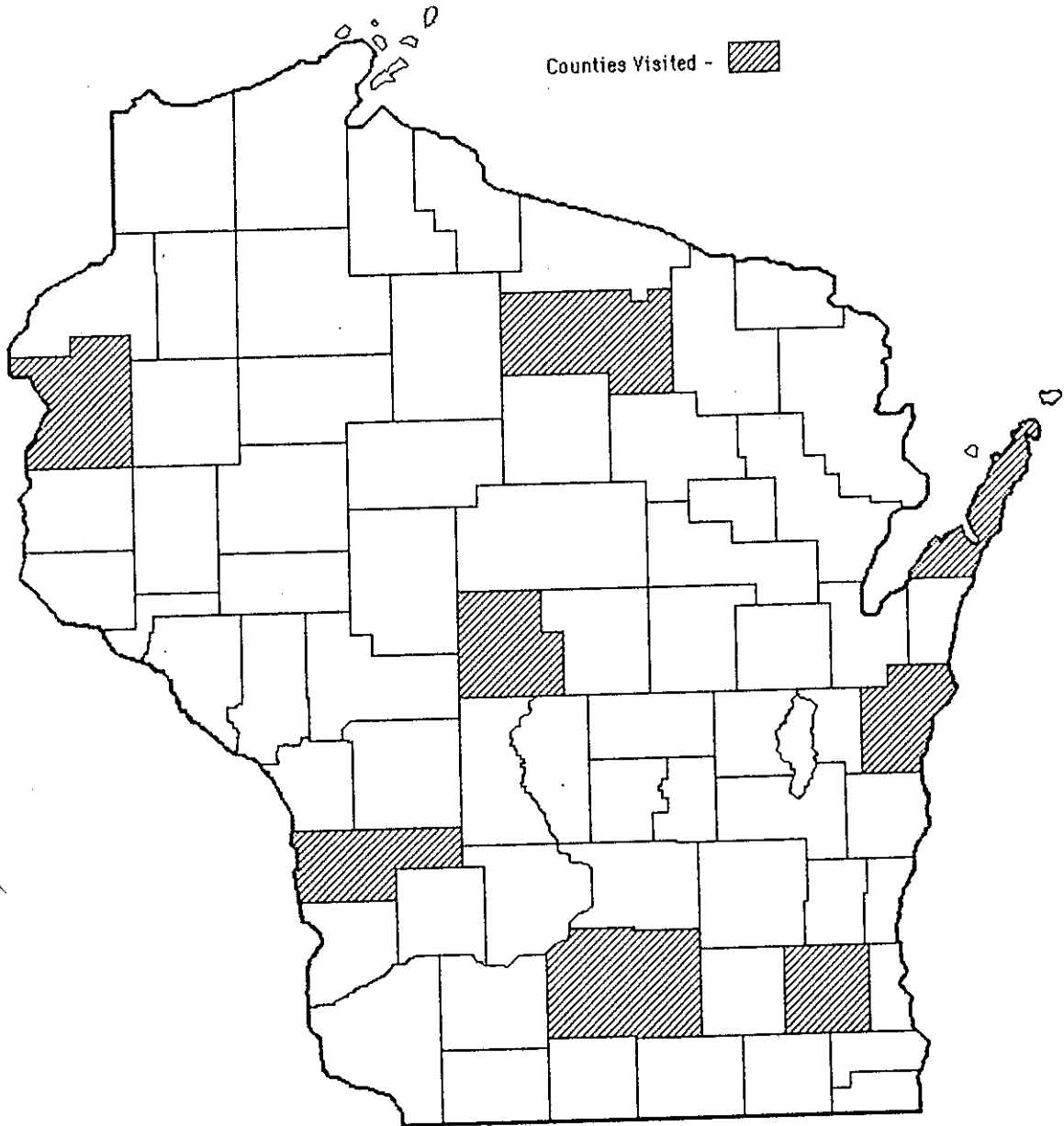
3. Research Method

Data for assessing the land use impacts of private sewage systems was collected in three ways. The primary method was a field survey in eight of Wisconsin's 72 counties. The counties that were selected represented a cross section of conditions: urban and rural areas, areas with high and low numbers of second homes, areas experiencing different rates and types of rural land development pressures, and areas with soils suitable or unsuitable for conventional on-site sewage systems. The counties that were selected are noted in Figure 1. For these counties, a stratified random sample of thirty private sewage system sites per county was visited. The sample was stratified by the three primary types of sewage systems: conventional, mounds and holding tanks. The actual sites visited were randomly selected from those installed in the period 1981-1985. A landscape assessment form was filled out at each site, in most cases by two members of the research team.

In addition to the landscape survey, a mail survey of actual users of different types of private sewage systems and a phone survey of county planners and sanitarians (those public officials who regulate the installation and monitor the functioning of these systems) was conducted. The mail survey was conducted on a group of users from six of the eight field survey counties. A

FIGURE 1

Counties Visited In Field Survey



group of 180 usable questionnaires, representing a response rate of 58% were collected from a sample also stratified by type of sewage system. The survey group represented those who received permits to install a private sewage system, though they did not necessarily do so, in the period 1981-1985. The phone survey was conducted with 31 professionals in 22 counties in the state, including the eight in which the field survey was conducted. In each case, the survey focused on experiences and motivations of private sewage system users, and in addition, the planners and sanitarians were asked to react to the analysis of the field survey.

In addition, to understand the current pattern of private sewage system use in Wisconsin, a comprehensive analysis of permit data collected by the Wisconsin Department of Industry and Labor Relations, the regulating agency, was conducted. This analysis concentrated on the period 1982-1984, that period for which the agency had the most complete records.⁴

4. Structure of Paper

The overall amount and pattern of private sewage system use in Wisconsin for the period 1970-1985 is addressed in section II. This data provides a general context for the material that follows. Then, in section III, the characteristics and motivations of private sewage system users are reviewed, with particular attention to the impact of a private sewage system on their location decisions. The specifics of the land use impacts of private sewage systems are taken up in section IV. Section V closes the paper with thoughts on the policy implications of the information presented.

II. PATTERNS OF PRIVATE SEWAGE SYSTEM USE IN WISCONSIN

As of 1985 there were over one-half of a million private sewage systems in place in Wisconsin. This was an increase of over 55% since 1960. This substantial increase in private sewage systems took place in a period of relatively slow population growth statewide, though it was reflective of substantial rural population growth and rural housing growth, especially rural recreational housing. Of the 288,000 persons added to Wisconsin's population in the 1970 decade, 226,000 were in totally rural municipalities. In this same decade rural recreational housing increased 98.5%.

The vast majority of existing private sewage systems, 95%, are conventional systems, with mounds comprising only 2% and holding tanks 3% of the total. However, this is not surprising. Holding tanks only began to be used in the state in 1968, and mounds in 1975. Previous to that, conventional systems were installed on many sites now deemed unsuitable for them.

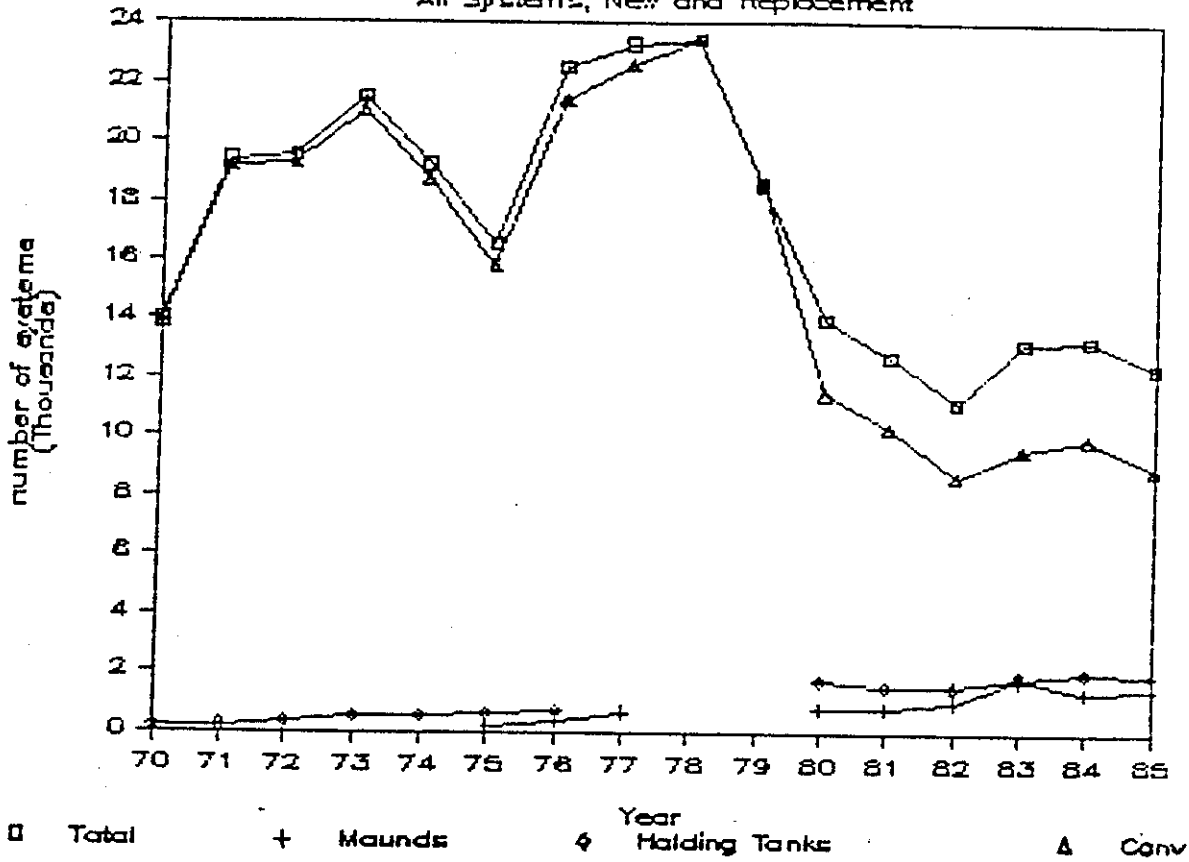
In the period 1970-1985 permits for private sewage system have varied between 11,000 to nearly 23,500 per year, see Figure 2, with the variation closely correlated with the swings in the national and regional home building market. Figure 2 displays records of permits for both new and replacement private sewage systems. It is estimated that in the 1970s nearly 80% of permits were issued for new systems; in recent years, permits for new systems have dropped to about 60% of total permits issued.

As Figure 2 indicates, mounds and holding tanks represent a relatively small proportion of total private sewage system permits issued. However, as is also noted, that proportion has been rising dramatically. As of 1985, conventional systems had fallen to 73% of total permits issued, while mounds were 12% and holding tanks 16% of total permits.

FIGURE 2

PRIVATE SEWAGE SYSTEMS PERMITTED

All Systems, New and Replacement



SEPTIC TANK PERMITS ISSUED

YEAR	TOTAL	CONV	% of Total	MOUND	% of Total	HOLDING TANK	% of Total
66	2996	2996	100%				
67	9516	9516	100%				
68	12016	11991	100%			25	0%
69	12743	12684	100%			59	0%
70	14032	13925	99%			107	1%
71	19396	19207	99%			189	1%
72	19547	19256	99%			291	1%
73	21516	21022	98%			494	2%
74	19239	18736	97%			503	3%
75	16585	15838	95%	116	1%	631	4%
76	22518	21455	95%	326	1%	737	3%
77	23324			658	3%		
78	23446						
79	18571						
80	14024	11492	82%	800	6%	1732	12%
81	12742	10342	81%	837	7%	1563	12%
82	11185	8671	78%	1008	9%	1506	13%
83	13211	9554	72%	1788	14%	1869	14%
84	13308	9983	75%	1331	10%	1994	15%
85	12353	8966	73%	1448	12%	1939	16%

Actual installation of private sewage systems varied somewhat from the number of permits issued for them. Table 1 displays installation data for the period 1982-1984. Installations in this period ranged from 7,900 in 1982 to 11,700 in 1984. As Table 1-A shows, 63% of these installations were for new systems, representing new construction. In this period, 75% of the systems installed were conventional systems, 9% were mounds, and 16% were holding tanks, see Table 1-C.

However, as with much of this analysis, the data varied widely by county, reflecting the differing soil, slope, water-table conditions and development pressures throughout the state. While mound systems only represent 9% of new installations for the study period, in one county they were 39% of new installations, and in a total of seven counties they were at least 25% of new installations. These counties correlate with those parts of the state with natural conditions which make on-site sewage disposal by conventional systems difficult. Likewise, while holding tanks make up 16% of total installations for the period 1982-1984 statewide, in four counties they represent over 50% of installations, and are the most common form of system installed in a total of eight counties. As with mound systems, these are counties where natural conditions limit the use of other types of private on-site systems.

III. PROFILE OF PRIVATE SEWAGE SYSTEM USERS AND THEIR MOTIVATIONS

While both natural, site based conditions and state and local policy influence the pattern of rural development, personal preferences regarding living environments and particular building sites are a significant determinant of where development takes place. In some cases, site acquisition occurs

TABLE 1

PRIVATE SEWAGE SYSTEM INSTALLATION TRENDS
WISCONSIN TOTALS, 1982-84*

A. New and Replacement Systems as a Percentage of Total, 1982-84

YEAR	TOTAL SYSTEMS INSTLD	% OF TOTAL SYSTEMS*	TOTAL NEW SYST	% OF TOTAL SYSTEMS	TOTAL REPL SYST	% OF TOTAL SYSTEMS
1982	7,902	100%	4773	60%	3129	40%
1983	10,814	100%	7002	65%	3812	35%
1984	11,673	100%	7346	63%	4327	37%
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1982-84	30,389	100%	19,121	63%	11,268	37%

B. New and Replacement Systems by Type

TYPE OF SYSTEM INSTALLED	TOTAL	% OF TOTAL	NEW SYSTEMS	% NEW	REPL SYSTEMS	% REPL
CONVENTIONAL	21,691	100%	14,333	66%	7,358	34%
ALTERNATIVE	4,044	100%	1,761	44%	2,283	56%
HOLDING TANK	4,654	100%	3,027	65%	1,627	35%
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TOTAL	30,389		19,121	63%	11,268	37%

C. Type of System as a Percentage of Total, 1982-84

TYPE OF SYSTEM INSTALLED	TOTAL	% OF TOTAL	NEW SYSTEMS	% OF NEW	REPL SYSTEMS	% OF REPL
CONVENTIONAL	21,691	71%	14,333	75%	7,358	65%
ALTERNATIVE	4,044	13%	1,761	9%	2,283	20%
HOLDING TANK	4,654	15%	3,027	16%	1,627	14%
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TOTAL	30,389	100%	19,121	100%	11,268	100%

*PRIVIES NOT INCLUDED

before individuals consider site limitations or state and local regulations for sewage systems or land use.

In fact, among all private sewage system users surveyed the type of sewage system tended to not be a factor in the respondents decision to build in a particular location. Over two-thirds of survey respondents indicated that they were not particularly concerned with the type of system they were required to use. This finding holds true across sewage system types. However, primary home owners may be avoiding use of holding tanks. As noted in Table 2, 49% of second home owners used holding tanks. In contrast, primary home owners seem more strongly inclined to use conventional or mound systems.

TABLE 2

OWNERSHIP PATTERNS, BY PERCENT, OF PRIVATE SEWAGE SYSTEMS, 1982-1984

	Conventional Systems	Mound Systems	Holding Tanks
Primary Homes	88%	80%	51%
Second Homes	13%	20%	49%

The survey also showed that the cost of constructing and maintaining a private sewage system tended not to be a factor in the choice of a property. The factors which were most important in the location decision were view or natural environment, rural setting, outdoor recreation opportunities, proximity to work, and the availability of family owned land.

These survey results, along with earlier surveys in the state (Wisconsin Department of Administration 1974, Wisconsin Department of Development 1982), indicate several factors influencing the pattern and location of private sewage system use in Wisconsin. First, for at least the last decade people in the state have wanted to live in a rural setting. Their reasons have been

consistent -- access to the natural environment and outdoor recreation. And, as the Wisconsin Department of Administration and Development (1974, 1982) surveys and U.S. Census figures indicate, people are acting on these desires. With regard to private sewage system use, with the exception of holding tanks for primary homes, most rural residents chose their locations regardless of the type or cost of sewage disposal. In the case of holding tanks, there is some evidence to suggest that their use with primary homes is being avoided because of high operating costs and their possible negative impact on property resale value.

IV. THE LAND USE IMPACTS OF PRIVATE SEWAGE SYSTEMS IN WISCONSIN

1. Patterns of Development

For the purposes of this research, three types of non-sewered land development patterns were defined. Scattered development is that which is removed from an urban area, with less than five contiguous dwelling units. Clustering refers to residential development occurring in groups of five or more dwelling units, and includes rural subdivisions and linear lakeshore development. Infill refers to development which is contiguous or within one-quarter mile of an urbanized area.

The field survey of 240 selected sites (30 sites in 8 counties) revealed a great deal about land development patterns. Sampled sites were very dispersed, and with the exception of one county, private sewage system use did not vary greatly by type of sewage system.

Of the total systems observed, 61% were found to be scattered; while 33% were found in a clustered pattern and only 6% were identified as infill. As noted, each type of private sewage system was dominated by a scattered pattern

of use, although conventional systems were somewhat less scattered and more often clustered than the other types of systems, see Figure 3.⁵

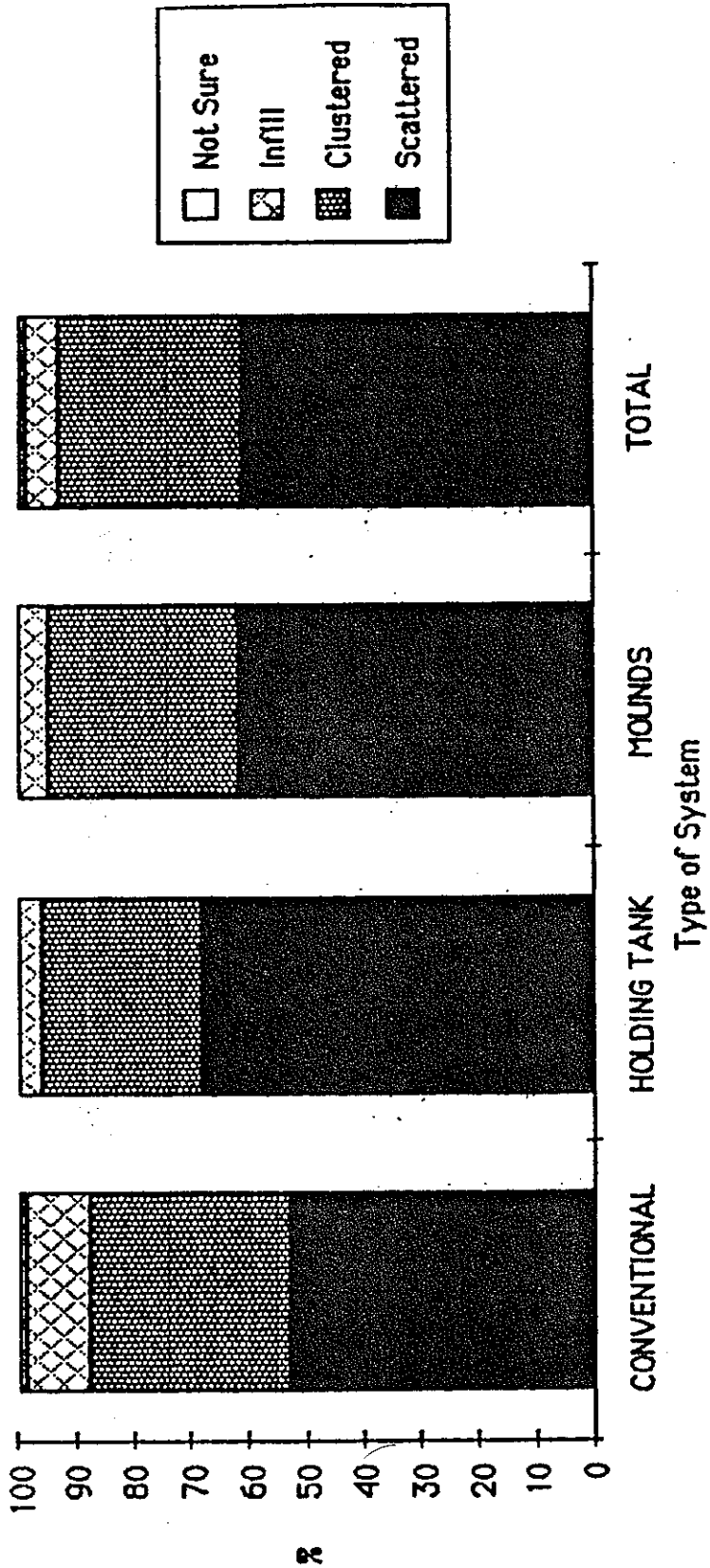
However, land use patterns varied widely among the sampled counties. In the most striking example, in Vernon County, in the southwest corner of the state, 93% of the sites were scattered. In contrast, in Waukesha County, adjoining Milwaukee on the eastern border of state, and Oneida County, in the north central part of the state, two-thirds of the sites were clustered. In Waukesha County this phenomenon is due to the prevalence of rural subdivisions; in Oneida County it is due to linear lakeshore development. In Vernon County all systems contribute equally to scatteration, while in Waukesha County conventional systems are more likely to be clustered, due to the subdivision activity. In Oneida County, mound systems, and to a lesser extent holding tanks, are more likely to be clustered than are conventional systems due to the site limitations of available lots in lakeshore areas.

The telephone survey of planners and sanitarians substantiated these observations. In two-thirds of responding counties, it was believed that the type of private sewage system had no impact on the pattern of development. Several exceptions to this were noted, however. While most survey respondents stated that all private sewage systems contributed to a scattered pattern of development, respondents from six counties noted that conventional systems were the primary systems used in subdivisions, thus contributing to more clustering among these systems. Other respondents suggested that pockets of soils of a particularly suitability located in high demand areas could influence the pattern of development.

In summary, very few private sewage systems were being used for infill, and those that were used for infill were fairly evenly divided among the major

FIGURE 3

PATTERNS OF DEVELOPMENT



types of systems. Scattered rural development is more common than clustered development for all types of systems, although conventional systems are more often used in clustered development because of existing state policy for rural subdivisions. Finally, the availability of the mound system does have an impact on land settlement patterns in selected locations, depending upon attitudes toward the use of holding tanks. In areas where holding tanks are avoided for new development and suitable sites for conventional systems are not available, the availability of the mound system does contribute to a more scattered pattern of land settlement.

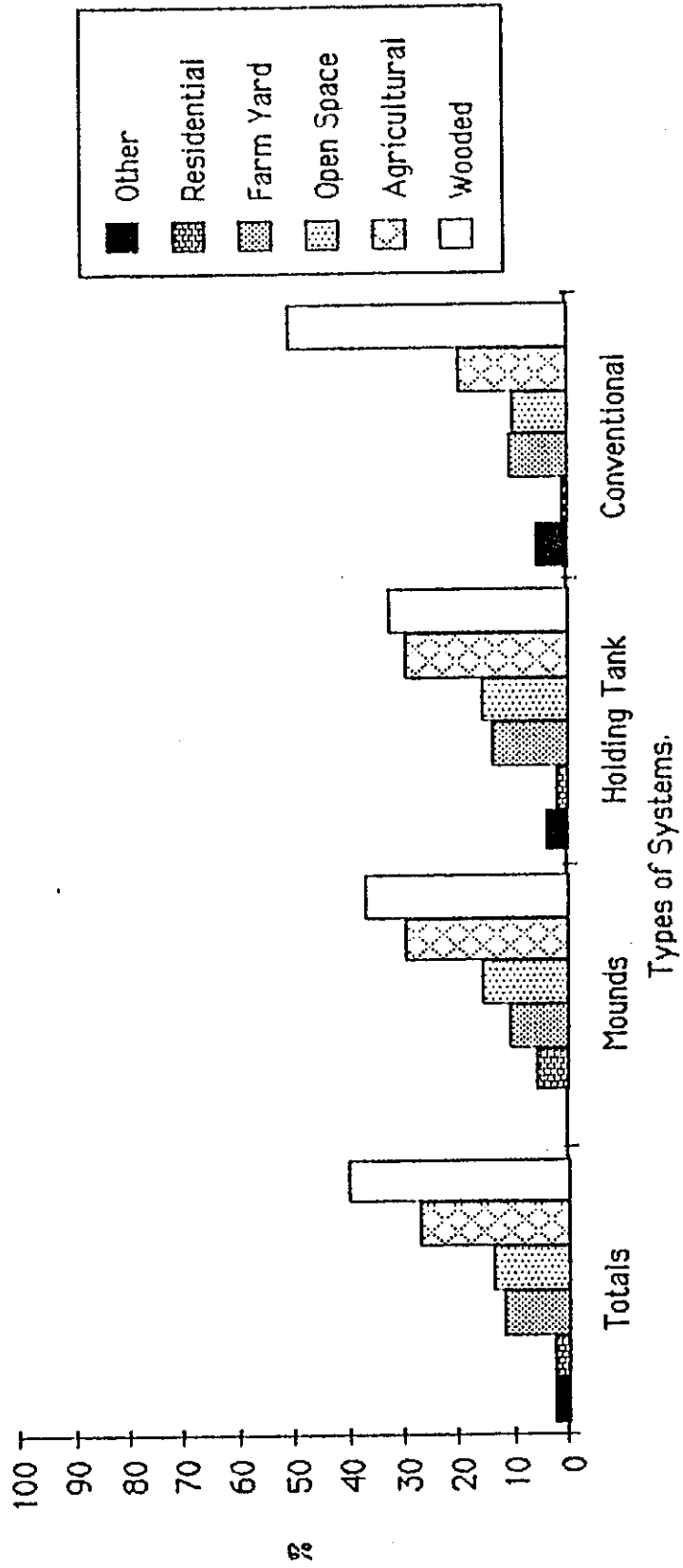
2. Land Resource Impacts

In the eight sample counties, the general character of newly developed areas varied greatly by county. In four of the counties development occurred in primarily agricultural areas; in three of the counties it was in primarily wooded areas or non-productive open areas, and in the remaining county it was evenly distributed among these areas. However, as Figure 4 shows, percentage wise it was wooded land that absorbed the greatest impact of development.

Among the eight counties, 29% of all sites occupied areas of agricultural land. This proportion was similar for all types of systems, as shown in Figure 4. As with other characteristics, a great deal of variation occurred among counties. In counties where agriculture is prominent, much higher percentages of new systems replaced agricultural land. However, as the quality of the soil on sites observed was not determined, it was unknown whether it was prime or marginal agricultural land that was involved.

In the county interviews, two-thirds of planners and sanitarians considered agricultural land to be a major type of land converted for rural development. In approximately half of these counties, the opinion was that the

FIGURE 4
Previous Use of Site
All Eight Counties



type of land converted was marginal. The vast majority of county personnel surveyed, 79%, believed that the type of land developed had no correlation with the type of system used.

Thus, while private sewage systems are having an impact on the conversion of agricultural land to non-agricultural uses, as these systems are bound to in rural areas, it does not appear that mound systems or holding tanks have a measurably greater impact than do conventional systems.

The land resource most impacted by private sewage systems is forested land. A higher proportion of conventional systems are going into wooded land, and considering the large number of conventional systems (77% of all systems installed in the eight counties were conventional systems), it is likely that a great number of Wisconsin's woodlots are being subdivided for rural residential development. This perception was substantiated by the survey of county professionals, 55% of whom stated that forested land is the most common type of rural land being developed.

V. CONCLUSIONS: LAND USE AND THE TANK

1. Summary

The trend of the last two decades has been toward substantial nonmetropolitan growth in Wisconsin. This has resulted in a dramatic increase in the use of private sewage systems. Between 1960 and 1985 the number of systems increased 55%, with over one-half of a million systems now in use. This dramatic increase in private sewage system use took place against a backdrop of relatively slow overall population growth, though substantial rural population and especially rural housing growth. The use of private sewage

systems has varied throughout the state, correlating with the capacity of the natural environment to accommodate particular types of systems.

In terms of the land use impacts of private sewage system use, the research found the following:

Private sewage systems have facilitated the major movement of population during the last 20 years to the state's rural areas. However, the movement has been motivated by various factors, including the strong desire on the part of Wisconsin residents to live in rural places. In fact, it does not appear that in general people take the type of cost of a private sewage system into consideration in making a rural site location decision.

There is no evidence to suggest that any particular type of private sewage system is contributing to any pattern of rural land use more or less than any other type. Rather, rural land use is occurring in a widely dispersed pattern, both scattered and clustered. In particular, except for isolated instances, there is no evidence that any type of private sewage system, or private sewage systems in general, are contributing to urban or urban-edge infill.

A significant portion, over 30%, of new development in the period 1981-1985 using private sewage systems occurred on agricultural land. Development associated with the use of mound systems and holding tanks appears more likely to occur on agricultural land than development with conventional systems. It is not possible, though, to determine the quality of agricultural land being developed. Impressions of county level professionals is that it is not prime land.

Forest land is the land resource most impacted by private sewage systems, with over 40% of new development occurring on forested land.

The relative proportion of private sewage systems which are mounds or holding tanks has increased significantly. In those areas of the state where land suitable for conventional systems is limited and development pressures is high, the availability of these alternatives has substantially increased the amount and pattern of land development that can occur.

2. Policy Considerations and Issues

Clearly these findings present a problem for planners and others concerned with settlement, landscape and land-use planning policy. Private sewage systems have an impact on land-use. And except for particular areas, it does not appear that any one system has any more impact than any other on scatteration or the conversion of agricultural and forest land. But this is, in itself, not surprising; that is what these systems are designed to do -- allow individuals to safely actualize their desires to live in non-urban areas. But this is also the root of the problem of attempting to deal with the land use impacts of private sewage system via private sewage system policy.

Private sewage system policy, that is policy designed to regulate the installation and monitoring of these systems, is, in effect, health policy. It is policy designed to assure the healthful treatment of human effluent on-site. In particular, it is designed, in part, to remove bacteria and viruses from effluent before the water that makes up this effluent comes into contact with groundwater. As such, private sewage system policy is not designed to be concerned with broad scale settlement, landscape and planning impacts. As long as a particular site, with its soil, slope and water-table conditions, can

safely accommodate a private sewage system, the policy structure in Wisconsin is designed to allow system installation.

Why this becomes a problem is because in many rural areas, in Wisconsin and elsewhere, local officials have for many years used soil, slope and water-table based health policy as de facto land-use planning policy. As long as certain critical environmental areas, such as steep slope, thin soil and high water-table and wetland areas, were off-limits to the installation of private sewage systems it was not necessary to address the politically touchy issue of land-use planning. Now, however, with the development of mounds and holding tanks the previously inherent restrictiveness of this policy approach no longer works. When you can, in effect, put a private sewage system anywhere health policy no longer can act as de facto land-use planning policy.

Popper (1980) recognized this in his study of private sewage systems: "(m)any localities and states have in the past used health or sanitary codes in such a way as to inadvertently transform them into indirect devices to control land use or growth . . . (T)he advent of the alternative [private sewage system] technologies may make this approach outmoded, and force some local and state governments to deal with land-use directly rather than indirectly for the first time" (ibid: 19-20). In fact, "(A)lternative technologies have potential for increasing compactness of fringe and nonmetropolitan growth (and) increasing infill . . . only if effective land use controls are in place to shape growth. The technologies will generally work against all these goals where land-use controls are absent" (ibid: 2).

In Wisconsin these conclusions are fully warranted. Most of the impacts of private sewage systems can not be mitigated using private sewage system policy. Private sewage system policy exists in an environment of larger

social, economic, and market forces for rural settlement, and the policy mechanisms most suited to mitigating settlement impacts are settlement policies -- i.e. land-use policies. Private sewage system policy by itself is a limited and indirect approach to mitigating these impacts. And yet, at this time, it does not appear that local and/or state officials are aware or concerned enough about the impact of this development process to institute any serious process of local, state or coordinated local-state land use planning.⁶ It is yet one more example of the critical need for such policy and the difficulty of demonstrating and/or implementing it.

ACKNOWLEDGEMENTS

Much of the data and analysis presented in this paper is drawn from Hanson, Jacobs et al. (1986). As such, I want to acknowledge the collaboration of Mark E. Hanson, my colleague at the University of Wisconsin-Madison, and especially the research and writing assistance provided by three former graduate students: Elizabeth D. Ham, K. Leigh Leonard and Kerri J. Simmons.

NOTES

1. The Wisconsin regulatory program addresses three basic types of private on-site sewage systems. Conventional systems handle sewage waste by pretreating them in a septic tank where solids, scum and liquids are separated. The solids and scum remain in the tank to be pumped out periodically. The liquids flow from the tank to a soil absorption field where they are distributed through a system of perforated pipes. Bacteria and oxygen in the soil help purify the liquid before it comes into contact with groundwater. Wisconsin regulations require at least three feet of soil and slopes of less than 20% for the installation of a conventional system. Mound systems are similar in concept to conventional systems, except that they are designed to be used in areas where there is some, but not enough soil or too great a slope for the proper functioning of a conventional system. They are constructed above the ground level by mounding sand fill on top of the natural land surface. The liquid distribution pipes are placed on top of this sand fill and usually a subsoil material with top soil is used to cover the system. Liquid wastes get to the mound via a pump. Holding tanks are watertight, underground

tanks, generally of steel or concrete, which hold sewage until it can be pumped from the tank and hauled away. With holding tanks there is no contact of the sewage with the land. Once the sewage is pumped it is then treated either in a wastewater treatment plant or it is landspread. Theoretically, because they are watertight, holding tanks can be installed in any land conditions where it is physically possible to place a tank.

2. One of the important issues about private on-site sewage systems, and one closely related to their land use impacts, that this paper does not address is their environmental impacts, such as their impacts on groundwater, surface water and wetlands. These impacts are addressed in Hanson, Jacobs et al. (1986: 97-120).
3. This paper takes up opponent's and supporter's arguments about the direct land settlement impacts of private sewage systems. The one point noted as of concern to both groups which is not addressed in the paper is the impact of private sewage systems on demands for and provision of public services. However, this point is addressed in Hanson, Jacobs et al. (1986: 121-127).
4. Details on the research methodology are contained in Hanson, Jacobs et al. (1986: 11-18).
5. Some of this difference is explained by Wisconsin law which discourages the use of mounds and holding tanks in rural subdivisions.
6. One reason this may be true is that the long-term environmental impacts of mounds and holding tanks are not yet clear. Mounds have not yet reached their design life, and issues of their on-site failure and how and where

on-site replacement will occur have not necessarily been fully addressed; and it is only recently that municipalities and the state have begun to become aware of the dangers and complexities of the disposal of holding tank septage. If, as it appears, these problems will grow in time, this may lead to interest in land use planning.

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