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An Economic and Environmental Evaluation of Alternative Land Development Around New Hampshire Lakes

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ABSTRACT

The overall objective of the study was to evaluate alternative land developments around New Hampshire lakes. The analytical method used was based on a combination of a mathematical programming model and a phosphorus nutrient budget model. Alternative development patterns, evaluated by their impacts on the lake area environment and area economy, included residential patterns, commercial patterns, and combinations of these two types. Economic impact from each alternative development was measured in terms of net public revenue and total private expenditures to the local area, to the State and to other states. The impact of the alternative developments on the lake area environment was measured in terms of crowding levels and the level of phosphorus concentration in the lake. Phosphorus loading of the lake water was used as a proxy variable to reflect the changes in the lake water quality.

Commercial developments yielded the highest revenues to the town and local areas. It also attracted the most lake users to the area as well as contributing the largest phosphorus loading in the lake waters. Residential developments, although contributing high total revenues to the area, yielded less net revenue to the town. Phosphorus loading levels from residential developments were much lower than lake phosphorus loading by commercial developments.

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AN ECONOMIC AND ENVIRONMENTAL EVALUATION OF ALTERNATIVE LAND DEVELOPMENT AROUND NEW HAMPSHIRE LAKES

By

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INTRODUCTION

The State of New Hampshire has an abundance of recreational lakes. There are roughly 1400 standing water bodies; counting all natural water bodies, natural water bodies controlled by dams, artificial impoundments and larger river impoundments. Of this total, 780 water bodies are ten or more acres in size. Lake Winnipesaukee is the largest lake in the State. There are nineteen lakes in New Hampshire with 1,000 to 7,500 acres and sixteen with 500 to 1,000 surface acres. Smaller water bodies are numerous. (New Hampshire State Planning Project, 19.)

Lake (or reservoir) related land development for recreation and second home purposes has been shown to contribute to local and regional economics (29, 10, 11, 4, 6, 16, and 23). Very isolated areas may not be greatly affected economically (18), but most New Hampshire lakes are not located in such isolation.

Current lake-related land development in New Hampshire consists of residential areas and commercial-industrial development. The residential areas range from permanent homes on the lakeshore to vacation type second homes of a seasonal nature. Most lake-related industries are based on recreation services. The principle ones include: vacation cottages, youth camps, motels

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(providing vacation by the week), tenting and mobile parks, marinas, and boat building industries. Secondary services include: retail outlets such as grocery stores, repair services, road construction, cottage construction, real estate, financial services, and public services. Certain areas have reached a level of development where entire shopping centers and service areas are based solely on the lake development.

Widespread and rapid lake related development in the past decade prompted numerous communities to instigate zoning ordinances and planning commissions which previous to 1967 had no such organizations. They fear that lakes may become overpopulated, overdeveloped, or misdeveloped. The 780 lakes (excluding Lake Winnipesaukee) have an average shoreline length of 2.7 miles. Due to the very irregular shoreline of most New Hampshire lakes, a large amount of shoreline is available for cultural development in relation to the amount of water surface acreage. This high shoreline to water surface acreage ratio increases the possibility of damages to the lake water quality due to extensive recreational development.

The New Hampshire Water Supply and Pollution Control Commission has listed 11 lakes and four bays on Lake Winnipesaukee as exhibiting moderate to severe eutrophic (algal) problems. A detailed study by Douglas Lash (1) has associated those lakes classified as problem lakes to having experienced either a high nutrient load from a feeder stream or to having a rather long retention time.

Kesar Lake in Sullivan County and Lake Winnisquam, located in Belknap County, were classified among the most severe problem lakes because lake-destined effluents from point sources carried nutrients in quantities ideal for algal growth. On the other hand, lakes that were found to exhibit an algal problem with no known point sources included: Mirror Lake, Woodstock; Governor's Lake, Raymond; Angle Pond, Sandwich; Captain Pond, Salem; and Partridge Lake, Littleton. These latter lakes had generally suffered, at most, one algal population of 'bloom' proportions, although localized algae problems were generally reported annually. These lakes share the characteristics of small forested watersheds with minimal drainage systems and no inlets (Lash, 1). These hydrological characteristics give the lake a long water residence time, causing nutrient load accumulation in the waters. The higher nutrient concentrations stimulate additional plant growth, accelerating the lake's aging process. Short lake residence time allows for more rapid removal of these nutrients, limiting the plant growth in the lake and slowing down lake eutrophication.

Lake water users have been demonstrated to be aware of the lake water quality (3 and 15). Yet, few studies have examined economic and environmental impact simultaneously for interaction and tradeoffs which may exist.

Objective of the Study

The overall objective of this study was to evaluate alternative economic futures for lake and related land resources and the impact of these futures on the ecological and environmental features of the area. Because the impact of lake-related land resource development on the environment was believed to depend on geological and hydrological features of the area, an attempt was made to integrate the respective features of the overall problem. The reason for this approach was to establish guidelines for lake-related resource development.

GENERAL PROCEDURE

Lake-related land uses around New Hampshire lakes were studied and a list of typical uses was established. The land uses represented the most common types of water recreation oriented developments. Each use was identified by size of land holdings, location on the lakeshore, lake usage, and other characteristics relevant to the study. Table 1 presents these general characteristics for each of the land use developments.

A mathematical programming model was developed to analyze the different lake-area developments. The simplex linear programming method was modified to include environmental quality constraints and income generated in the public and private sectors. The model was constrained by the physical features of the lake and related land area. Alternative futures were developed and the objective function was modified in order to evaluate each alternative.

Vollenweider (32) developed guidelines for determining trophic lake water quality status and Dingman and Johnson (8) developed a method for predicting the accumulative "environmental" effects over time. Their procedures were incorporated in the analysis.

Water Quality

The major concern about most lakes is the acceleration of eutrophication. Eutrophication is a normal phenomena occurring in water bodies; it is simply the natural aging process and is characterized by large populations of plants. Typical features at the outset of eutrophication include a quantitative rise in the biomass (macrophytes and periphytic algae); changes on the littoral, benthic, and planktonic fauna, and in the fish population; and the decreasing transparency and changing water color, as well as the overall decline in the hypolimnic layer oxygen content in the summer (Vollenweider, 32). However, when conditions accelerate the aging process, the natural system is replaced, the life of the lake is shortened, and algal blooms may occur.

Phosphorus and nitrogen are generally considered to be the two main nutrients involved in the lake eutrophication process. Nitrogen is plentiful and exists in various inorganic and organic forms such as nitrite, ammonia, and nitrate nitrogen. These compounds are very soluble and are easily leached

Table 1. Summary of selected land use activities.

Land use	Capacity[1] s	m	l	Land[2] s	m	l	Shore[3] line	Second[4] tier	Usage[5] public	private
Vacation home, private	x	x	x	x	x	x	x	x		x
Vacation home, cluster dev.	x	x		x	x		x	x	x	x
Condominium		x	x	x	x		x	x		x
Marina	x	x		x	x		x	x		x
Campground	x	x	x		x	x	x	x	x	x
Boat Landings		x		x			x		x	x
Beaches		x		x			x	x	x	
Cabins	x	x		x	x		x	x		x
Motels		x			x		x			x
Lodges		x			x		x			x
Idle Land				x	x		x		x	x

1. This category includes: number of units, slips, sites and people served summarized by small, medium and large size capacities.
2. Land describes the acres of first tier land owned where small describes land holding of less than one acre; medium, one acre; and large, over one acre.
3. Shoreline describes the footage of shoreline owned.
4. Second tier describes the amount of second tier land owned by the land use activity.
5. Public and private usage describes the level of use of each activity.

from the soils into groundwater and surface waters. Phosphorus, an essential element for aquatic plants, in natural waters is often low enough in concentration to limit plant growth. Phosphorus is considered the most limiting nutrient in lakes (Shannon and Brezonik, 26). Limnologists generally accept nutrient load levels in the lake waters, especially phosphorus amounts, as a reliable proxy for lake water quality. The indicator of eutrophication and water quality used in the analysis was the phosphorus concentration in the lake.

Vollenweider (32), and Dillon and Rigler (7), developed the relationship between the nutrient phosphorus and trophic level of lakes. This relationship was the basis for determining permissible loading ranges of phosphorus. For distinguishing between oligotrophic and eutrophic states, two phosphorus loading levels were identified; permissible and dangerous. Lakes with phosphorus loadings less than the permissible level were classified oligotrophic; those with loading above the dangerous level were classified eutrophic. There was an unidentified area in between the permissible and dangerous levels. Permissible loading levels varied among lakes because of different nutrient assimilative capacities. Vollenweider developed the relationship between total phosphorus loading, mean depth, and water residence time. Two updates of Vollenweider's original work (1968) were available for this study.

Dillon and Rigler (7) and Dingman and Johnson (8) used lake hydrological characteristics in predicting the nutrient accumulation potential for many New Hampshire lakes. Dingman and Johnson (8) employed water-balance and mass-balance equations to attain an expression for the concentration of a dissolved nutrient in a lake as a function of time. Complete mixing was assumed. Their equations reduce to the following:

1) $$C_1 = C_p + C_s + C_g + (C_a e^{-1/t_w})^t$$

where

C_1 = concentration of dissolved constituent in lake;

C_p = average annual concentration of dissolved constituent in precipitation;

C_s = average annual concentration of dissolved constituent in stream inflow;

C_g = average annual concentration of dissolved constituent in groundwater inflow;

C_a = preceding year's initial lake nutrient concentration;

t_w = lake residence time;

t = time.

This equation was used in the phosphorus analysis of the study. The primary study lake has an average residence time of 1.4 years and an average depth of 34 feet.

Another important water quality measure is fecal coliform bacteria. The presence of coliform bacteria in water is generally accepted as an indicator of recent fecal-waste contamination. The State of New Hampshire recommends for primary-contact recreation, such as swimming, that the count does not exceed 250 colonies per 100 millilitres. Most New Hampshire lakes have very low coliform counts (under 100 colonies per 100 millilitres). Other water quality indicators include: water temperature, light penetration (secchi-disk visibility), dissolved oxygen content and the specific conductance of the water.

In addition to water quality evaluation as an indication of environmental quality, lake and lake area crowding was measured. The additional environmental quality indicators were lake surface use, beach area use, and user days.

Source of Data

Data on lake-related land use were collected within the Lakes Region of New Hampshire, mostly along the eastern border of the State. Primary data were obtained by survey using a stratified sampling technique. Eighty-five vacation home owners and eighty-three lake-oriented business establishments were included in the sample.

The questionnaires were designed to determine the economic impact of each land use type and covered expenditures within the State and outside the State. Off-season and summer season distinctions were made on each expenditure item because prices tended to change with the time frame. The survey schedules also contained questions which provided information for specifying the physical characteristics of each lake-oriented land use (land acreage, size of buildings, size of family, number of people served, facilities provided, etc.).

Secondary data were obtained from the following sources: 1) Lake associations; 2) Soil Conservation Service, U.S. Department of Agriculture; 3) Town records and annual reports, Carroll County; 4) Environmental impact studies involving phosphorus budget equations; and 5) Census publications, U.S. Department of Commerce. Lake associations were a valuable source of information on past history, density of development around the lake, hydrological data from past testings of the waters, residential attitudes and references to other individuals of the town community who might have been of further help regarding the study. The lake associations were the only source of specific hydrological testing of the lake waters.

The Environmental Protection Agency (30 and 31) has measured the contribution to the annual phosphorus load of a water body by the type of land uses found in the watershed. These data were used to establish the average yearly phosphorus contribution to the lake from each land use type located in the watershed. The initial load of phosphorus in the lake before any development occurred on the shoreline was determined through ortho-phosphate testing of the sample lake and was provided by the lake association.

Soil types were essential in evaluating the environmental impact of each land use as porosity of the soil, slope of the soil area, soil features affecting the use of the area (stoniness, etc.) plus other soil qualities ultimately determined the rate of nutrient influx into the lake. This information was obtained from soil surveys.

Public expenditures by local governments to supply town services to the area were included in the model. Because select census data for the public sector was available only on a county level, a representative county had to be chosen. Carroll County was chosen because it was representative of an area with many lakes. Per capita town service expenditures used in the study represented the average per capita public service expenditures incurred by the towns in Carroll County, New Hampshire. It is possible that lake areas located within a town might influence the town's public service expenditures when compared to expenditures of towns without lake areas; however, possible differences were assumed to be slight and would not bias the results.

THE ANALYTICAL MODEL

The Objective Functions

Two forms of objective functions were used in the model.[1/] The first form of an objective function was a maximization of local private expenditures (expenditures in the private sector) and net revenue to the town (public sector). The second objective function form diverged from the usual optimizing technique. Objective function values were assigned such that predetermined lake-area development conditions were evaluated on the basis of their economic and environmental effects on the local area. These lake-area conditions were possible outcomes of alternative local area policies.

Activities and Constraints

The model consisted of 35 activities and 73 rows. (The original matrix is found in Appendix C, Pickering, 21.) The activities in the model included all the lake-recreation oriented land uses presented in Table 2. A detailed description of each of the land uses in the model is found in Appendix B. The rows covered four different sectors which were: 1) Public sector income and costs, 2) Resource constraints, 3) Private sector expenditures, and 4) Land use constraints.

Public sector incomes and costs from each land use type are found in rows 1-7 of the model. (See Table 3.) *Real estate tax, Property evaluation, Rooms and meals tax* and *Other licenses* measured the income to the State and town from each land use. Town costs of providing and maintaining public services, listed in rows 3-5, included: *Fire and police protection, Roads and highways maintenance,* and *Overhead and legal expenses.*

Resource constraints in the model, listed in rows 8-15, described the lake's inherent physical ability to support development. The first three resource constraints: *Shoreline length, Land acreage,* and *Land acreage 1000'* described the physical characteristics of the lake. *Shoreline length* is self-explanatory. The land constraints described the total acreage around the

[1/] The mathematical expression of the programming model used in the study is found in Appendix A.

Table 2. Summary of specific land use activities.

Column	Description
1.	Vacation home type 1, small home, small lot.
2.	Vacation home type 2, medium home, medium lot.
3.	Vacation home type 3, medium home, medium lot.
4.	Vacation home type 4, large home, large lot.
5.	Vacation home type 5, large home, large lot.
6.	Vacation home type 6, large home, large lot.
7.	Vacation home type 7, large home, large lot
8.	Vacation home type 8, large home, large lot.
9.	Vacation home type 9, large home, large lot.
10.	Vacation home type 10, large home, large lot.
11.	Vacation home type 11, second tier home.
12.	Vacation home type 12, second tier home.
13.	Vacation home type 13, cluster development.
14.	Vacation home type 14, cluster development.
15.	Youth camp, 275 boy/girl camp, public.
16.	Youth camp, 150 boy/girl camp, public.
17.	Youth camp, 150 boy/girl camp, private.
18.	Large condominium.
19.	Small condominium.
20.	Small marina.
21.	Large marina.
22.	Transient campground.
23.	Seasonal campground.
24.	Large campground.
25.	State campground.
26.	Private landings.
27.	Public landings.
28.	Public beach.
29.	6-unit cabins.
30.	17-unit cabins.
31.	30-unit motel.
32.	High income lodge.
33.	Idle land, first tier, publicly owned.
34.	Idle land, second tier, privately owned.
35.	Idle land, first tier, privately owned.

Table 3. Public sector incomes and expenditures.

Row	Description
1.	Real Estate Tax
2.	Property Evaluation
3.	Fire and Police Protection
4.	Roads and Highways
5.	Overhead Legal
6.	Rooms and Meals Tax
7.	Other Licenses

Table 4. Lake resource constraints.

Row	Description	Quantity
8.	Shore Length	750,000 Feet
9.	Land Acreage - First Tier	684 Acres
10.	Land Acreage - Second Tier	1512 Acres
11.	Lake Surface Weekday Use	1300 Boats/acre
12.	Lake Surface Weekend Use	2600 Boats/acre
13.	Phosphorus Loading Level	.037 g/m^3
14.	Beach Swimming Days	3750 ft^2/day
15.	Direct Lake Use Days	22,500 days per season

study lake that was available for development. *Land acreage* measured the available acreage on the first tier of the shoreline, and *Land acreage 1000'* described the available land acreage on the second tier (up to 1000' deep). The last four constraints measured different quality aspects of the lake area. *Lake surface usage* was used as a physical crowding limit to motor boat usage and was separated by weekday and weekend limits. *Beach swimming* was a crowding constraint restricting the total number of people to use a public area in a day. The constraint, *Phosphorus loading level*, restricted the influx of the nutrient phosphorus into the lake waters. The final constraint, *Direct lake use days*, indicated the maximum number of days allowable in direct lake use before the area began to lose its aesthetic value. Table 4 lists the limits of each of these constraints for the sample lake.

Private sector expenditures, including area employment for each land use type, are found in rows 16-38 of Table 5. The number of people employed in each land use activity, distinguished by area and season, is listed in rows 16-20. These employee distinctions included: *Year-round employees, Seasonal local employees, Seasonal in-state employees, Seasonal out-of-state employees,* and *Unpaid family members*. Rows 2-35 represented the yearly private sector expenditures according to each land use type. They included: *Building repair, Publicity and advertisement costs, Groceries, Goods resold, Household supplies, Utilities,* and *Other*. The final three rows (36-38) described the *Gross sales* from lake-oriented businesses. Sales included retail sales (supplies, groceries, boats, etc.) and services sales (rentals and repairs).

Land use constraints, rows 39-73, defined limits for each land use. The lake area must be able to economically and physically support the combinations of land uses in the lake watershed. For example, the sample lake area could economically and physically support only a limited number of large marinas. Over-saturation of marinas along the lakeshore would reduce the marina revenues and the aesthetic quality of the lake and lake area. These constraints maintained a limit on the level of each land use type allowable for lake development. Land use constraints were used to evaluate alternative local policies.

Alternative Development Types

In Alternative Development Type 1, the study lake was assumed to be in a natural state, with only forest and a small acreage of agricultural land surrounding the lake. (See Figure 1.) The major influx of phosphorus came from agricultural and forested aand runoff and groundwater seepage. Phosphorus from the atmosphere was also included in the total influx level.

Alternative Development Type 2 represented the current level of development around the study lake. Roughly 30-35% of the first tier land area was developed. This development included seasonal vacation homes, 6-unit cabins, private landings and a transient-based campground. The second tier of the lake was mostly forested land.

Alternative Development Type 3 used the current study lake status, Development Type 2, as a point of departure. Development alternatives 3a and 3b described a local policy alternative, where the lake area was placed under two-acre residential zoning regulations. Type 3 represented first-tier usage with the second-tier left in forest. Lake development trends indicate that second tier usage will occur on most lakes in the future. Alternative Development 3b described two-acre residential usage on both tiers.

Alternative Development Type 4 (initiated from the current level of lake Development Type 2) represented complete residential development around the study lake. The development consisted of small acreage land holdings (1/8 to 1/2 acre) with a small-sized home. This development type resulted in the highest vacation home density and congestion around the lake. No acreage in the first tier remained idle. Development Type 4a allowed the second tier to remain as idle land while the first tier was crowded with small vacation homes. Type 4b allowed the same density vacation home development in the second tier as well as in the first tier.

Alternative Development Type 5 began with an initially forested lake area, as in Alternative Development Type 1. Lake-oriented commercial developments were then inserted around the lake until the area was filled. This development type represented complete commercial development of water-related land resources.

For Alternative Development Type 6, net public revenue was maximized. Net public revenue was quantified in terms of total town property tax income from lake-oriented land uses less the town costs of fire and police protection, town building upkeep and other services provided to the residents.

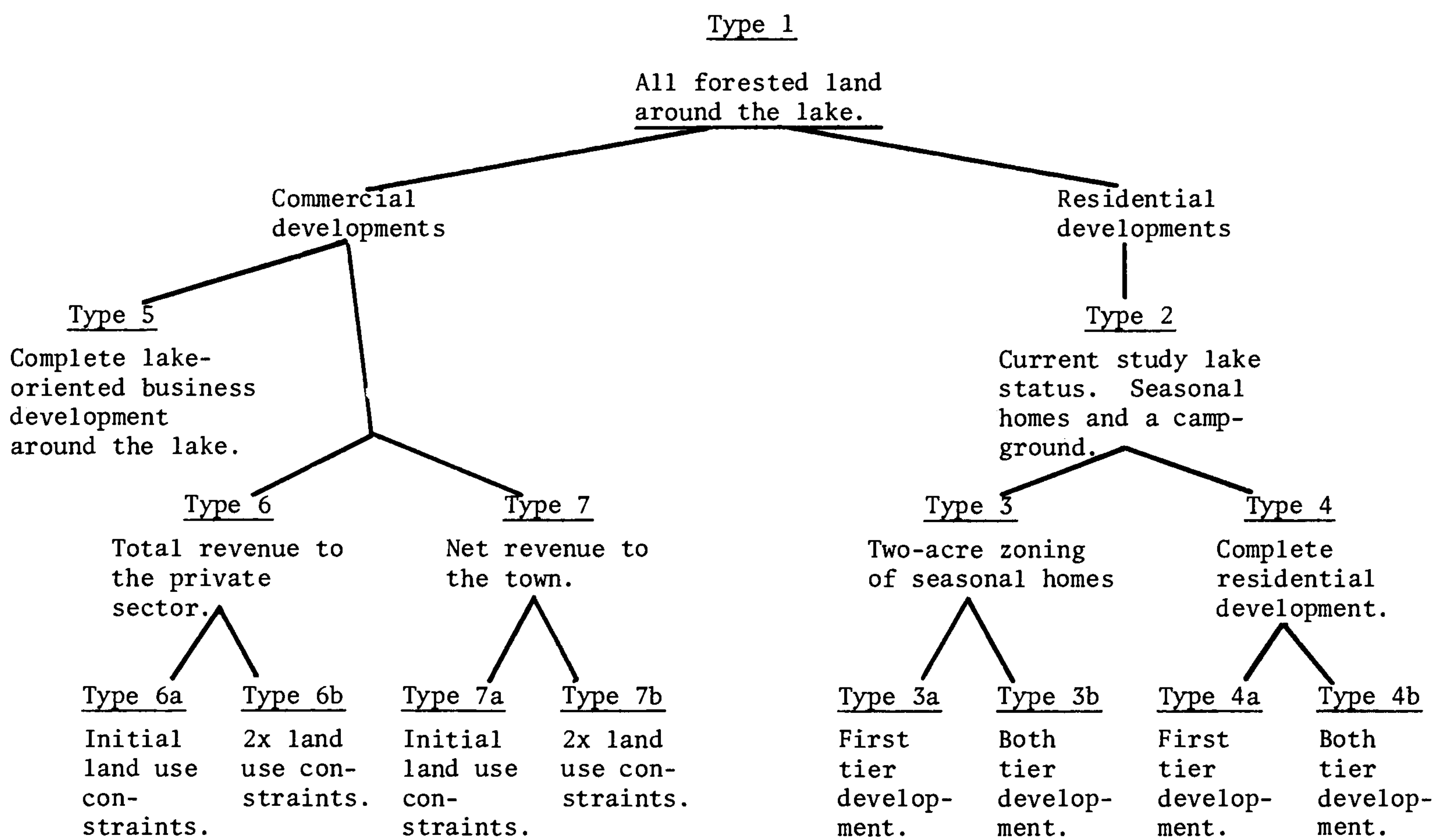
Land use type constraints allowed a wide range of alternatives to be considered for Alternative Development 6a (see Table 2). Alternative Development 6b was based upon land use constraints twice as large as they were in Alternative Type 6a.

For Alternative Development Type 7, local expenditures in the private sector in Alternatives 7a and 7b were maximized. Private sector services

Table 5. Private sector expenditures.

Row	Description
16.	Year Round Employees
17.	Seasonal Local Employees
18.	Seasonal State Employees
19.	Seasonal Out-of-State Employees
20.	Unpaid Family Employees
21.	Employee Payroll In-State
22.	Employee Payroll Out-of-State
23.	Building Repair
24.	Advertisement In-State
25.	Advertisement Out-of-State
26.	Goods Resold In-State
27.	Goods Resold Out-of-State
28.	Groceries
29.	Household Supplies and Equipment
30.	Utilities
31.	Recreation Supplies
32.	Interest
33.	New Construction
34.	Gas/Oil/Auto Repair
35.	Other
36.	Gross Business Sales
37.	Main Business Sales
38.	Supplementary Business Sales

Figure 1. Alternative Developments Selected for Study.



included: construction and repair, and retail services, e.g., foodstores, financial and personal services. Land use constraints in Development Types 7a and 7b were identical to those used in Development Type 6a and 6b.

For all of the Alternative Development Types, only the first 1000 feet from the shoreline was considered in the analysis. The remainder of the watershed was assumed to stay in its current status.

RESULTS OF THE ANALYSIS

The analysis of the alternative developments was based upon comparisons and tradeoffs. Items included in the analysis were: the impact on tax revenue to the town and the impact on town expenditures in the provision of public services, the economic spinoff effects from lake developments on grocery stores, gas stations, utility companies, building repair, new equipment purchases and other purchases, and the effects on lake water quality in terms of phosphorus loading levels and the impact of developments on crowding levels of the lake and lake area.

Economic Impact

A summary of the economic impacts of each development type is shown in Table 6. (The complete numerical results of the analysis are presented in Appendix C.) The data on each alternative development were summarized by the following categories:

Public Sector

1. Public sector costs
2. Public sector income
3. Net public revenue

Private Sector

4. Total private expenditures
5. Local private expenditures
6. Local lake-oriented business gross sales.

Both total and local private expenditures were directly related to the level of development around the lake. If the area was largely undeveloped, expenditures in the area were low; whereas expenditures were high when recreational development was extensive. Commercial land uses contributed the most private expenditures to local private business.

Commercial land uses created greater net public revenue than residential land uses. Commercial Alternative Development Type 5 yielded between 3 and 20 times more net public revenue than residential developments. Residential developments had a varied effect on net public revenue.

Table 6. Economic impact of alternative developments.

Revenues and Costs	1	2	3a	3b	4a	4b	5	6a	6b	7a	7b
	1,000 dollars										
Public sector cost	-	65	163	677	189	752	52	244	255	323	430
Public sector income	147	191	346	708	412	1007	690	1026	1730	1019	1702
Net public revenue	147	126	183	31	223	255	638	782	1475	696	1272
Total private expenditures	-	439	1050	2938	2052	5486	5675	6256	11624	7013	12622
Local private expenditures	-	434	1045	2933	2047	5481	5491	6103	10777	6795	11679
Local lake-oriented business gross sales	-	147	147	147	147	147	2761	2094	4112	2528	4210

Scattered development (Type 2) generated a lower net public revenue than all forested land (Type 1). Forested land use generated public income through property taxes and required little public service expenditure. Alternative Development Type 2 generated a higher public income than Alternative 1, but also generated a higher public cost, so net revenue was less.

First tier development alternatives (3a and 4a) produced a much higher level of net public revenue than Types 1 and 2. The increased development levels, although generating higher public sector income, required additional public sector expenditures. Public sector income increases, at this development level, were still large enough to offset the increment in public costs. Second tier residential developments (3b and 4b), however, generated only a moderate increase in public sector income while requiring the largest public service expenditures of all residential development alternatives. Public sector costs tripled when second tier development surrounded the lake. This was due to the larger number of people demanding public services.

Commercial developments (Types 5, 6, and 7) attracted the most recreational visitors to the lake area. Many more recreational services were provided (boat rentals, tours, and beach areas) by commercial development than were available under residential development. Greater expenditures in the private sector as well as increased net town income originated from commercial developments than from residential development.

Alternative Developments 6a, 6b, 7a, and 7b represented the most intensive use of the lake area. These developments were a combination of both commercial and residential land uses. Each land use that was included in each development alternative is listed in Table 7.

The land uses which contributed the larger revenue to the local area and town were included in lake Developments 6 and 7. Alternatives 6b and 7b produced the highest private expenditures and net public revenue of all development alternatives.

Environmental Quality

The environmental quality of the study lake and the surrounding lakeshore was evaluated by four different measures. They included: both weekday and weekend lake surface usage, beach swimming usage, user days and lake water phosphorus loading level. The first three measures described crowding characteristics of the lake area; phosphorus loading level described the physical effects of alternative developments on the lake water quality.

Table 7. Land use activities by alternative development.

Rows	Land use	Alternative Development 1	2	3a	3b	4a	4b	5	6a	6b	7a	7b
Vacation home												
	1					210	210		100	200	100	200
	2		10	10	10	210	210		17		100	5
	3		5	5	5	210	210		100	200	100	200
	4		20	20	20	20	20					
	5		30	30	30	30	30					
	6		10	10	10	10	10		100		100	
	7		10	10	10	10	10		100	123	100	200
	8		5	5	5	5	5					
	9		5	5	5	5	5					
	10			268	268				100			
	11						545				100	200
	12		50		1140		595				100	200
	13										100	
	14						545		100	200	100	200
Youth camps												
	275 public							1			1	2
	150 public							2			1	2
	150 private							2	1	2	1	
Condominium												
	large							2	1	2	1	2
	small							5	5	10	5	10
Marina												
	small							2	3	6	3	6
	large							1	2	4	2	4
Campground												
	transient							1				
	seasonal		1	1	1	1	1	4			2	
	large											
	state											
Landings												
	private		5	5	5	5	5	10			5	10
	public							4				
Beach												
	public							3				
Cabins												
	6-unit		2	2	2	2	2	20	10		10	
	17-unit							10	10	20	10	20
Motel												
	30-unit							11	10	20	5	
Lodge												
	lodge							10	15	30	15	30
Idle land												
	public, 1st	10	10	10		10	10					
	private, 2nd	302	218	218		218			277	252	159	
	private, 1st	365	273			18	18					

Lake surface use by forested and residential first tier developments (1, 2, 3a, and 4a) was slight when compared to the other development types. (See Table 8.) The forested and residential first tier developments supported a small residential clientele and a few guests to use the lake's recreational facilities. More dense development, second tier residential development, 3b and 4b, resulted in a moderate recreational use of the number of second tier residential lake users.

Commercial enterprises was associated with more lake use through increased motorboating and waterskiing. Businesses attracted a large non-resident clientele to the area to take advantage of the recreational opportunities offered by water. The commercial developments (types 5, 6, and 7) created the greatest demand on both weekday and weekend water surface area, but the degree of demand varied from weekday to weekend. Development Types 7b and 6b had the greatest effect on the weekday lake use followed by 7a, 5, and 6a, in that order. On the weekend, Developments 7b and 6b again had the greatest effect, but the order of the last three types became: 6a, 7a, then 5. This weekday/weekend "reversal" is due to the fact that development type 7a consists of mostly residential activities and the residential users are in the area during the entire week.

Public swimming beach was a category to measure the level of public swimming beach use. Forested and residential development of the first tier (Types 1, 2, 3a, and 4a) was associated with the least beach usage. Second tier developments, 3b and 4b, were associated with greater beach use. Commercial development, Types 5, 6, and 7, resulted in the highest levels of beach use.

Direct lake use days followed similar patterns. The development alternatives that were associated with the smallest number of people using the lake were the forested and residential first tier developments, 1, 2, 3a, and 4a. The highest use totals for residential development were from the residential second tier developments 3b and 4b. Comparing first tier use totals to first and second tier development totals showed a fourfold increase in use. Second tier lake development attracted a great number of people into the recreational area. Commercial developments, Types 5, 6, and 7, attracted the largest number of visitors to the lake area.

The phosphorus loading level of the lake was directly related to the level of development around the lakeshore. (See Table 8.) Scattered residential

Table 8. Impact of alternative developments on lake phosphorus loading and lake use.

Alternative development	Lake surface usage Weekday	Lake surface usage Weekend	Beach swimming	Direct lake use	Phosphorus loading level
	Percent of potential boat use		ft^2 per day	Persons per day	Grams P per m^3 per year
1	-	-	-	-	.000959
2	12	8	111	251	.001362
3a	18	9	248	469	.001976
3b	32	25	960	1609	.004995
4a	26	22	286	816	.002305
4b	52	46	1066	2501	.005832
5	68	49	2039	2580	.007751
6a	47	51	925	1420	.008483
6b	83	100	1479	2269	.014197
7a	67	63	1322	2093	.008970
7b	100	99	1622	2711	.014190

development (alternatives 1, 2, 3a, and 4a) generated the lowest phosphorus load, whereas dense development (types 3b and 4b) created a more moderate phosphorus load. Commercial developments, the most dense developments, created the highest phosphorus loading of the lake waters. It should be noted that the phosphorus loading in Table 8 is from the specified development and not from the entire watershed.

Phosphorus Loading Over Time

The equation for evaluating nutrient accumulation in the lake system, derived from Dingman and Johnson, was used to determine lake phosphorus concentrations over time. This equation related phosphorus concentration in the lake to water retention time and yearly nutrient inflows from the alternative development types. The first year lake phosphorus load was determined from the testing of the lake waters by the lake association. (This load was based on tests of water samples taken near the dam during late July and early August. Tests were carried out with a Hach kit.) The equation represents a discreet approximation of a continuous phosphorus loading curve. Annual phosphorus loads were computed for the lake and these points were graphed to represent a continuous curve. Calculations were based on the assumption that the phosphorus loading of the lake from precipitation was not at an equilibrium level in year 1, but that it gradually attained equilibrium over time. Further, development was assumed to occur instantaneously and that the phosphorus was thoroughly mixed throughout the lake water.

Figure 2 presents the phosphorus concentration in the lake derived from a first year phosphorus load of .004995 g $P/m^3/yr$. (This phosphorus concentration is the loading from Alternative Development Type 3b.) The middle curve was based on the current hydrological status of the lake with a residence time of 1.4 years and a mean depth of 34 feet. If the lake residence time was different, the impact of the phosphorus concentration would change. The other curves in Figure 2 represent two different residence times for the study lake; 1 year and 2.8 years, with the same phosphorus load. These different residence times had a direct influence on the phosphorus concentration in the lake waters. Low residence time (1 year) decreased the overall effect of the annual phosphorus load; stabilization occurred sooner. High residence time (2.8 years) increased the phosphorus concentration; stabilization occurred later.

Each alternative development contributed a different level of phosphorus influx into the lake, and the lake phosphorus concentration varied with each

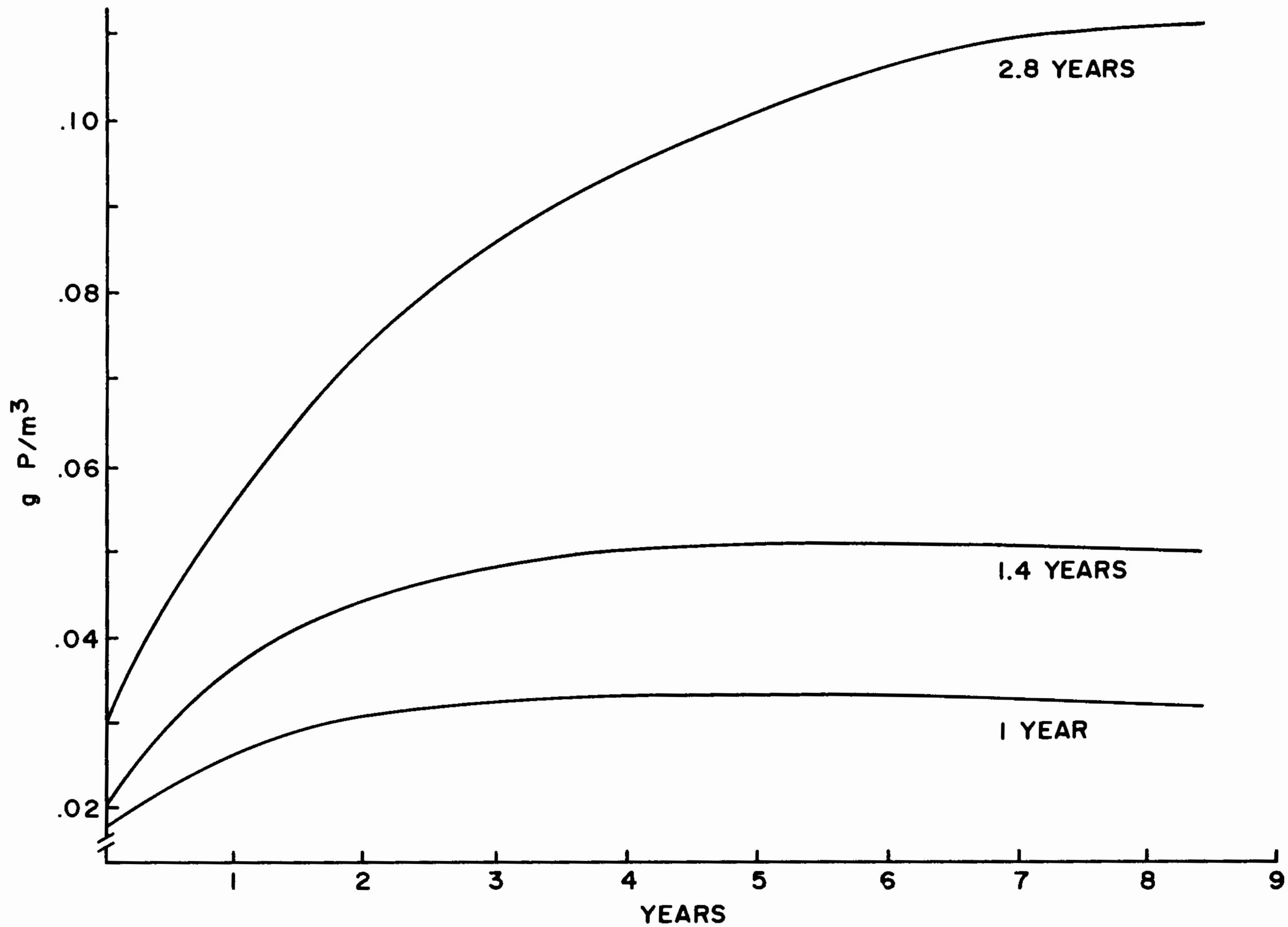


Figure 2. The accumulation of phosphorus in the sample lake for three residence times.

alternative development considered. The phosphorus concentrations over time for each development alternative is shown in Figure 3. Phosphorus concentrations in the lake rapidly increased over the first five to eight years, then gradually stabilized.

Development Alternatives 1, 2, 3a, and 4a can be located around the lake and the lake will still retain low phosphorus levels. All other development alternatives would cause higher nutrient loadings. Developments 6b and 7b created the highest phosphorus level concentration.

Alternatives 3b and 4b, two-tier residential development of two acre lots and less than 1/2 acre lots respectively, generated roughly the same phosphorus lake concentrations (See Table 8). Alternative Development 3b maintained more idle land areas around the lakeshore and supported fewer seasonal residences which were larger in size than Alternative Development 4b. Yet phosphorus load levels for Alternative Development 3b were only slightly lower than Type 4b. In comparison with the other alternative developments, commercial developments (5, 6, and 7) produced a much higher phosphorus concentration in the lake waters.

Table 9 lists for each development alternative the first year phosphorus loading concentration, the stabilized phosphorus load in the lake, and the number of years before stabilization occurs in the study lake. The lake system incorporates and reduces the yearly nutrient influx mainly through assimilation by plants, outflow (washout rate), and sedimentation. The reduced phosphorus lake concentration changes as additional nutrient loads enter the lake and will eventually stabilize at a level where inflow concentration equals outflow concentration. Approximate stabilized phosphorus loads for the study lake by development alternative is found in column three of Table 9.

Phosphorus concentration stabilized in the lake over time. The amount of time before stabilization is directly related to the amount of the phosphorus load. If the nutrient load is larger, the lake requires a long time to stabilize.

Economic and Environmental Tradeoffs

Comparisons were made between: *Local private expenditures* and *net public revenue* in terms of their effects on the environmental quality factor, *phosphorus loading level*. Town planning bodies are interested in net public revenues from lake development. The towns can plan to use the lake area development revenues in an effort to reduce the town tax rate, which is always a

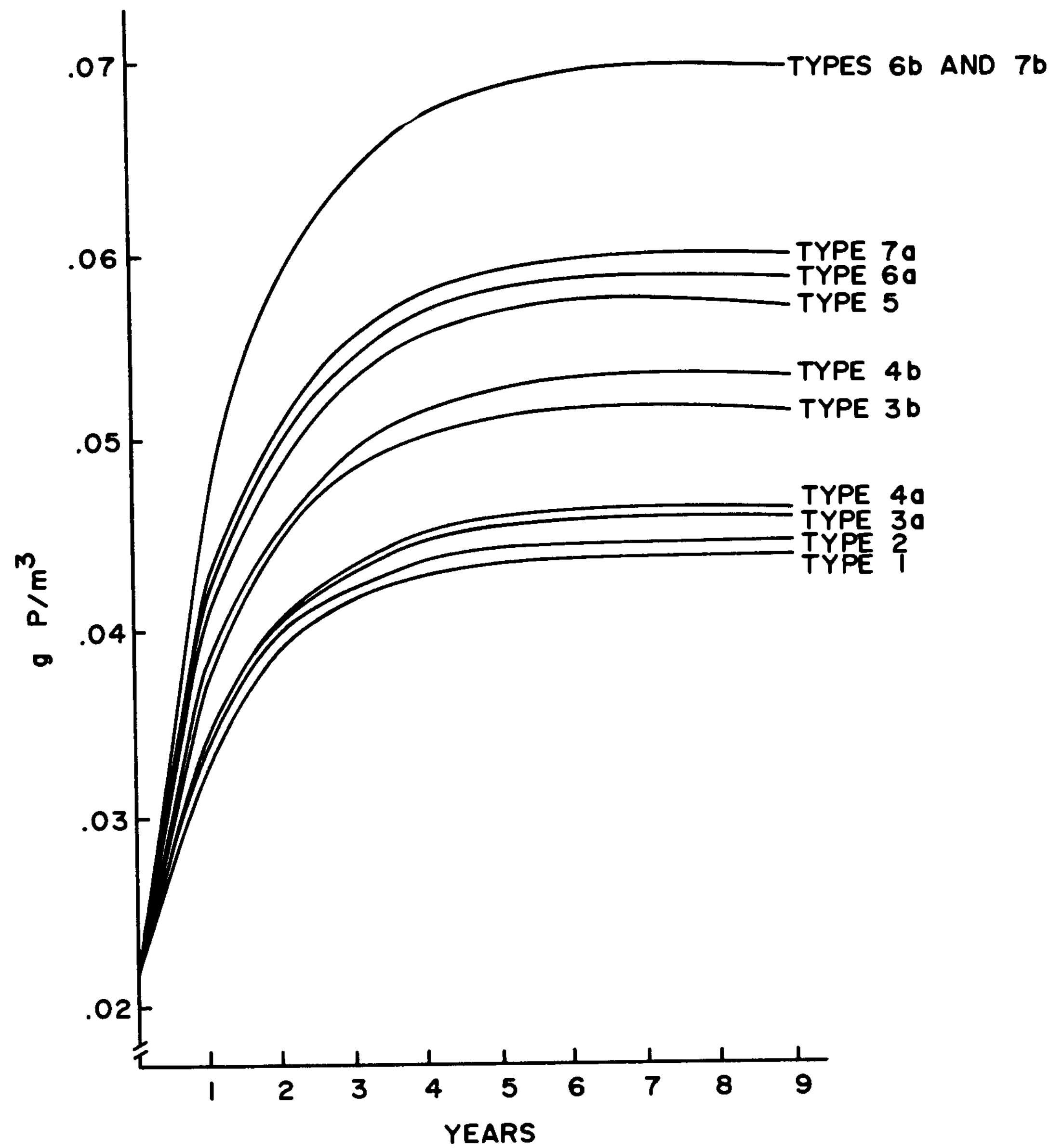


Figure 3. Phosphorus accumulation resulting from alternative developments.

Table 9. Phosphorus resulting from alternative developments by time period

Alternative developments	Annual phosphorus input	Stabilized phosphorus load	Differences between Types 3a - 7b & Type 2	Years before stabilization
units	g P/m^3/year	g P/m^3	percent	years
1	.000959	.0056	-	5
2	.001362	.0065	-	5
3a	.001976	.0075	14.	6
3b	.004995	.0139	114.	7
4a	.002305	.0081	27.	6
4b	.005832	.0151	132.	7
5	.007751	.0188	189.	7-8
6a	.008483	.0201	209.	7-8
6b	.014197	.0285	338.	8-9
7a	.00897	.0211	225.	7-8
7b	.014190	.0285	338.	8-9

concern of town residents. Lake area development practices can be instituted by the town body to maximize the net public revenue or meet other town planning goals.

Local private expenditures was used as the second economic indicator in this analysis because of its prime importance to the local area businessmen. Local area businessmen, as voters in the town, exert a certain influence on town planning practices. Their main interest lies in the level of lake area residents expenditures in local areas. *Total private expenditures* (all areas) is less of a concern to the area businessmen when compared to the interest in the expenditures in the local areas.

Results of the comparisons are found in Figures 4 and 5. Figure 4, local private expenditures versus stabilized lake phosphorus concentration, reflects a linear in logs relationship. The relationship indicates direct proportionality (or a constant rate of change) between local private expenditures to the area and stabilized lake phosphorus concentration level. It is evident that maximizing the level of private expenditures in the local area results in a reduction of environmental quality.

Figure 5, net public revenue versus stabilized lake phosphorus concentration, indicates two distinct groupings of alternative developments, a residential grouping and a commercial grouping. Residential development tended to achieve low net public revenues while causing moderate phosphorus concentration levels. Residential developments 3b and 4b, although highly dense developments, generated a very low net town revenue. Commercial developments clustered at the higher end of the scales.

Again, it seems evident that an effort to maximize the economic contribution to net town revenue would result in environmental quality being reduced.

Trophic Status

Vollenweider (32) developed trophic relationships of lakes based on annual phosphorus loading per square meter of lake surface, mean depth, and water residence time. (Cubic measure was converted to square measure by dividing mean depth by residence time. Graphic analysis was customarily used.) His 1968 work was updated in 1973 and results presented by Jordan (14) and in 1975 with results presented by O'Hayre and Dowd (23). Estimates of permissible

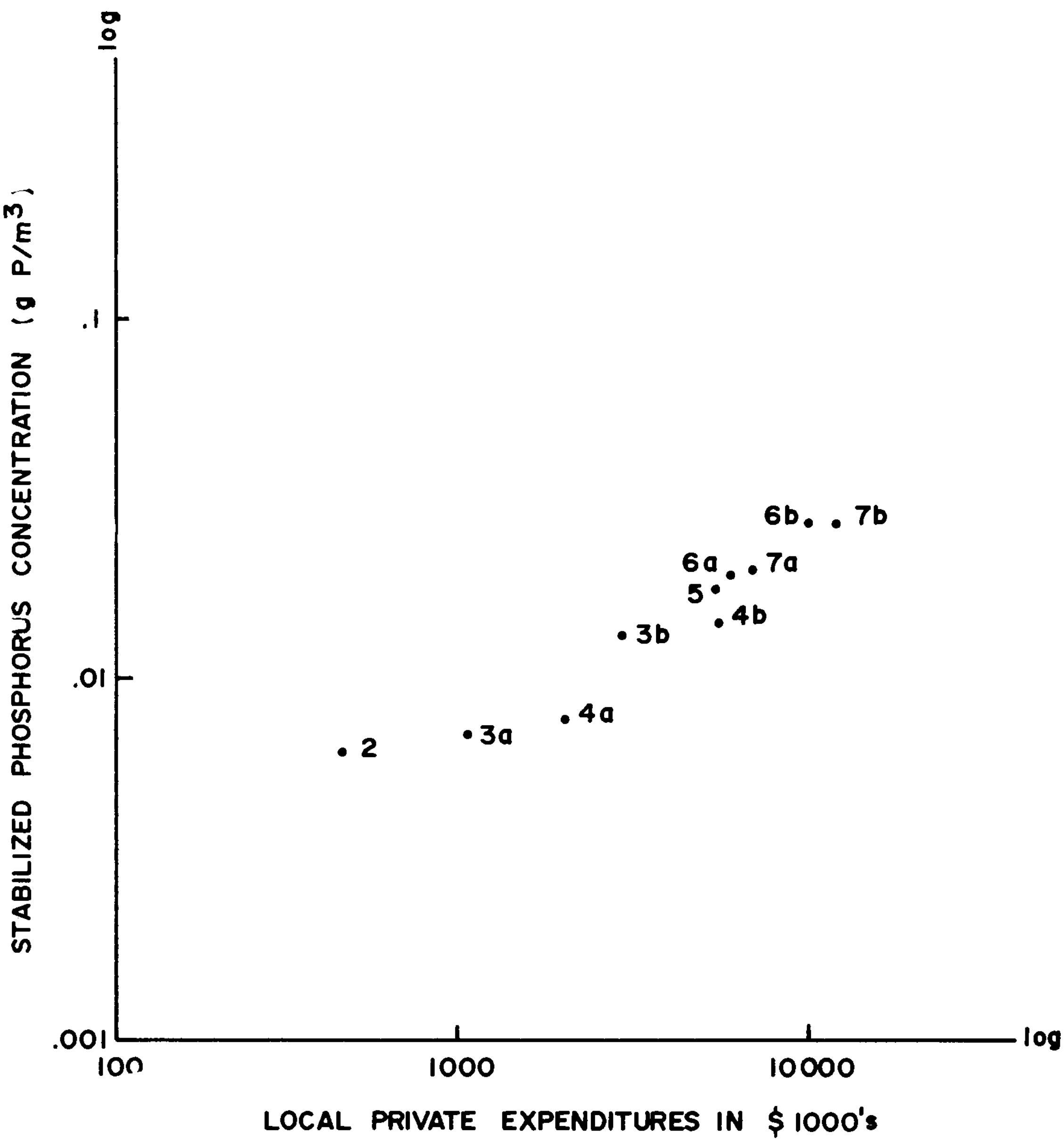


Figure 4. Alternative development tradeoff: local private expenditures and stabilized phosphorus concentration.

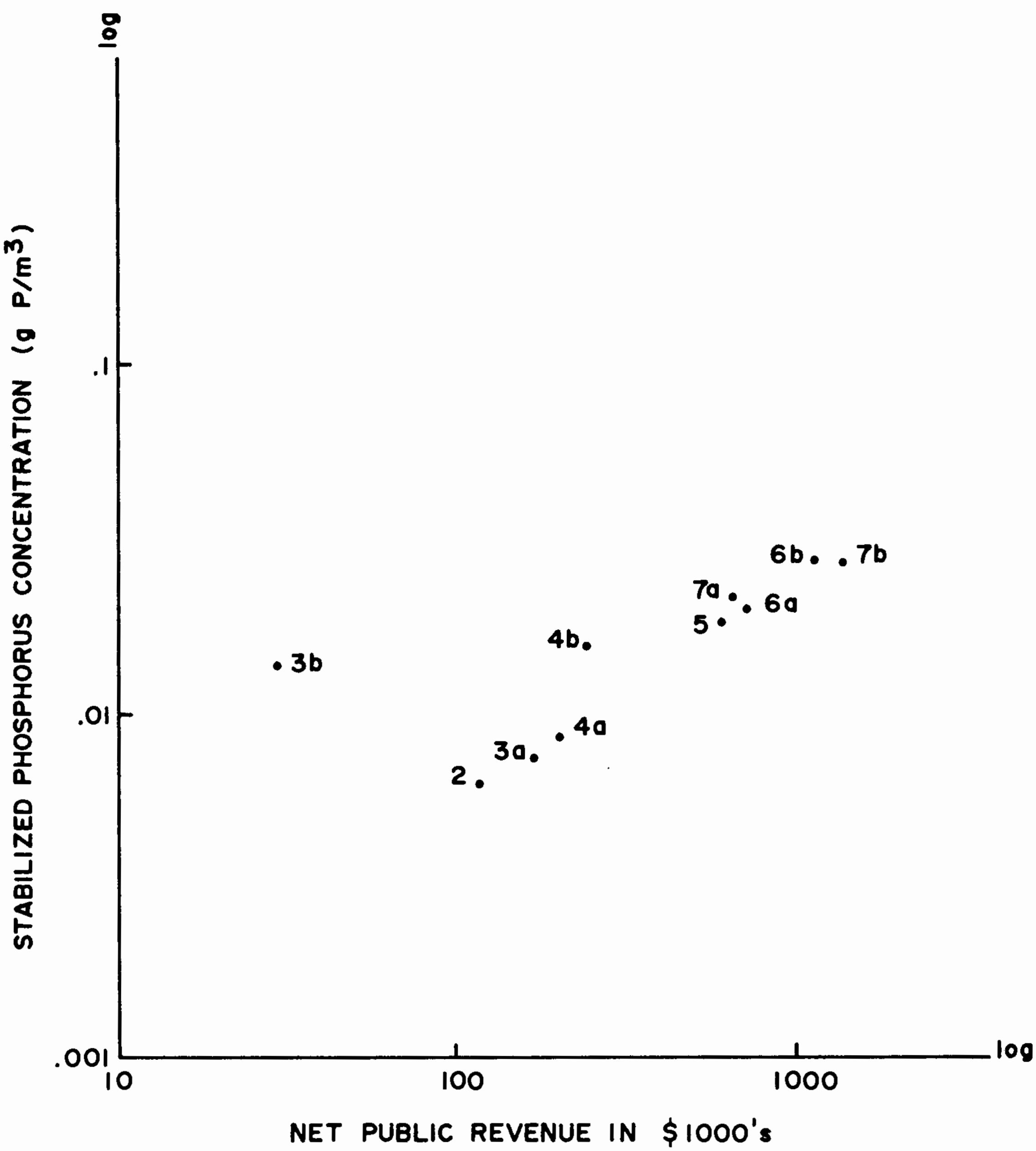


Figure 5. Alternative development tradeoff: net public revenue and stabilized phosphorus concentration.

and dangerous levels were obtained from these graphs. They were as follows:

	1973	g P/m^2/year	1975
Permissible	.19		.28
Dangerous	.37		.51

In this study, volumetric measure was used. The study results were converted to g P/m^2/year for comparatability and are presented in Table 10. Because phosphorus loading data by land use type was the average of several observations, differences from 25 to 100 percent of the study results were calculated. (See Table 10.) To these data, phosphorus from the remainder of the watershed and sedimentation should be added before comparisons are made with the data from Vollenweider's graphs. The amount of phosphorus from these sources is unknown. Based on lake water test results for phosphorus concentration and phosphorus from all sources, the possibility of the lake becoming eutrophic at high levels of development cannot be ruled out.

Table 10. Annual phosphorus loading per square meter of lake surface by alternative development type and by percent difference from study results.

Percent difference from study results	Alternative Development Type									
	2	3a	3b	4a	4b	5	6a	6b	7a	7b
(Study results) 0	.014	.020	.051	.024	.060	.080	.088	.147	.093	.147
25	-	.025	.064	.030	.075	.100	.110	.183	.116	.183
50	-	.031	.078	.036	.090	.120	.131	.220	.139	.220
75	-	.035	.090	.042	.105	.140	.154	.257	.162	.257
100	-	.041	.102	.047	.120	.160	.175	.294	.185	.294

SUMMARY AND CONCLUSION

The overall objective of the study was to evaluate alternative land developments around New Hampshire lakes. The analytical method used was based on a combination of a mathematical programming model and a phosphorus nutrient loading model. Alternative development patterns, evaluated by their impacts on the lake area environment and area economy, included residential patterns, commercial patterns, and combinations of these two types. Economic impact from each alternative development was measured in terms of net public revenue and total private expenditures to the local area, to the State and to other states. The impact of the alternative developments on the lake area environment was measured in terms of crowding levels and the level of phosphorus concentration in the lake. Phosphorus loading of the lake water was used as a proxy variable to reflect the changes in the lake water quality.

Environmental Quality

Dynamic study of water quality demonstrated the importance of water residence time as a determinant of the level of lake nutrient loading. Lake residence time is directly related to nutrient load levels. High (low) residence time yields high (low) levels of phosphorus concentration in the lake waters.

The level of watershed development ecologically permissible on the lakeshore will depend on the lake water residence time and average depth. Similar lake areas (similar surface acreage and shoreline) will not be able to support the same development schemas unless depth and residence times are also similar.

Initial planning of the recreational area should include detailed study of the hydrological characteristics. Estimates of allowable total nutrient loading of the lake before lake water quality is reduced can be determined. Nutrient load limits should then influence the kind and degree of lake area development.

Implications for Alternative Developments

The first development type evaluated in the analysis described a forested watershed. As expected, this alternative, among all alternatives, was found to maximize the environmental quality of the lake in terms of minimum phosphorus loading levels and low "people crowding" levels. There was little man-made nutrient loading of the lake waters. Income to the private sector was almost nil and income to the public sector was mainly from property taxes of the privately owned land. Public service costs were very small.

The second development alternative described the current lake's development status. The lake retained high water quality, i.e., low phosphorus loading, with little use of the lake waters or lake shoreline. Although this development did contribute more to the area economy than did the first development, the increase was relatively small.

The remaining analysis of development types evaluated different policy alternatives available to the planning body of the sample lake. Residential lake development patterns were of two types: 1) planned development; and 2) a specific case of unplanned development. Planned residential development was based on two-acre zoning around the study lake. The town governing body could initiate two-acre zoning on both tiers. This zoning would help maintain open space and prevent high density land use.

Two-acre zoning on the first tier, with the second tier in forested and agricultural land uses, contributed twice as much to the area economy as current development, while causing a little less than twice the phosphorus input into the lake. Two-acre residential development on both tiers brought a moderate total revenue into the area, yet contributed the least net revenue to the town. Of all the developments analyzed, both tier residential development contributed the least to net town revenue. Public services costs were high, to meet the needs of the increased number of inhabitants, and public income, tax revenue, was low; however, a policy of two-acre zoning would help restrict development, maintain open space and prevent high density land use.

Unplanned residential development represented a planning policy where all zoning restrictions were relaxed and small lot size was assumed to dominate. Residential low income development was allowed on the first tier, with the second tier held as forested land; then low income residential development was allowed on both tiers. The compact housing on the first tier and second tier contributed the most to the town economy of all the residential developments evaluated. Unplanned residential development, among the four residential developments studied, caused the highest phosphorus loading of the lake with increased beach and lake usage.

The planning policy where the lake area was completely developed for commercial lake-oriented businesses, contributed more to net town income and total revenue to the area than residential development. Environmental quality was reduced because of the large phosphorus loading of the lake waters and increased crowding levels on the lake area. The development types that maximized net revenue to the town and total revenue to the area included residential and commercial development. Lake water quality was reduced due to high phosphorus loading. Usage of the lake (lake surface use, beach swimming) and lake area under these developments were quite extensive.

Several distinctions can be made between the residential and commercial development alternatives. Commercial developments yielded the highest revenues to the town and local areas. It also attracted the most lake users to the area, as well as contributing the largest phosphorus loading to the lake waters. Residential developments, although contributing high total revenues to the area, yielded little net revenue to the town. Residential development created an increased demand for public services (increased town costs). Town income from property taxation of residential dwellings increased at a slower rate than the costs of providing public services.

From this analysis, based on environmental quality and economic contribution to the local area, a combination of first tier residential and commercial development around the lake is suggested. Commercial development can be either land "intensive" (marinas), which brings in a higher local area revenue, or land "extensive" (youth camps), which maintains a large acreage of forested land and brings in a low local area revenue.

There are a large number of development choices open to a planning body. The alternatives included in this study described the most common alternative development types. From this information, planners can decide which development alternative could best be located on their lake areas. Only by chance would any one of the eleven alternative developments employed in this analysis be optional. But rather, the optimal would be found somewhere within the bounds of the alternatives studied.

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APPENDIX A

MATHEMATICAL EXPRESSION OF THE PROGRAMMING MODEL

This format describes the linear programming model used for Development Alternatives 1 through 5.

Let $$\begin{bmatrix} Y \\ T \\ E \end{bmatrix} = C_{01}x;$$

and $$\begin{bmatrix} Y \\ T \\ E \end{bmatrix} = z_1$$

Find z_1 when:

$$z_1 = C_{01}x;$$

Subject to:

$$0 \leq r_{ip} \leq x_{ip} \leq s_{ip}$$

and

$$b_1 \geq a_{ij}\ x_j$$

Max $z_0 = C_{01}x_i$ (Maximized the number of units equal weight. Also any C_{01} can be maximized or minimized.)

Y = Money income, private sector.

T = Tax base.

E = Community expenditures.

x_i = Level of the ith activity of lake resource use.

z_i = Income levels.

$C_{01}ij$ = Per unit money income private sector, tax base and community expenditures.

r_{ip}, s_{ip} = Some constant to vary with kind of lake development, $r_{ip} = s_{ip}$ sometimes.

k_{ip} = Level of the ith alternative use in each alternative future.

b_i = Level of resource availability and hydrological, geological and environmental constraints.

p = Kind of development, also can equal a time period.

a_{ij} = Technical coefficient relating lake resource use to total resource available.

A Simplex Linear Programming model was used for Alternative Developments 6 and 7 where the economic criteria net public revenue and local private expenditures were maximized.

APPENDIX B

DESCRIPTION OF LAND USE ACTIVITIES

Vacation homes:

Type	Description
1.	Vacation home, small lot (50' x 100'), 50 feet of shoreline, low-value home with less than or equal to three rooms, winterized or non-winterized, located on the first tier.
2.	Vacation home, medium lot (100' x 200'), (100' x 150'), approximately 1/2 acre, 100 feet of shoreline, 4-5 rooms, non-winterized, located on the first tier.
3.	Vacation home, medium lot (100' x 200'), (100' x 150'), 1/2 acre, 100 feet of shoreline, 4-5 rooms, winterized and located on the first tier.
4.	Vacation home, large lot (200' x 200'), one acre, 200 feet of shoreline, large home, 6+ rooms, non-winterized, located on the first tier.
5.	Vacation home, large lot (200' x 200'), 200 feet of shoreline, 6+ rooms, winterized and located on the first tier.
6.	Vacation home, large lot (100' x 400'), one acre, 100 feet of shoreline, large home, 6+ rooms, non-winterized located on the first tier.
7.	Vacation home, large lot (100' x 400'), one acre, 100 feet of shoreline, large home, 6+ rooms, winterized, located on the first tier.
8.	Vacation home, large lot, two acres, large home, 6+ rooms, 200+ feet of shoreline, non-winterized and winterized, located on the first tier.
9.	Vacation home, large lot, 5+ acres, large home, 6+ rooms, 200 feet of shoreline, winterized and non-winterized, located on the first tier.
10.	Vacation home, large lot, 2 acres, 200 feet of shoreline, large home, 6+ rooms, winterized and non-winterized, located on the first tier. (This activity is to be used in anticipation of a minimum acreage zoning law of two acres.

APPENDIX B (Cont'd)

Type	Description
11.	Vacation home, medium lot (100' x 200'), (100' x 150'), roughly 1/2 acre, 4-5 rooms, winterized and non-winterized, located on the first tier.
12.	Vacation home, large lot, one acre, large home, 6+ rooms, winterized and non-winterized, located on the second tier.
13,14.	Development adjustment: a series of combinations for two types of developments, #2. and #11., existing in a privately run cluster development; also another category exists where all the homes are located on the second tier and beach and shoreline is publicly owned.

Commercial activities:

Type	
Boy/girl camps, youth camps	
1.	Large size camp, 275 youth capacity, publicly or privately owned.
2.	Medium size camp, 150 youth capacity, publicly maintained, non-profit organization.
3.	Medium size camp, 150 youth capacity, privately owned, profit organization.
Condominium	
4.	(Sunapee model), large size condominium, 90 units, land holding 50 acres, ballooning in acreage from the shoreline, 50 feet of shoreline.
5.	Small condominium, 70 units, land holdings of 3 acres, shoreline footage 200-300'.
Marinas	
6.	Small sized marina, less than one acre land holding, major business concerns include: gas/oil sales, storage and boat slips, 100 slip capacity.
7.	Medium sized marina, 1-1/2 acres land holdings, 200 boat/slip capacity, storage facilities.
Campgrounds	
8.	Small sized campground, 150 campsites, transient camper basis, daily and weekly use.

APPENDIX B (Cont'd)

Type	Description
9.	Small sized campground, 150 campsites, seasonal camper basis, seasonal use.
10.	Medium sized campground, 300 campsites, seasonal and transient basis.
11.	State owned campground, small sized, 150 campsites, transient camper basis.
Boat Landings	
12.	Privately owned landing, fees charged for use, other facilities include: gas/oil, groceries and service.
13.	Public owned landing, no fees for use, limited facilities, boat ramp.
Public Beach	
14.	Public town beach, 200 foot shoreline, large acreage, 41 acres, fees charged to non-residents.
Cabins, resorts and accommodations	
15.	Small sized cabins, family owned, 6-unit cabins, 200 foot shoreline, located along the first tier.
16.	Medium sized cabins, family owned, 17-unit cabins, 200 foot shoreline, located on the first tier.
17.	Medium sized motel, 30 units, housekeeping cottages and motel units, 600 foot shoreline, located on the first tier.
18.	High income lodge, rooms and cottages, 375 foot shoreline, located on the first tier.
Idle Land	
19.	Publicly owned idle land, one acre holdings, 200 foot shoreline, ownership by either town, state or other concern, located on the first tier.
20.	Privately owned idle land, 5 acre units, located on the second tier.
21.	Privately owned idle land, one acre units, 200 foot shoreline, located on the first tier.

APPENDIX C

SUMMARY OF RESULTS

			Alternatives
		units	1
1.	Real estate tax	$ 1000's	147
2.	Property evaluation	$10000's	834
3.	Fire and police protection	$ 1000's	
4.	Roads and highways	$ 1000's	
5.	Overhead legal	$ 1000's	
6.	Rooms and meals tax	$ 1000's	
7.	Other licenses	$ 100's	
8.	Shore length	ft/100	750
9.	Land acreage	acres	375
10.	Land acreage 1000'	acres	1510
11.	Lake surface day	ft^2/day	
12.	Lake surface end	ft^2/day	
13.	P loading level	g P/m^3/yr	.0009595
14.	Beach swimming	ft^2/day	
15.	User days	user days	
16.	Yr. rnd. local employ.	number	
17.	Seas. local employ.	number	
18.	Seas. N.H. employ.	number	
19.	Seas. o.s. employ.	number	
20.	Unpd. family	number	
21.	Employ. income N.H.	$ 1000's	
22.	Employ. income o.s.	$ 1000's	
23.	Building repair	$ 1000's	
24.	Advertisement N.H.	$ 100's	
25.	Advertisement o.s.	$ 100's	
26.	Goods resold N.H.	$ 1000's	
27.	Goods resold o.s.	$ 1000's	
28.	Groceries N.H.	$ 1000's	
29.	Household N.H.	$ 1000's	
30.	Utilities N.H.	$ 1000's	
31.	Recreation supplies	$ 1000's	
32.	Interest N.H.	$ 1000's	
33.	New construction N.H.	$ 100's	
34.	Gas/oil/auto repair	$ 1000's	
35.	Other N.H.	$ 1000's	
36.	Gross bsns. sales	$ 1000's	
37.	Main sales	$ 1000's	
38.	Supplementary sales	$ 1000's	

APPENDIX C (Cont'd)

	Alternative Developments				
	2	3a	3b	4a	4b
1.	180	318	635	364	882
2.	798	948	1576	1073	2202
3.	23	56	233	65	259
4.	23	56	233	65	259
5.	20	51	211	59	234
6.	2	5	9	10	20
7.	9	23	64	38	105
8.	749	719	719	749	749
9.	431	684	684	404	404
10.	1509	1459	1509	1459	1509
11.	157	229	411	333	679
12.	205	354	662	563	1197
13.	.001362	.001075	.004996	.002305	.005832
14.	111	248	960	286	1066
15.	251	469	1609	816	2501
16.					
17.	3	3	3	3	3
18.	1	1	1	1	1
19.	5	5	5	5	5
20.	39	39	39	39	39
21.	3	3	3	3	3
22.	2	2	2	2	2
23.	74	155	440	305	821
24.	.7	.7	.7	.7	.7
25.	3	3	3	3	3
26.	1	1	1	1	1
27.	50	50	50	50	50
28.	146	388	1222	772	2199
29.	17	45	73	87	181
30.	26	56	127	102	244
31.	71	190	413	415	978
32.	5	5	5	5	5
33.	9	9	9	9	9
34.	49	109	302	183	494
35.	35	86	340	167	548
36.	147	147	147	147	147
37.	145	145	145	145	145
38.	2	2	2	2	2

APPENDIX C (Cont'd)

	Alternative Developments				
	5	6a	6b	7a	7b
1.	660	968	1509	948	1611
2.	1865	2768	4255	2517	4427
3.	18	84	88	111	148
4.	18	84	88	111	148
5.	16	76	791	101	134
6.	3	11	155	12	16
7.	27	47	66	59	86
8.	347	750	750	750	750
9.	673	684	684	684	684
10.	1289	1235	1512	1511	1512
11.	890	617	1082	874	1300
12.	1271	1329	2600	1646	2579
13.	.007751	.008483	.014197	.008970	.014190
14.	2039	925	1479	1322	1622
15.	2580	1420	2269	2093	2711
16.	47	36	72	42	74
17.	110	56	92	67	81
18.	69	23	46	48	66
19.	205	67	134	121	194
20.	286	138	236	214	288
21.	406	287	563	338	579
22.	171	55	110	116	148
23.	318	421	613	569	779
24.	39	39	77	39	76
25.	13	98	190	102	194
26.	199	295	590	302	585
27.	290	328	657	378	749
28.	2447	2607	4680	2872	5096
29.	254	257	449	283	466
30.	333	362	664	388	661
31.	518	782	1280	856	1395
32.	53	22	45	36	62
33.	85	46	93	58	74
34.	672	657	1169	715	1263
35.	572	615	1117	677	1222
36.	2761	2094	4112	2528	4210
37.	2222	1506	2940	1839	3027
38.	542	587	1172	689	1183