RECREATIONAL USE OF SMALL STREAMS IN WISCONSIN

Technical Bulletin No. 95
DEPARTMENT OF NATURAL RESOURCES
Madison, Wisconsin
1976

PREFACE

A field survey of 80 small stream reaches was conducted during the summer of 1975 to determine the amount of recreational use of small streams in Wisconsin. Data gathered from the survey have been used to assess the significance of small streams as a recreational resource.

The 1972 amendments to the Federal Water Pollution Control Act established a 1983 goal of bringing the waters of the nation up to a quality which provides for recreation in and on the water. Certain small streams in Wisconsin currently are not meeting the 1983 goals. This report attempts to measure the potential recreational benefits to be gained from improving the water quality on these streams.

This study was undertaken in conjunction with the DNR water quality standards revisions for small streams. These designate standards for stream reaches based upon the hydrologic characteristics and potential beneficial uses of the streams. The small stream survey was designed to determine if the proposed standards are in accord with the recreational uses which occur on small streams.

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INTRODUCTION

Wisconsin is a headwaters state, in that for all practical purposes the streams flowing through it also originate within its boundaries. This means that there are large numbers of small creeks, streams, and rivers throughout the state.

Many Wisconsin communities are located along or near small streams. Some of these communities were established along railways and roads which followed watershed divides. Whatever the reason, the result of this locational tendency is the necessity for such communities to discharge treated wastewater into nearby small streams. This arises because the small streams often provide the only viable discharge conveyance for that wastewater.

The ability of these small watercourses to assimilate waste discharges is very limited and some degree of pollution may be observed in the streams. Effects of wastewater discharge on a small stream will vary greatly depending upon a number of factors, including the size, temperature, and gradient of the receiving stream, the degree of treatment, and the amount of effluent being discharged. The most evident problems associated with small streams receiving wastewater discharges are odor and other unaesthetic changes resulting from inadequate treatment. These problems occur largely because this type of discharge lends itself to anaerobic conditions derived from the deposition and decomposition of sludge solids in the stream bed. Additional problems may arise from toxic conditions, especially ammonia and chlorine toxicity, which cause a change in the ecosystem of the stream. Many types of fish, as well as other types of aquatic life, will not tolerate these conditions, while slimes and other tolerant species may often become established in these reaches of the stream.

The 1972 amendments to the Federal Water Pollution Control Act established a 1983 goal of bringing the waters of the nation up to a "quality which provides for the protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water". Upgrading all of the small streams in Wisconsin to a higher level of water quality would require advanced levels of wastewater treatment for the communities which discharge to small streams. Many of these communities have asked why they should be required to attain these high levels of treatment on streams which have little or no value as a recreation resource, and which could not support a significant, diverse aquatic population regardless of the quality of the wastewater discharge. This study was directed toward determining the significance of small streams as a recreational resource, and measuring the potential recreational benefits to be derived from improving the water quality of these watercourses. The information is needed by the Department to determine appropriate water quality standards for these streams and to set priorities in its pollution abatement effort.

A survey of the literature was made to determine what information had previously been generated on this topic. There were a few site specific studies of usage on high quality trout streams (Hunt 1966), but nothing of a broad nature needed for state level decision making. Other studies of a more comprehensive nature have been directed only at large watercourses, especially lakes (Reiling, Gibbs and Stoevener 1973). A study of the relationship between water quality and recreation demand on lakes in southeastern Wisconsin is currently being undertaken by the Water Resources Center at the University of Wisconsin (Schneider and Petrie 1976). However, none of these studies examined recreational uses of small streams nor did they attempt to assess water quality standards on small streams from a recreational use perspective.

STUDY DESIGN

EXPLANATION OF TERMS

Small Streams

The term small stream has no clear-cut definition. However, for the purposes of this study, the operational meaning of "small stream" can best be expressed by reference to one of the two categories of small streams — either **discharge-affected streams** or **nonaffected streams**. A discharge-affected stream reach is that reach downstream from an outfall of a municipal wastewater treatment plant. The discharge-affected stream is considered a small stream when there is a large amount of effluent in proportion to the stream's base flow. As a result, secondary levels of treatment will generally not produce the quality of effluent required to attain water quality standards. A nonaffected stream reach meets the following two criteria: (1) The stream reach does not receive the effluent of a wastewater treatment plant; (2) The reach has flow and physiographic characteristics similar to that of a discharge-affected stream located nearby. The reason for defining nonaffected reaches in this way will become clearer in the discussion of the study design.

The small streams were also classified according to three hydrologic categories as outlined in DNR Water Quality Standards Revisions for Small Streams (1976): continuous streams, noncontinuous streams, and effluent ditches. Definitions of these categories are as follows:

Continuous Stream — a watercourse which has a natural Q7,10 low flow of greater than 0.1 cubic feet per second (cfs) or which exhibits characteristics of a perpetually wet environment, and capable of supporting diverse aquatic biota and flow in a defined stream channel. The Q7,10 low flow is the 7-day mean low flow which has a probability of occurring once in 10 years.

Noncontinuous Stream — a watercourse which has a defined stream channel but with a Q7,10 low flow of less than 0.1 cfs and does not exhibit characteristics of being perpetually wet without wastewater discharges.

Effluent Ditch — a discharge conveyance, constructed primarily for the purpose of transporting treated effluent from the wastewater treatment plant outfall to a naturally occurring watercourse (e.g., continuous or noncontinuous stream).

The small stream reaches were also categorized as either fish and aquatic life, or less than fish and aquatic life. Definitions of these categories, as outlined in DNR Water Quality Standards Revisions for Small Streams (1976) are as follows:

Fish and Aquatic Life — applied to natural streams or rivers where the maintenance of a fishery habitat is feasible or where public health considerations are important, or for recreational activities.

Less Than Fish and Aquatic Life — applied to streams which would not meet the Fish and Aquatic Life criteria listed above.

This categorization was used basically because Public Law 92-500, the Federal Water Pollution Control Act Amendments of 1972 mandates that all surface water courses must meet fish and aquatic life (and body recreation) standards by 1983.

Users and Property Owners

A **stream user**, or **recreational user**, is an individual who, while a particular stream reach is being surveyed, is engaging in recreational use which is related to the presence of that stream.

A **property owner** is defined here as an individual owning property adjoining a surveyed small stream. Property owners were classified as either **residential** or **agricultural**. A residential property owner is defined as a property owner having a residential dwelling unit on a lot with frontage on a surveyed stream. An agricultural property owner is defined as a property owner using his land for agricultural purposes and whose farmstead is adjacent to a surveyed stream.

PAIRED STREAM CONCEPT

The basic goal of the study was to gather and analyze recreational use data for small streams. A paired stream design was employed to that end. For each discharge-affected small stream reach surveyed, a corresponding nonaffected stream reach in the immediate area was also surveyed. Whenever possible, both reaches were surveyed on the same day. For each discharge-affected-nonaffected pair, the nonaffected reach was of approximately equivalent flow and physiographic characteristics to the discharge-affected reach. The fundamental reason for making use of such paired stream reach observations was to obtain comparable recreational use data for discharge-affected and nonaffected reaches. These data facilitate inferences concerning differences in recreational use between discharge-affected streams and nonaffected streams. We expected that total recreational use would be greater on the nonaffected streams than on the discharge-affected streams. Presumably the absence of effluent in the nonaffected reaches should result in better water quality, and therefore stream-related recreational use should increase as water quality improves. Therefore, paired observations would enable inferences to be made regarding potential recreational benefits to be gained from upgrading water quality in discharge-affected streams. Potential recreational benefits would be estimated on the basis of recreational use levels on the nonaffected streams.

STREAM SURVEY

A total of 80 stream reaches were surveyed. Of these, 40 were discharge-affected streams and 40 were nonaffected streams. This number of surveys was chosen in order to achieve a sample of sufficient size. More surveys could not be conducted due to budgetary and time constraints.

The geographical distribution of surveyed streams was designed to be similar to the spatial distribution of discharge-affected reaches. Accordingly, we decided to survey a certain number of streams per DNR District, based upon that District's percentage of discharge-affected watercourses (Table 1, Fig. 1).

TIME CONSTRAINTS

In order to achieve a representative sample of frequencies of recreational use

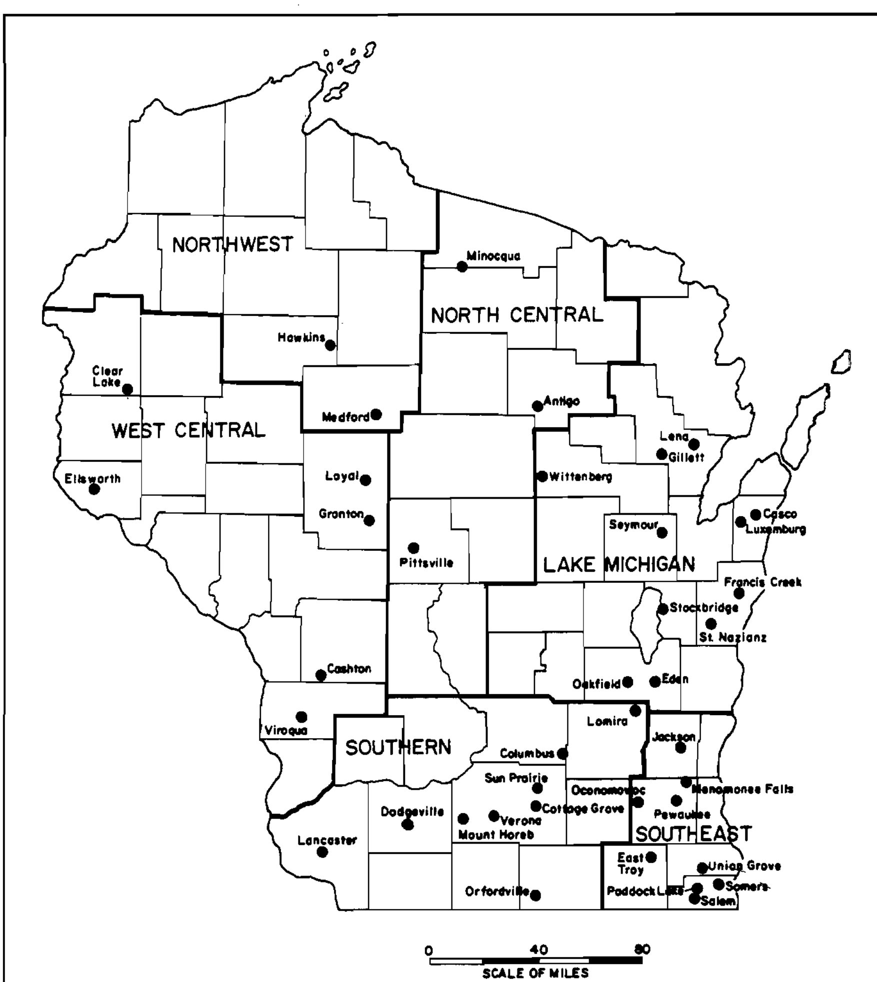

FIGURE 1. *Stream survey locations within DNR districts.*

TABLE 1. *Proportion of stream survey allocated to each DNR District*

District	Number of Municipalities	Percentages of Total Municipalities	Number of Stream Pairs Surveyed
North Central	19	8.3	3
Lake Michigan	71	31.1	12
Southeast	43	18.9	8
Southern	51	22.4	9
West Central	33	14.5	6
Northwest	11	4.8	2
Totals	228	100.0	40

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
JUL. 27	JUL. 28	JUL. 29 Southeast	JUL. 30	JUL. 31 Southern	AUG. 1 Southern	AUG. 2 Southern
AUG. 3 Southern	AUG. 4 North Central	AUG. 5	AUG. 6	AUG. 7 Lake Michigan	AUG. 8 Lake Michigan	AUG. 9 Lake Michigan
AUG. 10 Lake Michigan	AUG. 11	AUG. 12 West Central	AUG. 13 West Central	AUG. 14 West Central	AUG. 15	AUG. 16 Southeast
AUG. 17 Southeast	AUG. 18 Southeast	AUG. 19	AUG. 20	AUG. 21 Southern	AUG. 22 North Central	AUG. 23 North Central
AUG. 24 Northwest	AUG. 25 Northwest	AUG. 26 Southeast	AUG. 27 Southeast	AUG. 28	AUG. 29 West Central	AUG. 30 West Central
AUG. 31 Lake Michigan	SEPT. 1 Lake Michigan	SEPT. 2 Lake Michigan	SEPT. 3 Lake Michigan	SEPT. 4	SEPT. 5	SEPT. 6 Southern
SEPT. 7 Southern	SEPT. 8	SEPT. 9	SEPT. 10	SEPT. 11	SEPT. 12	SEPT. 13

FIGURE 2. *Calendar showing dates of stream surveys for each DNR district.*

of small streams, certain time constraints were incorporated into the survey schedule. Surveys were conducted over all days of the week: both weekend days of expected heavy use and weekdays of expected light use. A schedule of stream surveys was derived so that an equal number of streams would be surveyed each day of the week (Fig. 2). This particular chronology of stream surveys was set up to avoid spatial and temporal bias.

The survey was also designed to assure equal survey frequency over all hours of the day. Planning surveys for all parts of the day was advantageous in that the schedule included times of expected heavy use, e.g., Saturday and Sunday afternoons and weekday evenings, as well as times of expected light use, e.g., mornings and early afternoons on weekdays.

In order to achieve comparability between discharge-affected streams and nonaffected streams, the survey was designed so that the total sample would contain a nearly equivalent number of discharge-affected and nonaffected streams on each day of the week. The time of day of the surveys was designed to be similar in discharge-affected and nonaffected samples.

STREAM SELECTION CRITERIA

Several criteria were used in the selection of the particular streams to be surveyed. Each DNR District was allotted its representative share of the surveys. Locations of the streams to be surveyed within a particular district were chosen from that district's list of municipalities whose treatment plants discharge effluent into small streams. In addition, stream pairs were selected such that various sizes of communities, from a few hundred to a maximum of 32,000, were represented.

A discharge-affected, nonaffected stream pair was chosen for each municipality. The nonaffected stream was nearly equivalent to its discharge-affected partner in every significant respect, except for its lack of discharge from a wastewater treatment plant. Equivalent channel characteristics included continuous or noncontinuous character of flow, amount of flow, and extent of modification of the stream course. Lengths of stream courses through a community, or distances of stream reaches from the community, were kept as equivalent as possible within each stream pair in order to minimize biases in recreational use due to population. It was also advantageous to attain nearly equivalent accessibility characteristics for both members of a stream pair. Furthermore, similar topographic characteristics were required for a discharge-affected stream and its nonaffected equivalent.

A stream reach of approximately 2 miles was surveyed in every case. This distance was selected because the degrading characteristics imparted to streams by the discharge from a wastewater treatment plant (WWTP) were normally assimilated within 2 miles of the discharge point. In addition, it was found that two or three stream surveys per day could be accomplished with 2-mile stream reaches, thereby allowing a large sample of streams to be surveyed within a few weeks' time. Figures 3-6 illustrate examples of the types of stream reaches surveyed.

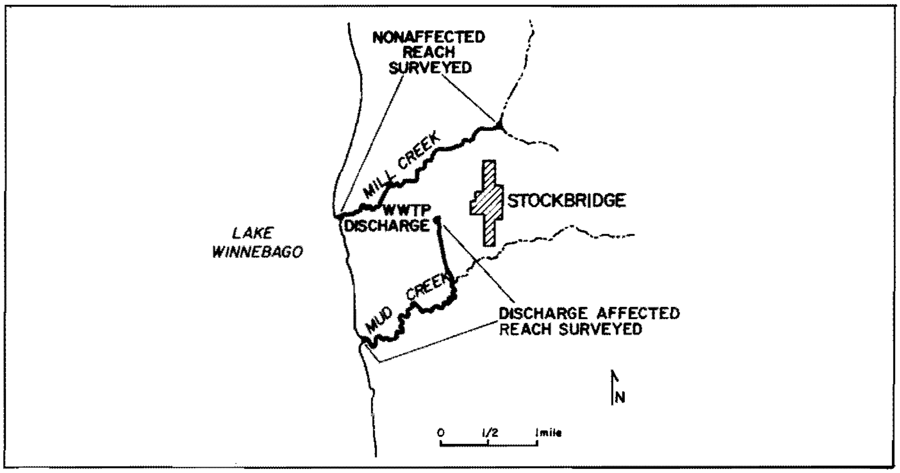

FIGURE 3. *Paired stream reach Example #1 — "Similar but separate streams".*

FIELD SURVEYS

Stream use data collected in the field at the stream site included: (1) recreational use data from stream users, (2) recreational use data from property owners along the stream, and (3) land use data along the stream reach. These data were gathered by walking the stream course and filling out questionnaires and data sheets designed specifically to obtain information about stream use. Where the stream was inaccessible (only a few cases) the surveyor walked as near the stream course as possible. The surveys required a median time of 2¼ hours of field work per 2-mile stream reach. Duration of individual surveys varied from 1 hour for the most accessible streams to 3¼ hours for the least accessible streams.

For collecting data on stream users, each user encountered on the stream was interviewed and type of recreation along with starting and ending times of that use were noted. The user was then asked to estimate the number of days he or she used that stream reach for various recreational purposes within the past year. Age, sex, and residence of the user were recorded, as well as distance from the user's residence to his or her point of recreational use. The location of the stream reach, type of stream (discharge-affected or nonaffected), and time of the interview were also recorded on the questionnaire.

For collecting recreation use data from property owners, the type of property, i.e., agricultural, residential, or commercial (however, no commercial properties were surveyed) was noted. The property owner estimated the frequency of each type of recreational use on the small stream for the entire household for the previous year. The property owner's concept of the stream, age and sex of the property owner, stream reach on which the property was located, and time of interview were also recorded.

Not every property owner on each stream reach was interviewed. Because of time constraints, a maximum of two

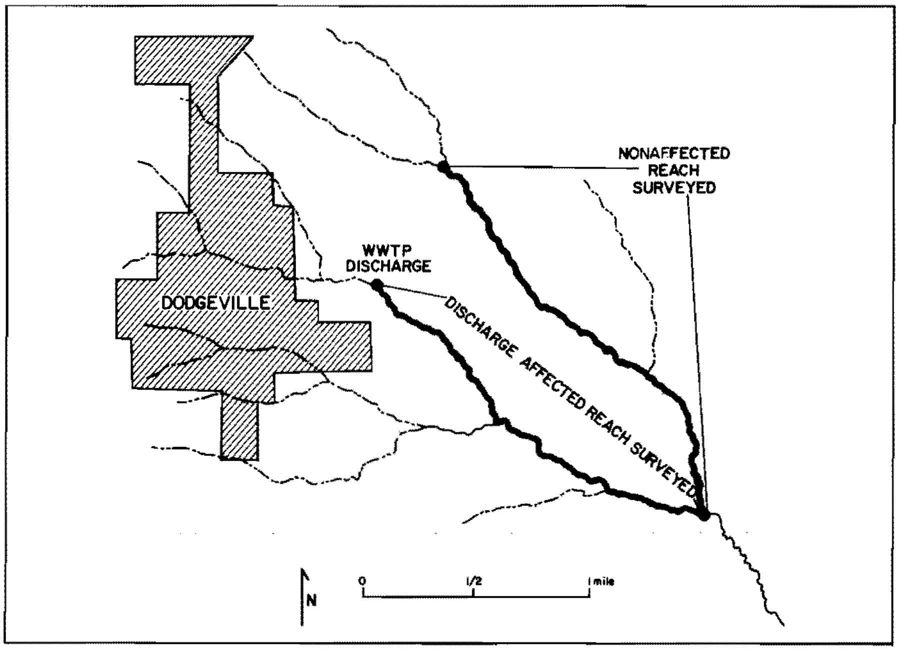

FIGURE 4. *Paired stream reach Example #2 — "Branches of same stream".*

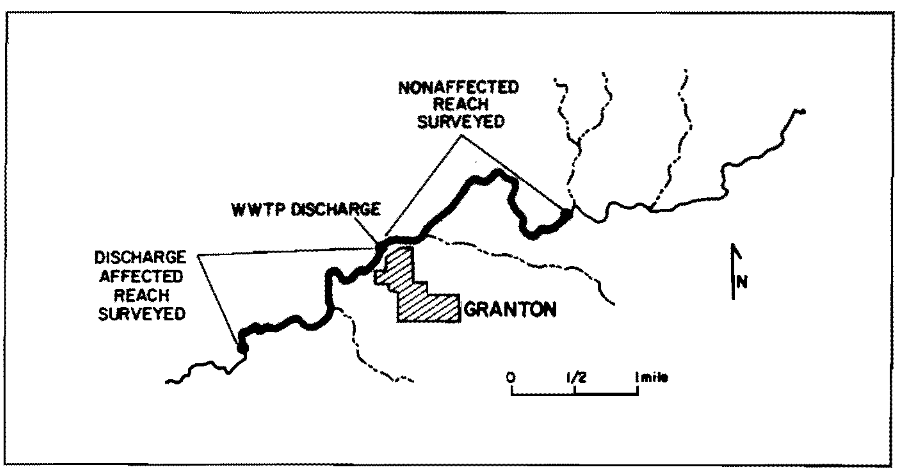

FIGURE 5. *Paired stream reach Example #3 — "Upstream-downstream reaches on single stream".*

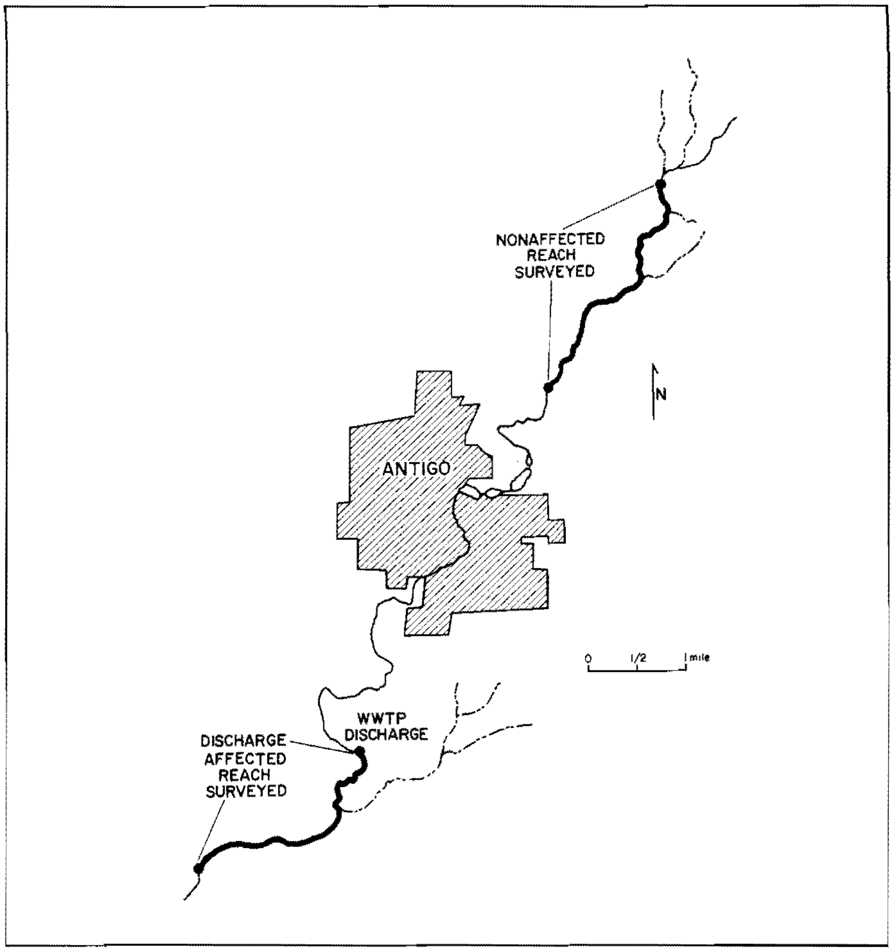

FIGURE 6. *Paired stream reach Example #4 — "Upstream-downstream reaches with community between".*

property owners per stream reach was interviewed. The average number of property owners who were interviewed was slightly over one per stream reach. Lack of property owner dwellings near the stream or absence of property owners from their dwellings resulted in no interviews on 20 percent of the stream reaches.

Very early in the survey it was apparent that use by agricultural property owners varied considerably from that by residential property owners. This difference, in addition to the desire to obtain comparable observations within individual stream pairs, resulted in the implementation of certain criteria in choosing which property owners to interview on individual stream reaches. Wherever possible, both the number and type of property owners interviewed were the same on both reaches of a stream pair. In addition, the total sample of property owners was nearly equally split into agricultural and residential categories to best facilitate comparison of recreational use between these types of property owners.

Land use information, including types of land use and percentage of the stream reach occupied by each land use, was recorded upon completion of each field survey. Characteristics of the channel course, flow in the channel, and channel banks were also observed and recorded. Slopes, relief, and lithology of the surrounding topography were noted. The accessibility of the stream was described, as were weather conditions, time of survey, and location of survey.

CHARACTERISTICS OF STREAM REACHES

PHYSICAL CHANNEL CHARACTERISTICS

The stream channels of the surveyed streams were very small, i.e., generally a few feet wide, and a few inches to a few feet deep. Documented measurements of discharge at points on the stream reaches indicated very low flow (Gebert and Holmstrom 1974). Eighteen percent of the streams had Q7,10 of 0.00. Q7,10 of 0.1 cfs or less occurred on 47 percent of the streams; only 6 percent of the streams had Q7,10 of 1.0 cfs or greater.

Most stream channels were natural; only 38 percent had straightened portions, with only 7 percent of the reaches entirely straightened (Table 2). Discharge-affected streams were more often straightened than were nonaffected streams, most likely because certain discharge-affected streams were constructed to transport wastewater effluent to a nearby natural stream. Reaches with dry or intermittent flow were entirely absent on discharge-affected streams, but occurred on one-fourth of the nonaffected streams (Table 2). This suggests that about one-fourth of the discharge-affected streams would be dry or intermittent, rather than continuous, without the wastewater treatment plant discharge.

About three-fourths of the small streams had rapids along parts of their courses. Rapids were defined to be those portions of the watercourses where the water moved swiftly due to a sudden elevation change in the stream bed. Numbers of rapids varied from one or two per stream reach to hundreds per stream reach. Those streams without rapids were usually straightened reaches on flat topography. The average stream gradient for the entire sample was 18.7 ft per mile, although slopes on individual reaches varied from 2 ft per mile for a few straightened segments on flat topography to over 100 ft per mile in hilly topography near Cashton.

VISIBLE WATER QUALITY CHARACTERISTICS

Vegetation occurred in portions of both types of streams, but was found in a slightly higher percentage of discharge-affected streams (Fig. 7). However, vegetation in the stream bed may have occurred because of a dry bed, agricultural nutrients, or nutrients from wastewater treatment plant discharge, in addition to other factors.

Certain negative water quality characteristics occurred more frequently on discharge-affected streams than on nonaffected streams (Fig. 7). Off-color water and/or excessive algae growth occurred on portions of 62 percent of the discharge-affected streams, but occurred on only 15 percent of the nonaffected streams. Offensive smells were evident on one-fourth of the discharge-affected streams but were not evident on any nonaffected streams.

TABLE 2. *Channel characteristics of small streams*

Channel Characteristic	Discharge-Affected Streams	Nonaffected Streams	All Streams
Average length surveyed	2 miles	2 miles	2 miles
Streams all or partially straightened	48%	28%	38%
Streams entirely straightened	10%	5%	7%
Average portion of stream reach which is straightened	22%	15%	18%
Streams with dry or intermittent flow in portions of the reach	0	28%	14%
Streams with entirely dry or intermittent flow	0	3%	1%
Average portion of stream reach with dry or intermittent flow	0	16%	8%
Streams with rapids	78%	75%	76%
Average gradient of stream (ft./mile)	17.6	19.8	18.7

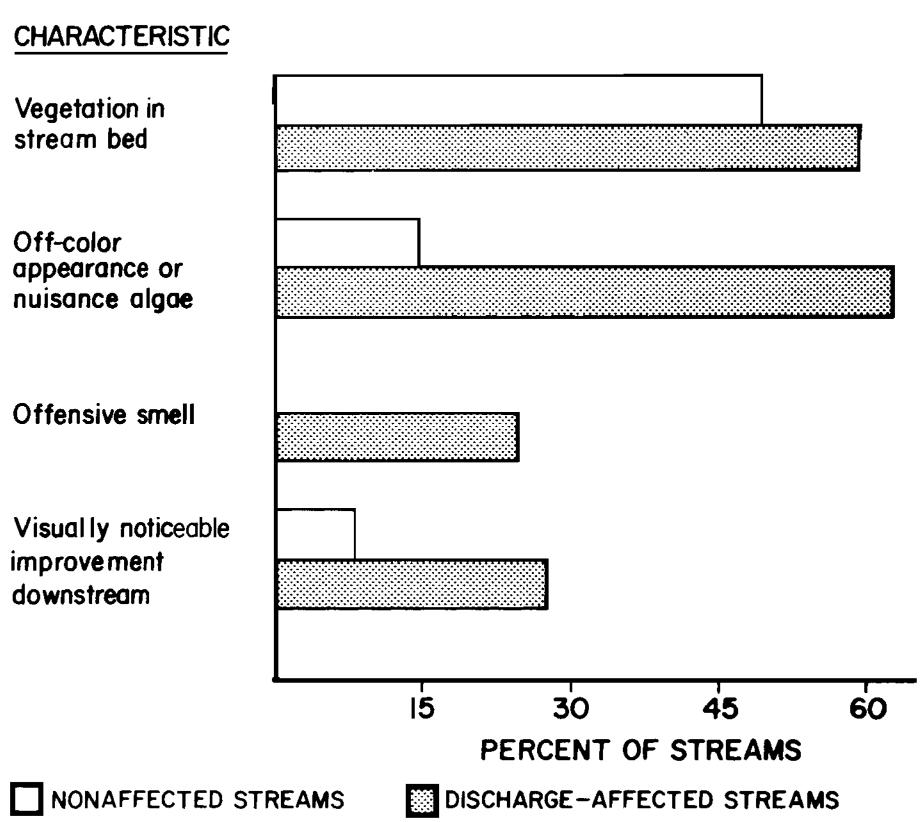

FIGURE 7. *Frequency of selected water quality characteristics.*

TABLE 3. *Accessibility of small streams*

Accessibility	Discharge-Affected Streams	Nonaffected Streams	All Streams
Overall accessibility rating (Percent of streams)			
Inaccessible	33%	15%	24%
Intermediate	42%	52%	47%
Accessible	25%	33%	29%
Transportation crossings per reach (Number of streams)			
Roads	1.18	2.45	1.81
Driveways, farm roads, paths	0.93	0.93	0.93
Railroads	0.18	0.20	0.19
Total	2.29	3.58	2.93
Transportation bordering all or part of stream course (Percent of streams)			
Roads	23%	5%	14%
Paths	3%	18%	10%
Railroads	5%	3%	4%

TABLE 4. *Average land use on small stream reaches*

Category	Discharge-Affected Streams	Nonaffected Streams	All Streams
No. farmsteads and residences/mile	1.2	1.5	1.3
No. animals stockwatering or pasturing/mile	9.8	13.6	11.7
Percent of land in:			
Recreation	1.1	5.7	3.4
Crops	18.5	19.5	19.0
Pasture	28.6	26.1	26.4
Farmsteads and residences	2.4	2.9	2.7
Commercial	0.1	0.2	0.2
Industrial	1.0	0.2	0.6
Forest	23.5	26.4	24.9
Grassland	11.2	9.5	10.4
Marsh	11.4	7.4	9.4
Other	4.0	2.1	3.0

Although many discharge-affected streams exhibited unaesthetic water quality characteristics, these characteristics were sometimes visible only immediately downstream from the wastewater treatment plant discharge. Unaesthetic characteristics disappeared by the end of the 2-mile reach on about one-half of the streams. Streams improved in appearance mostly where many rapids were present and where the amount of flow greatly increased downstream.

Closer examination of those small streams exhibiting negative water quality characteristics suggests that certain properties of the stream reach helped promote these characteristics: for example, low stream gradient, small base flow in comparison to the quantity of discharge from a wastewater treatment plant, or certain agricultural practices, such as heavy fertilization of crops near the stream, or extensive stockwatering of the stream, which introduces large amounts of non-point pollutants into the small stream.

The appearance of the small streams varied during the weeks of survey, probably because of changing weather conditions. Hot and dry weather occurred during the first three weeks of the survey; cooler and much wetter weather prevailed during the final three weeks of the survey. Because the wet weather restored considerable base flow in the small streams, the appearance of the streams was generally more aesthetic during the last three weeks of the survey than during the first three weeks. Because changing weather conditions greatly affect the appearance of small streams, characteristics of a stream on any particular day should not be viewed as typical of conditions on that stream over the long run. On the other hand, since the interval of this particular survey was associated with a variety of weather conditions, this sample of streams probably represents a typical range of small stream conditions occurring over longer periods of time.

ACCESSIBILITY

Accessibility of the streams varied considerably from reach to reach. About one-quarter of the streams were rated easily accessible and another quarter as relatively inaccessible (Table 3). Accessible reaches were associated with recreation facilities, residences, pasture, cropland, and roads or paths following the stream course. Inaccessible reaches were associated with marsh, tall grassland, forest, and lack of nearby transportation routes. Nearly one-half of the streams were rated moderately accessible, i.e., they contained some easily accessible reaches interspersed between some inaccessible reaches.

Accessibility was nearly the same on discharge-affected reaches and nonaffected reaches, except that paths more often followed nonaffected streams than discharge-affected streams. It can be implied that paths more often followed nonaffected streams because these stream reaches offer more aesthetic appeal than do discharge-affected reaches, and therefore are used more frequently. The overall similarity in accessibility most likely prohibits any bias in user frequencies toward either discharge-affected or nonaffected stream types.

LAND USES

Land uses adjacent to watercourses varied from stream reach to stream reach. However, most individual stream reaches were associated with one of three predominant land-use types: usually either forest, pasture or cropland (Table 4). Marsh and grassland each accounted for about 10 percent of the average stream reach. Recreational facilities comprised an average of only 3.4 percent of the stream reaches. Farmsteads and residences, industries, and commercial enterprises occupy even lesser amounts of stream reaches than do recreational facilities. Other uses, associated with 3.0 percent of stream reaches, most often include waste refuse areas, roads and road construction.

Land uses on the discharge-affected streams were similar to those on the nonaffected streams, except for recreation (Table 4). Recreational facilities comprised an average of 5.7 percent of nonaffected stream reaches, compared to only 1.1 percent of discharge-affected reaches. The number of farm animals seen using the stream for stockwatering, or pasturing in the nearby vicinity, averaged 13.6 per mile on nonaffected reaches and 9.7 per mile on discharge-affected reaches. Thus, the frequency of stockwatering and pasturing was 40 percent higher on nonaffected streams than on discharge-affected streams, even though lengths of stream reaches devoted to pasturing were similar on both types of streams.

STREAM USE

USE BY GENERAL PUBLIC

General Characteristics

A total of 38 stream users was interviewed during the entire survey. They were located on 10 of the 80 reaches surveyed; 8 of these 10 reaches were nonaffected streams and 2 were discharge-affected streams. Most users were found in groups of 2 to 7 people. The largest portion of users who were interviewed (40%) were near Milwaukee; the next largest portion (32%) were in east central Wisconsin (Fig. 8). Almost all users were found in either Southeast, Lake Michigan, or North Central DNR Districts (Table 5). No users were seen during surveys in West Central and Northwest Districts.

For all people seen on or near the streams the highest recreational use occurred near Milwaukee and in east central Wisconsin (Fig. 9). This distribution suggests that greatest recreational use of small streams occurs where nearby population densities are highest.

About two-thirds of the users were seen on Sunday. Wednesday, Thursday, and Friday each had a few users; no users were interviewed on Monday, Tuesday, or Saturday. The absence of recreational use on Saturday was a surprise; however, the municipalities surveyed on Saturday were not located in large metropolitan areas, whereas some of those surveyed on Sunday were in large metropolitan areas. This was not intended in the study design; however, the small sample size probably permits large day-to-day differences in number of users encountered. User recreation activity was scattered throughout the day; times of recreation use extended from 8:00 a.m. to 8:00 p.m.

The stream users' residences were generally very near their points of recreation use. Sixty-three percent of the users were within 5 miles of their residences; 40 percent were within 1 mile. Only 13 percent of the users, all found in the North Central DNR District, were at least 100 miles from their residences, i.e., they were vacationing. Thus, there are apparently two categories of small stream users: (1) the majority of users residing in densely populated areas and using streams very near their residences, and (2) a minority of users who are vacationing and using streams far removed from their residences.

A large number of the users were children or adolescents. Two-thirds of the users were 19 years of age or younger; the median age of all users was about 15. Most of the users were youths probably because two-thirds of the survey interval coincided with the summer vacation of the public school systems.

Discharge-Affected Versus Nonaffected

Thirty-two of the 38 interviewed users were on nonaffected stream reaches; only 6 were on discharge-affected stream reaches (Table 6). The majority of all users were either fishing (17) or hiking/strolling (13). Lesser numbers were swimming, picnicking, or engaging in other uses. All users on discharge-affected streams were fishing, whereas users on nonaffected streams engaged in a variety of uses. No boating/canoeing users were encountered, most likely because the flow in most small streams is too small to attract boating or canoeing use.

The 32 users on nonaffected reaches used those nonaffected stream reaches a total of 1,034 days during the previous year, an average of 32 days per user. However, the 6 users on discharge-affected reaches used those reaches only 38 days during the year, or 6 days per user. These data suggest: (1) there are more users on nonaffected streams than on discharge-affected streams, and (2) there are greater frequencies of recreational use per user on nonaffected streams than on discharge-affected streams.

Not all people seen along the stream reaches could be interviewed. In certain cases, users were seen in the distance but had left the stream reach prior to the time that the surveyor was able to reach their point of recreational use. In other cases, large groups of about 50 people were using recreational facilities along a stream, and time constraints did not allow interviews of all these users. Although all users were not interviewed, the numbers of such users and their types of use were recorded. Thus, the total number of users either interviewed or seen along the stream reaches was 312. Of these 312, a large number were using recreational facilities constructed along the stream: 150 were golfing on three golf courses, 50 were in a campground, and another 50 were either picnicking or swimming at a man-made pool during a children's festival. Of those users involved in these large group activities, only 3 people were actually interviewed. In addition, 8 people bicycling or motorcycling, 3 people playing softball, and 13 people hiking/or strolling, were seen making recreational use of the stream reaches, but could not be reached for interviews.

Of the 274 people seen but not interviewed, the majority were making a less direct use of the stream than those interviewed. This large group of less direct users might be termed "secondary" users, whereas the smaller group that was interviewed and was making more direct use of the stream can be termed "primary" users. Even within the primary user group, there are those who use the stream most directly (for swimming and fishing) and those who use the stream less directly (for hiking).

It is noteworthy that a total 295 people were seen using the small streams or recreational facilities along nonaffected stream reaches, but only 17 people were seen along discharge-affected reaches (Table 7). Thus, based on the total number of people seen using small streams or recreational facilities along streams, there is much greater recreational use on nonaffected streams than on discharge-affected streams.

There were 24 man-made recreational

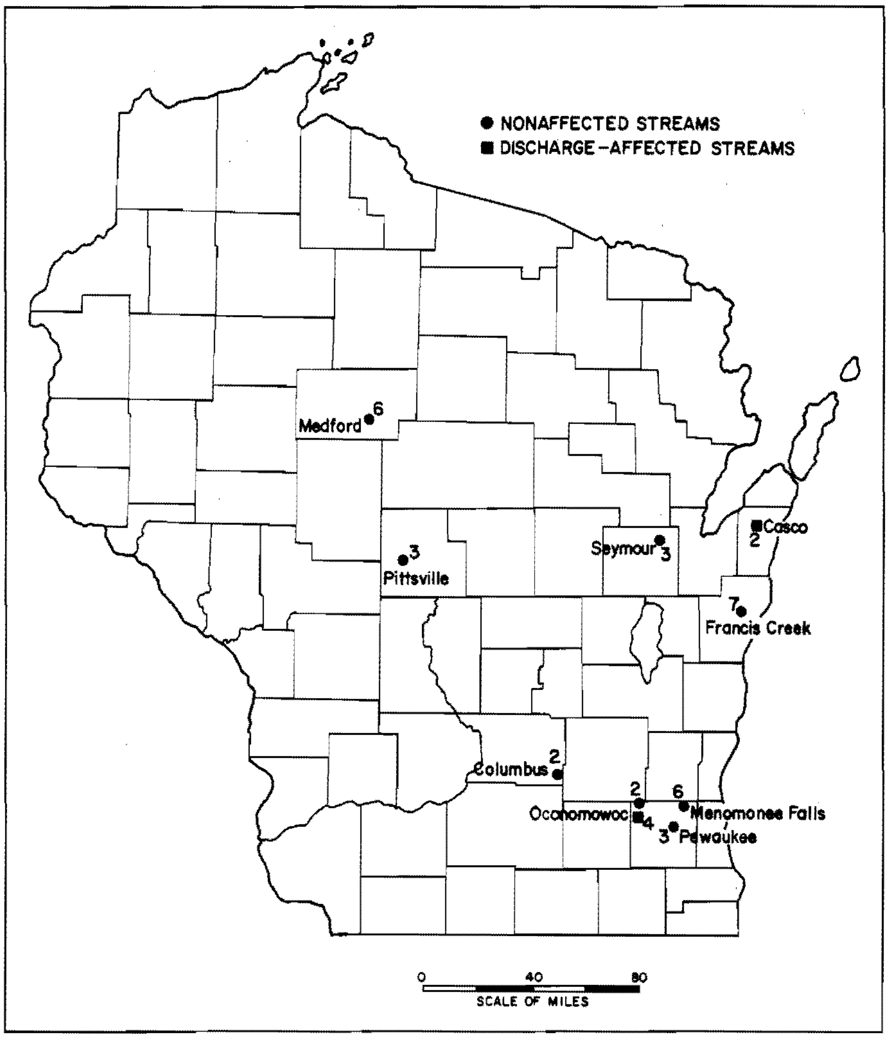

FIGURE 8. *Location and number of stream users interviewed.*

TABLE 5. *Number of users by DNR District*

DNR District	Discharge-Affected Streams	Nonaffected Streams	All Streams
Lake Michigan	2	10	12
North Central	0	9	9
Northwest	0	0	0
Southeast	4	11	15
Southern	0	2	2
West Central	0	0	0
Total	6	32	38

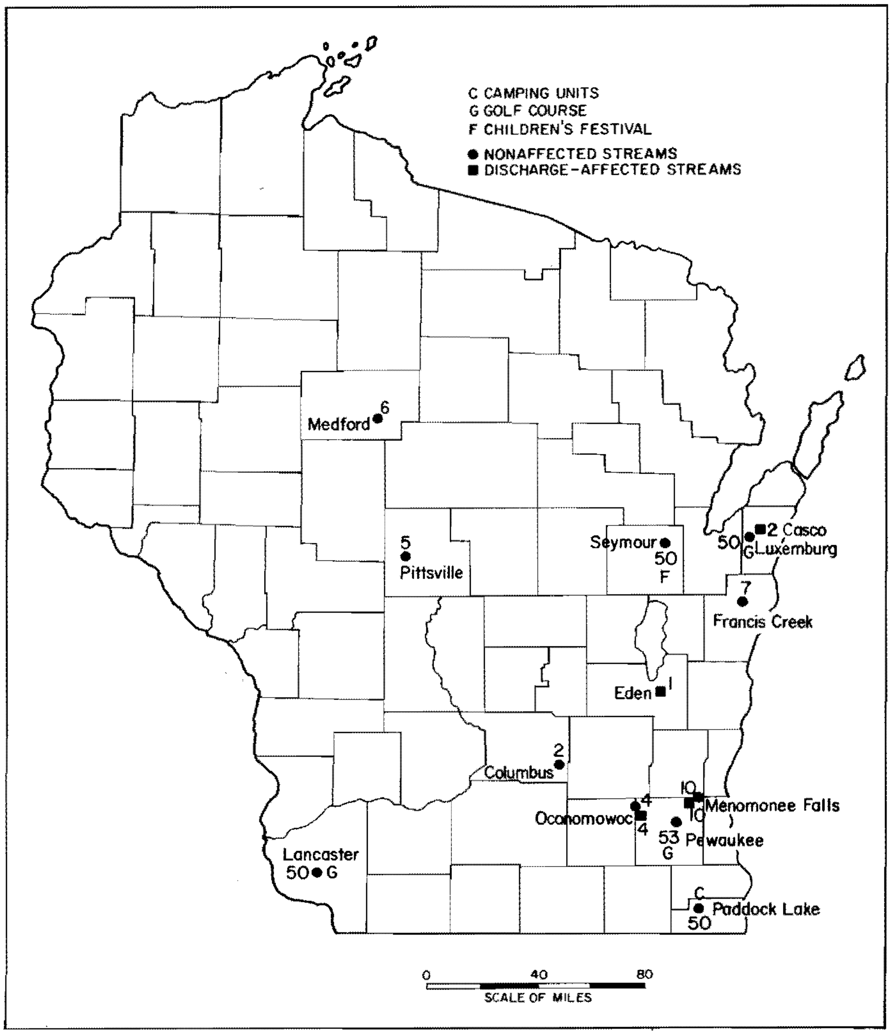

FIGURE 9. *Location and number of all people engaging in some form of recreation on or near small streams.*

TABLE 6. *Number of users interviewed*

Type of Use	Number Interviewed: Discharge-Affected Streams	Nonaffected Streams	All Streams
Fishing	6	11	17
Picnicking	0	1	1
Hiking/Strolling	0	13	13
Swimming	0	4	4
Boating/Canoeing	0	0	0
Other	0	3	3
Total	6	32	38

facilities on the nonaffected watercourses and only 6 on discharge-affected watercourses (Table 8). Frequencies of recreational facilities on nonaffected streams exceeded frequencies of recreational facilities on discharge-affected streams for every type of facility. City parks were located along nonaffected reaches in Granton, Pittsville, Oconomowoc, Menomonee Falls, and Seymour; a city park occurred along a discharge-affected reach only in Menomonee Falls. An "Official Kid's Trout Stream" was surveyed near Gillett. A campground was near Paddock Lake; golf courses were near Lancaster, Luxemburg, and Pewaukee.

Stream Classification Versus Use

User data were compared with the streams classified as continuous (19 streams) or noncontinuous (18 streams). The number of users was much higher on the continuous streams, with 26 users, than on noncontinuous streams, with 3 users.

The number of users was also determined for those streams classified as "fish and aquatic life" (15 streams) and "less than fish and aquatic life" (22 streams). Streams classified as suitable for fish and aquatic life had 26 users, compared to 3 users on streams less suitable.

Streams classified as continuous or suitable for fish and wildlife, therefore, support greater recreational use than do the other small streams.

Recreation Benefits Of Improved Water Quality

The higher number of users on nonaffected streams compared to discharge-affected streams is assumed to be associated with the character of the streams. Restoring to discharge-affected streams those characteristics of nonaffected streams would likely result in an equivalent rise in recreational use levels.

Given these assumptions, it is possible to estimate the recreational benefits of improving water quality on discharge-affected streams. In estimating the potential benefit, the data used are the 32 users on nonaffected streams and the 6 users on discharge-affected streams. It is assumed that this ratio correctly represents the ratio of use between these stream types. The units of recreational benefit to be estimated are expressed in hours per stream mile per year. Since each individual survey took place during only a few hours, a major part of the estimation of the recreational benefit involves exten-

TABLE 7. *Number of people seen along stream reaches undertaking various recreational activities**

Activity	Discharge-Affected Streams	Nonaffected Streams
Fishing	6	11
Picnicking	0	25
Hiking or strolling	6	20
Swimming	0	30
Boating or canoeing	0	0
Camping	0	50
Golfing	0	150
Bicycling or motorcycling	2	6
Other	3	3
Total	17	295

*Not all of these people were interviewed. Refer to text for a detailed explanation.

TABLE 8. *Number of man-made recreational facilities seen along stream reaches*

Type of Facility	Discharge-Affected Streams	Nonaffected Streams
City park	1	5
Private park	0	3
Official kids trout stream	0	1
Pond	5	11
Campground	0	1
Golf course	0	3
Total	6	24

sion of data from the short interval of the field survey to the long interval of an entire year. In this extension of the data it is assumed that the rate of use during the times of survey also occurred during the remainder of the recreational year (summer months).

Because the length of each survey comprised only a small fraction of each survey day, the probability of encountering a recreational user who used the stream reach during that day was rather small. It is even possible that a user was on the stream reach during the survey interval but not seen by the surveyor, because the surveyor had not yet reached the user's location on the stream by the time the user completed his recreational use and left the stream reach. This was especially possible, because the average duration of recreational use was less than the average duration of each survey (1.83 hours versus 2.14 hours, respectively). Thus, the probability of encountering a user, given that he uses the stream on the day of survey is estimated as:

$$P = \frac{\text{average duration of each survey}}{\text{length of recreation day}} \times \frac{\text{average duration of use}}{\text{average duration of each survey}}$$

Assuming that the recreation day is about 12 hours long, and given that 2.14 hrs is the average duration of each survey, and 1.83 hrs is the average duration of use, P is 0.15. This 0.15 probability of seeing a user during the survey, given that he uses the stream on the day of survey, is equivalent to a ratio of 1 user seen in the survey for each 6.67 users on that reach during the entire day.

Given a ratio 6.67 expected users per each user seen, the number of expected users per day per stream reach is:

$$\frac{\text{users interviewed on all streams} \times \text{expected users/user interviewed}}{\text{number of streams}}$$

Based on the 32 users from 40 nonaffected streams, there are, in the mean, 5.33 expected users per day per stream reach on nonaffected streams. Given the 6 users from 40 discharge-affected streams, there are 1.00 expected users per day per stream reach on discharge-affected streams. If these numbers of expected users per day per stream reach are extended over the recreation year, and then divided by the number of miles per stream reach, the number of users per stream mile per year can be estimated. This number is:

$$\frac{\text{expected users/day/stream reach} \times \text{180 days}}{\text{2 miles/stream reach}}$$

Note that the recreation year is assumed to extend over one-half year. The estimated number of users per stream mile per year is 480 on nonaffected streams and 90 on discharge-affected streams. If the number of users is multiplied by the average duration of use (1.83 hours), there are 880 expected hours of use per stream mile per year on nonaffected streams and 165 expected hours of use per stream mile per year on discharge-affected streams (Figure 10).

USE BY PROPERTY OWNERS

General Characteristics

A total of 86 property owners was interviewed, including 43 property owners along discharge-affected streams and 43 along nonaffected streams. The sample was almost equally split into agricultural and residential types; 41 were agricultural property owners and 45 were residential property owners. Of the 41 agricultural property owners, 21 were on discharge-affected streams and 20 were on nonaffected streams. The sample of residential property owners contained 22 from discharge-affected reaches and 23 from nonaffected reaches. In 84 percent of the entire sample of property owners, both the numbers and types of property owners were the same on both reaches of a stream pair.

Owners' Evaluation of Streams

Property owner evaluations of discharge-affected streams were greatly different from their evaluations of nonaffected streams. Only 21 percent of the property owners on discharge-affected streams perceived their streams to be "clean" while 79 percent of the property owners on nonaffected streams perceived their streams to be "clean". Those who classified their stream "polluted" were 72 percent on discharge-affected reaches and 16 percent on nonaffected reaches. About 6 percent of the property owners said they had no opinion, either because they had not observed their stream reach, or because the stream appeared to exhibit both "clean" and "polluted" characteristics at various times.

Those property owners who characterized their discharge-affected reaches as "polluted" most often cited sewage in the stream or discharge from an upstream wastewater treatment plant as their primary reason for designating the reach as "polluted" (Table 9). Negative water quality characteristics, such as offensive smells, off-color water, and excessive algae, were the next most frequently given reasons for categorizing the reach "polluted".

Among the few property owners who classified their discharge-affected reach to be "clean", the most frequent reasons were clean appearance of the stream and lack of debris or garbage. Two of the respondents stated that there was no sewage in the stream. These property owners usually had property near the downstream end of the 2-mile reach, such that most of the degrading wastewater discharges had already been assimilated into the stream.

Property owners on nonaffected streams who said their stream reaches were "clean" most often cited the clear or clean appearance of the stream. Other reasons included no sewage in the stream, presence of aquatic life, no debris or garbage, and spring-fed water (Table 10). Reasons most frequently given by the few property owners for designating their nonaffected stream "polluted" included off-color water or excessive algae, debris or garbage in the stream, death of aquatic life, and industrial waste.

Discharge-Affected Versus Nonaffected

Recreational use by property owners was substantially higher on the nonaffected watercourses than on the discharge-affected watercourses. Sixty percent of property owner households on nonaffected streams used their stream for recreation, while only 27 percent of property owner households on discharge-affected streams used their stream for recreation (Fig. 11). This higher percentage use occurred for each type of use (Table 11). However, these differences were larger for "in-stream" uses (fishing, swimming, and boating/canoeing) and smaller for "near-stream" uses (picnicking and hiking/strolling). Apparently, the degrading characteristics of effluent from wastewater treatment plants decrease in-stream uses more than near-stream uses.

The average frequency of recreation use per property owner household was significantly lower (20 days per year) on discharge-affected streams than on nonaffected streams (53.2 days per year) (Fig. 12). This difference in amount of use is statistically significant at the 99 percent confidence level($P = < .01$). It also occurred for each type of use (Table 11), and was more pronounced for in-stream uses than near-stream uses.

A comparison of recreational use on discharge-affected and nonaffected streams was made for individual stream pairs wherever property owners interviewed occurred on both streams in the pair in equal numbers and types. Figure 13 illustrates the average number of days per year of recreational use per property owner for each reach of the stream pairs. Three types of paired difference are apparent from examination of these individual stream pairs: 1) slightly over half the pairs exhibit greater use on the nonaffected reach than on the discharge-affected reach; 2) about ten percent of the stream pairs are associated with greater

TABLE 9. *Property owner evaluations of discharge-affected streams*

Evaluation	Number Answering	Percent
"Clean"	9	21
"Polluted"	31	72
No Opinion	3	7
Totals	43	100
Reasons for designating stream "Polluted"		
Sewage in stream	19	61
Offensive smell	14	45
Off-color appearance or algae	14	45
Aquatic life killed	8	26
Industrial waste	6	19
Cannot use for recreation	5	16
Cannot drink water	5	16
Debris or garbage in stream	3	10
Others	3	10
Reasons for designating stream "Clean"		
Clear or clean appearance	4	
No debris or garbage in stream	3	
No sewage in stream	2	
Spring-fed water	1	
Can use for recreation	1	

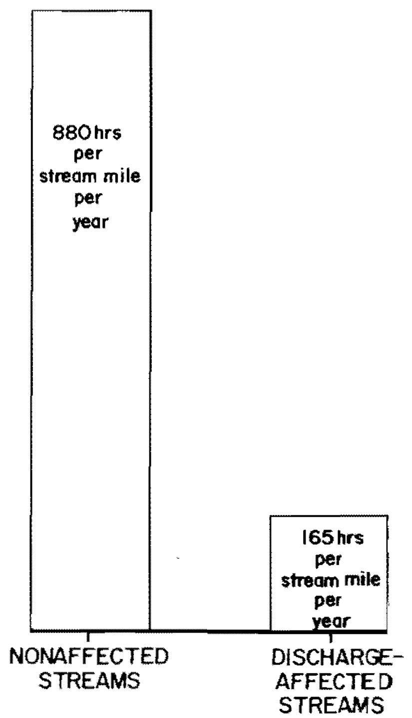

FIGURE 10. *Estimated recreational use of small streams by the general public.*

use on the discharge-affected reach than on the nonaffected reach; 3) and forty percent of the stream pairs appear to have no use on either nonaffected or discharge-affected watercourses. A paired difference test (Mendenhall 1968) was used to assess the significance of differences in recreational use between nonaffected reaches and discharge-affected reaches on individual pairs. Test results showed that property owner use on nonaffected streams was significantly greater than was property owner use on discharge-affected streams ($P= < .01$).

Agricultural Versus Residential

When the entire sample was divided into agricultural property owners and residential property owners, substantial differences in amounts of recreational use were noted between these two groups. Sixty-five percent of the residential households used their watercourse during the year prior to the survey, while only 26 percent of agricultural households used their watercourse (Fig. 14). Greater use by residential households than by agricultural households was evident for all types of recreational use (Table 12). The average annual frequency of use was much greater for residential property owners than for agricultural property owners, 55.0 days versus 16.2 days, respectively ($P= < .01$). A significant disparity was apparent between nonaffected streams and discharge-affected streams within either agricultural or residential property owner categories. For only agricultural property owners, use was significantly higher on nonaffected reaches (45%) than on discharge-affected reaches (9%) (Fig. 15).

Residential property owners also used nonaffected streams for recreation more frequently (73%) than they used discharge-affected streams (45%) (Fig. 16). There were a large number of residential users (45%) even on the discharge-affected streams. Of this, 60 percent occurred in the Southeast DNR District in Milwaukee, Racine and Kenosha SMSAs; 15 percent in the Madison SMSA, and only 25 percent over the remainder of the state. Apparently, the recreation demands on those small streams located in densely populated areas are sufficient to require recreational use on certain discharge-affected reaches. The average annual use for residential households is 74.3 days on nonaffected streams and 34.9 days on discharge-affected streams. The greater recreational use on nonaffected streams is statistically significant ($P= < .05$). Average annual residential household use of nonaffected reaches is about six times as great as average annual agricultural household use of discharge-affected rea-

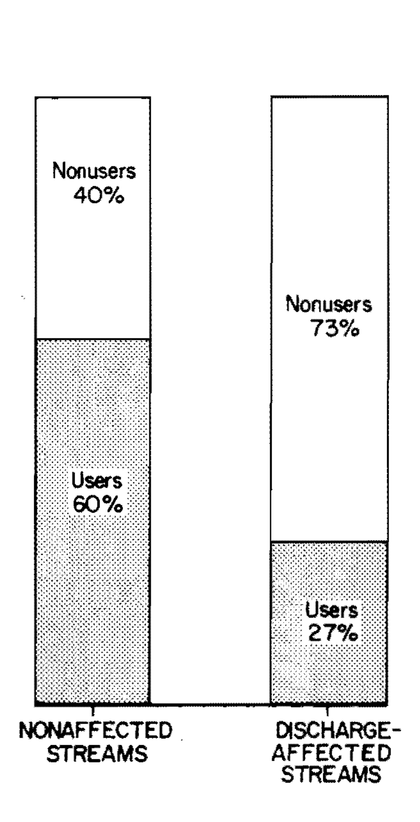

FIGURE 11.
Percentage of property owners who used adjacent stream for recreation.

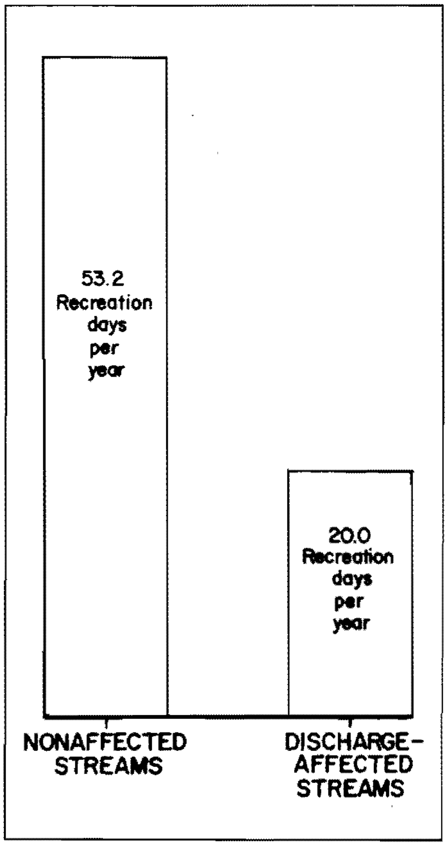

FIGURE 12.
Average frequency of stream recreational use by property owners.

TABLE 10. *Property owner evaluations of nonaffected streams*

Evaluation	Number Answering	Percent
"Clean"	34	79
"Polluted"	7	16
No Opinion	2	5
Totals	43	100
Reasons for designating stream "Polluted"		
Off-color appearance or algae	4	
Debris or garbage in stream	3	
Aquatic life killed	3	
Industrial waste	2	
Offensive smell	1	
Cannot use for recreation	1	
Sewage from houses	1	
Farm animals use stream	1	
Agricultural fertilizers	1	
Reasons for designating stream "Clean"		
Clear or clean appearance	19	56
No sewage in stream	11	32
Aquatic life in stream	8	24
No debris or garbage in stream	6	18
Spring-fed water	5	15
No offensive smell	2	6
Can drink water	2	6

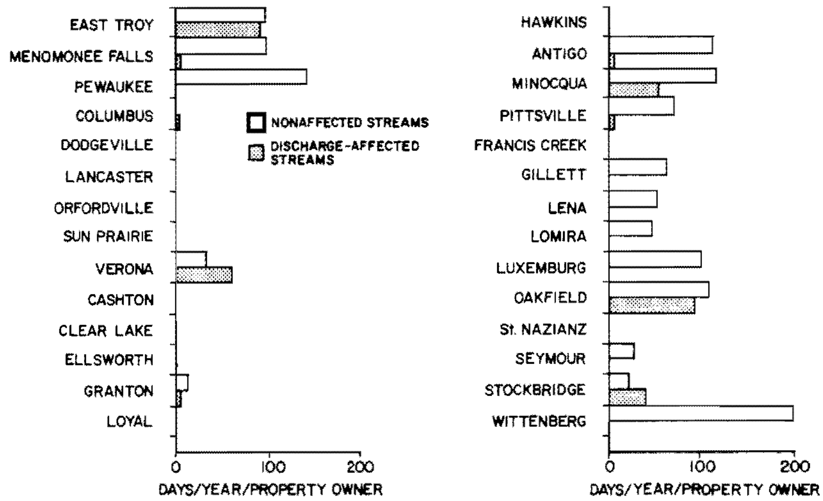

FIGURE 13. *Property owner recreational use — paired observations.*

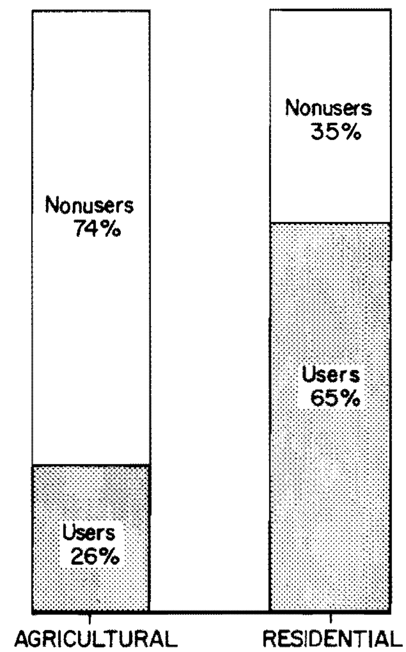

FIGURE 14. *Percentage of agricultural and residential property owners who were stream users.*

TABLE 11. *Recreational use of streams by property owners*

Use Category	Percent Who Use Streams: Discharge-Affected Streams	Percent Who Use Streams: Nonaffected Streams	Percent Who Use Streams: All Streams	Average Use, Days Per Year: Discharge-Affected Streams	Average Use, Days Per Year: Nonaffected Streams	Average Use, Days Per Year: All Streams
Fishing	16	48	32	3.8	13.6	8.7
Picnicking	11	18	15	3.1	3.2	3.1
Hiking/strolling	16	34	25	10.4	20.5	15.5
Swimming	6	25	16	0.5	7.2	3.9
Boating/canoeing	6	18	12	0.5	3.3	1.9
Other*	6	23	15	1.7	5.4	3.5
Total	27	60	44	20.0	53.2	36.6

*Hunting, camping, ice skating, ice hockey, cross-country skiing.

TABLE 12. *Comparison of recreational use of agricultural and residential property owners*

Recreation Type	Agricultural	Residential
Percent of property owners		
Fishing	21	46
Picnicking	7	24
Hiking or strolling	10	43
Swimming	12	21
Boating or canoeing	2	24
Other	5	26
Average number of days per year		
Fishing	6.0	11.1
Picnicking	2.3	4.4
Hiking or strolling	4.1	25.2
Swimming	2.8	4.8
Boating or canoeing	0.4	3.2
Other	0.6	6.3
Total	16.2	55.0

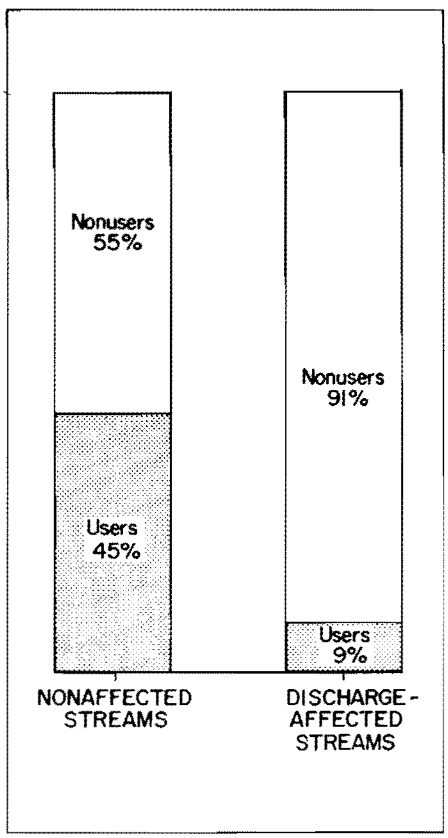

FIGURE 15.
Recreational use by agricultural property owners on discharge-affected and nonaffected streams.

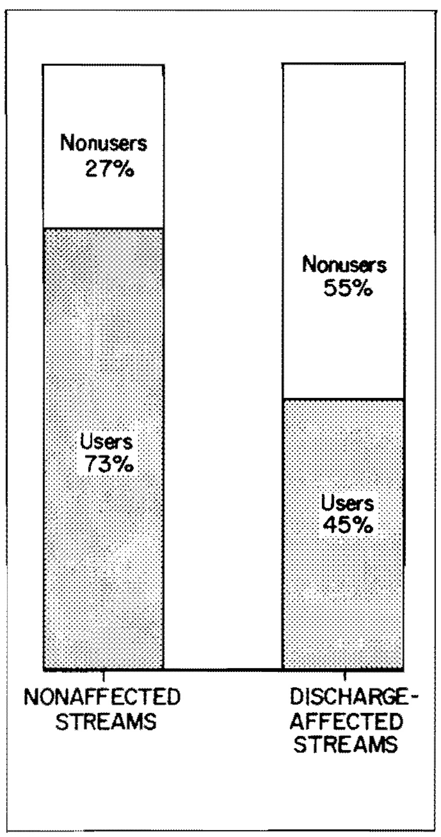

FIGURE 16.
Recreational use by residential property owners on discharge-affected and nonaffected streams.

ches, 28.5 days per year versus 4.6 days per year, respectively (P= < .05).

Stream Classification Versus Use

Property owner recreational uses were compared to hydrologic categories and use subcategories of the small streams. Stream classifications were available for 37 of the 40 discharge-affected reaches in the survey. At the time of the analysis the classifications from West Central and Southeast DNR Districts were only preliminary, while classifications in other DNR Districts were final. Because of the small sample size, the few effluent ditches in the sample were combined with the noncontinuous streams. In every case it was assumed that the nonaffected stream in each stream pair had the same hydrologic and use classifications as did its discharge-affected equivalent.

Recreational use by property owners on continuous streams averaged 51.0 days per year per household. On less than continuous streams (i.e., those classified either noncontinuous or effluent ditch) recreational use was only 25.6 days per year per household, or only about half that on the continuous streams (Fig. 17). The difference is statistically significant at the 95 percent confidence level.

On fish and aquatic life streams the average use was 52.8 days per year; for the streams classified as less than fish and aquatic life the average use was only 27.1 days per year (P= < .05) (Fig. 17).

Therefore, it is readily apparent that recreational use on continuous streams was significantly higher than recreational use on noncontinuous streams. Similarly, recreational use on streams classified as fish and aquatic life was significantly greater than recreational use on streams classified as less than fish and aquatic life.

Small Stream Classification, Water Quality, and Recreational Use

We have seen that recreational use of small streams is associated with the water quality of those streams. It has also been demonstrated that recreational use is related to the hydrologic characteristics of small streams. Recreational use of small streams increases as water quality improves. Is the recreational use related to water quality on all hydrologic categories of streams? Do streams with certain hydrologic characteristics serve to gain the most recreational use when the water quality improves?

For noncontinuous streams, nonaffected streams had only slightly more

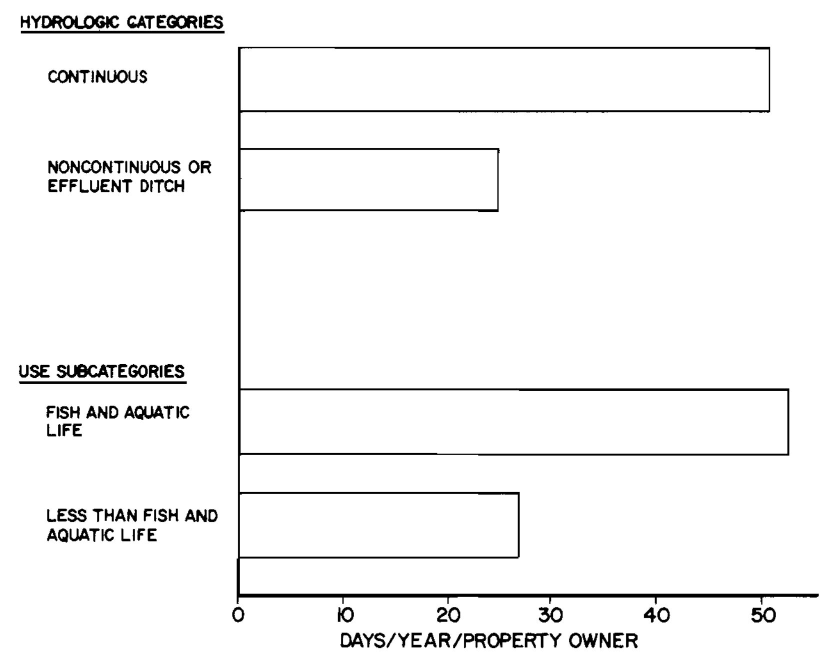

FIGURE 17. *Average recreational use by hydrologic categories and use subcategories.*

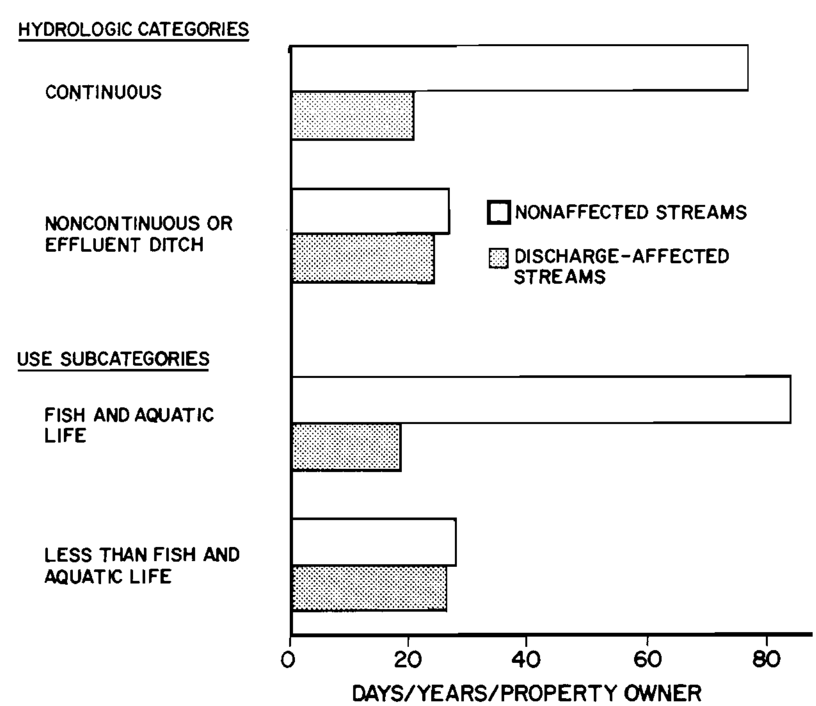

FIGURE 18. *Recreational use on discharge-affected and nonaffected streams for hydrologic categories and use subcategories.*

recreational use than did discharge-affected streams. The same was true for streams classified less than fish and aquatic life (Fig. 18). Apparently, improvement in water quality on streams which do not have continuous flow and cannot support a diverse aquatic life will probably result in little additional recreational use.

On the other hand, improvement of water quality from discharge-affected to nonaffected on continuous and fish and aquatic streams will probably result in great additional recreational use. For continuous streams, recreational use on the nonaffected reaches was nearly four times that on discharge-affected reaches ($P= < .01$) (Fig. 18). On fish and aquatic life streams, recreational use on the nonaffected reaches was nearly five times that on discharge-affected reaches ($P= < .01$).

Recreation Benefits of Improved Water Quality

The significantly greater use by property owners of nonaffected streams implies a substantial recreation benefit to be gained by restoring nonaffected stream characteristics to those streams which are presently discharge-affected. Given the same assumptions used earlier in the calculation of recreational benefits from user data, recreational benefits can be calculated from the property owner data. Amounts of recreational benefits calculated from property owner data serve as a useful comparison with recreational benefits calculated from user data.

The average use per property owner on nonaffected streams was 53.2 days per year, and on discharge-affected streams, 20.0 days per year. Assuming an average duration of use at 1.83 hours (derived from the user interviews), households of the property owners on nonaffected streams averaged 97.5 hours of recreational use per year, and on discharge-affected streams, 36.6 hours of recreational use per year. From county plat books and the surveyor's land use data, it was calculated that each 2-mile stream reach contained an average of 7.8 property owners. Hence all the property owners on the 2-mile nonaffected reaches used these stream reaches an average of 760 hours per year; on the discharge-affected 2-mile reaches, use was 285 hours per year. Therefore, the recreational use was 380 hours per mile per year on nonaffected streams and only 143 hours per mile per year on discharge-affected streams (Fig. 19).

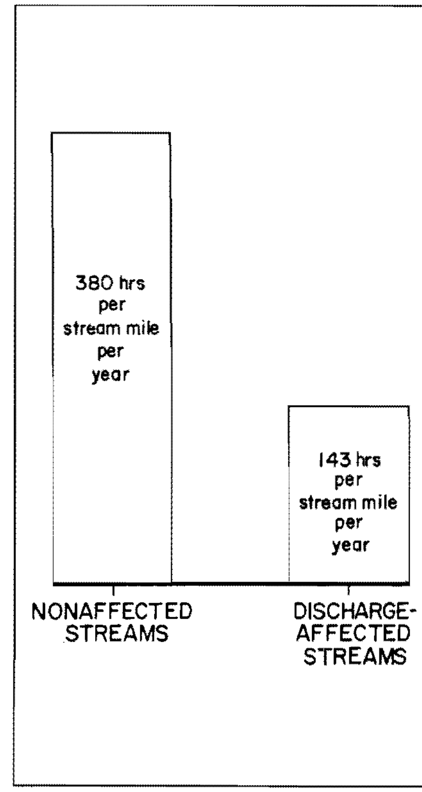

FIGURE 19.
Estimated recreational use of small streams by property owners.

SUMMARY AND CONCLUSIONS

SUMMARY OF RESULTS OF SURVEY

The small streams in Wisconsin are a significant recreational resource. Land specifically oriented toward recreational uses, such as village parks, private parks, hiking trails, and commercial recreational facilities occur adjacent to some small streams. There are considerable amounts of recreational use made of small streams flowing through these recreation facilities. In addition, large amounts of recreational use also occur on certain small stream reaches without adjacent formal recreational development. Amounts of recreational use on small streams, extrapolated from both stream users and property owners, suggest average uses of about 800 hours per stream mile per year. The value of this recreational use cannot accurately be expressed in terms of dollars and cents.

The amounts of recreational use vary from stream to stream, due, in part, to visible physical dissimilarities among the different reaches. One characteristic of small streams which measurably affects recreational use is the presence or absence of discharge from a municipal wastewater treatment plant. Recreational use on discharge-affected streams is considerably less than recreational use on nonaffected streams. The data suggest that there is only one-fourth to one-half as much recreational use on discharge-affected streams as on nonaffected streams. The differences in recreational use between discharge-affected streams and nonaffected streams were found to be statistically significant. Recreational facilities also occurred in greater numbers along nonaffected streams. Discharges from wastewater treatment plants apparently degrade the water quality on many small streams in a way that is noticeable to potential recreational users, thereby lessening the frequency of recreational activities on such streams. Viewed from a more positive perspective, improvement of water qualities on discharge-affected streams can be expected to significantly increase their potential for recreational uses.

However, factors other than the water quality of small streams are related to their recreational use. The type of property along the watercourse apparently is associated with the amount of recreational use found along a stream. Residential households with frontage on small streams made much greater use of their streams than did agricultural households whose farm adjoined the stream.

The hydrologic characteristics of small streams are also related to the frequency of recreational use on those streams. Small streams which experience continuous flow have much greater recreational use than do streams which do not experience continuous flow. The fact that continuous flow permits more types of recreational activities and the establishment of greater fish populations than does noncontinuous flow probably accounts for the larger recreation use on the continuous streams.

Small streams would appear to benefit from improvement in water quality according to the hydrologic category of the stream. Results of this study suggest that recreational use on continuous streams would improve significantly if the continuous streams were changed from discharge-affected to nonaffected. Similar recreational benefits would accrue to streams classified fish and aquatic life when the water quality improves. However, on streams classified as noncontinuous or less than fish and aquatic life, recreational use probably would not measurably increase when water quality improves. Therefore, there appears to be less benefit in improving water quality on noncontinuous streams classified less than fish and aquatic life.

FURTHER IMPLICATIONS

A major conclusion of this study is that the DNR Water Quality Standards Revisions for Small Streams (1976) are in accord with the recreational uses which occur on small streams. In the revised standards, the most stringent criteria are applied to those streams which are continuous and classified fish and aquatic life. It is precisely these types of small streams which would experience the greatest recreational benefits from improved water quality. On the other hand, the standards are less stringent on streams which are noncontinuous and classified less than fish and aquatic life, where improved water quality is less likely to result in significant recreational benefits due to the natural hydrologic characteristics of these streams.

The results of this study lend a measure of support to the policy of state and federal aid to municipalities for construction of wastewater treatment systems. Improved wastewater treatment systems result in higher quality effluent. Discharging higher quality effluent into the receiving small streams leads to improvement in water quality in the small streams. Improvements in water quality can be expected to be closely followed by substantial benefits to those who use the small streams for recreational purposes.

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ACKNOWLEDGMENTS

The author wishes to express his appreciation for the assistance and information provided by the following individuals who greatly aided the preparation of this report: John Cain, (Chief), Roy Christianson and Donald Theiler of the Water Quality Planning Section, and Duane Schuettpelz of the Water Quality Evaluation Section.

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