CONSERVATION AND RESTORATION OF NATURAL ENVIRONMENT OF WATERFRONT IN JAPAN

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KEYWORDS;waterfront, lakeshore, riparian zone, landscape, vegetation,

INTRODUCTION

In recent years, the natural state of waterfront of lakes and rivers in Japan has been damaged remarkably owing to construction works for flood and erosion control, water utilization, and other national and regional development programs.

The aim of this article is to report the present state of natural condition of littoral and riparian zones in Japanese lakes and rivers, and to discuss the fundamental viewpoints for conserving and restoring the waterside ecosystems.

1. PRESENT STATE OF WATERFRONT IN JAPAN

According to the report of the Third National Survey on the Natural Environment conducted by the Environment Agency of the Jpnanese Government in 1985, the ratio of artificialized waterfront of 479 lakes of natural origin (more than 1 ha in surface area) is 40.5 % for the total shoreline length of 3,165 km , (Table 1, and Figure 1) and the ratio of artificialized river bank for total

investigated length of 11,412 km of 113 First-class Rivers is 21.4 % (Table 2). But, in the river survey, as only the case in which water's edge is in contact directly with an artificial structure such as concrete revetment etc. was recognized "artificial", it is presumed that the actual decline of natural state of riparian zone remarkably exceeds the above value. On the other hand, artificial structures across the river, such as high dams, consolidation dams (low dam, less than 3 m in hight, layed for stabilizing the gradient of stream bed), groundsill (a flat and solid structure layed on stream bed to prevent downward erosion) and so on, have been constructed on every 5.2 km in average of watercourse of the above mentioned rivers (Table 3).

In small streams and torrents, the decline of natural state on bank and bed are more remarkable than in large rivers, because of river-repairing works planned for flood or erosion control and for farm irrigation in recent years.

2. ECOLOGICAL COMPONENTS OF LITTORAL AND RIPARIAN ZONES AND THEIR FUNCTIONS

Generally speaking, littoral zones developed on a lakeshore received successive alluviation have diverse vegetation composed of marshy trees, hygrophytes, emerged plants, floating-leaved plants and submerged plants (Figure 2). These plant communities have versatile functions (Table 4), as follows ;

1) Providing foods, nesting and spawning places, shelters and roost for birds (Figure 3, and Table 5), fishes, amphibians, crustaceans, insects and other wildlife.
2) Improving water quality.
3) Suppressing the force of wave and protect a bank from erosion.
4) Providing resources for agriculture and human life.
5) Creating natural and comfortable landscapes on waterfront.

Running waters diminish the growth of aquatic plants, but the principal structures and functions of riparian vegetation are much the same as those on lake littoral. On the other hand, for the watercourse of torrents or streams,

which we meet frequently in mountainous Japan, following factors have rather great ecological importance (Figure 4) ;

1) Meandering of watercourse.
2) Morphology of stream bed (presence or absence of deeps, shallows and rapids etc.)(Figure 5).
3) Materials of bank (soil, stone, rock, or concrete revetment etc.).
4) Materials of stream bed (mud, sand, gravel, stone, rock, etc.).
5) Stability of discharge.
6) Water quality.

3. RELATION BETWEEN THE DESIRABILITY OF LAKESHORE LANDSCAPE AND THE RICHNESS OF NATURAL COMPONENTS IN WATERFRONT

From the results obtained by a opinion survay, the relationship between desirability of lakeshore landscape and richness of natural components in the littoral ecosystem was analyzed. For the survey a color chart containing 30 photographs of lakeshore landscape (Figure 7) was used, and replies to the questionnaire were received from 2,551 persons all over Japan. The results of analysis suggests that the richness of natural components in a littoral zone, especially herbaceous and woody vegetation, makes the lakeshore landscape more desirable for many people (Table 6, and Figure 6).

4. ESSENTIAL VIEWPOINTS FOR CONSERVING AND RESTORING NATURAL ENVIRONMENT OF LITTORAL AND RIPARIAN ZONES

[1] Fundamental :

1) Preserve or give back an original territory of lake and river as wide as possible.
2) Conserve existing natural landforms of waterfront and vegetations on it.
3) Preserve or create diverse plant communities and habitats for wildlife.

[2] Factors to be preserved or restored :

1) Shallow water zone and aquatic vegetation composed of diverse life-forms and species on lake littoral and riparian zones.
2) Meandering of watercourse, and deeps, shallows, rapids and shoals in river bed (Figure 4 and Figure 5).
3) Shoreline and bank composed of soil.
4) Irregurality of shoreline.
5) Marshes, wetlands and inlets or coves along watercourse and lake-shore, including those created by artificial structures such as "kribbe groyne" (This type of inlet or cove is called "WANDO" in Japan).
6) Forest of high species diversity and multi-layered structure along watercourse and lake-shore.

[3] Relation to a regional biotope :

An ecosystem of waterside ecotone plays an important role in the regional biotope. It is recommended to make a plane based on this viewpoint for conservation and maintenance of waterfront environment.

[4] Maintenance :

In order to maintain a desirable state of waterside ecosystem, it is necessary to manage the condition of the system, especcially the state of vegetations. Reaping and taking out of reed plants (from late autumn to early spring) or scraping of reed stand surface are examples of such a maintenance.

[5] Supplement :

1) Remarkable fluctuation of discharge and water level must be controlled.
2) Water pollution must be controlled.

These problems belong mainly to the social management for the catchment area.

[6] Organization for planning and executing waterfront buisiness :

The collaboration among engineers, ecologists and landscape architects is necessary for making and executing a plan of waterfront management or improvement. Until now, we had no such an organization in Japan.

Table 1. Changes of the Waterside of Japanese Lakes (more than 1 ha in surface area).

Year of survey	Number of lakes investigated	Total length of shoreline (km)	Present state of the lakeshore			
			Natural (km)	Seminatural (km)	Artificialized (km)	Open water (km)
1979	479	3,150.49 (100.0)	1,899.56 (60.3)	326.73 (10.4)	903.36 (28.6)	20.84 (0.7)
1985	479	3,165.09 (100.0)	1,858.81 (58.7)	373.25 (11.8)	908.64 (28.7)	24.39 (0.8)

The Report of Third National Survey on the Natural Environment.
The Environment Agency, Government of Japan. 1987.

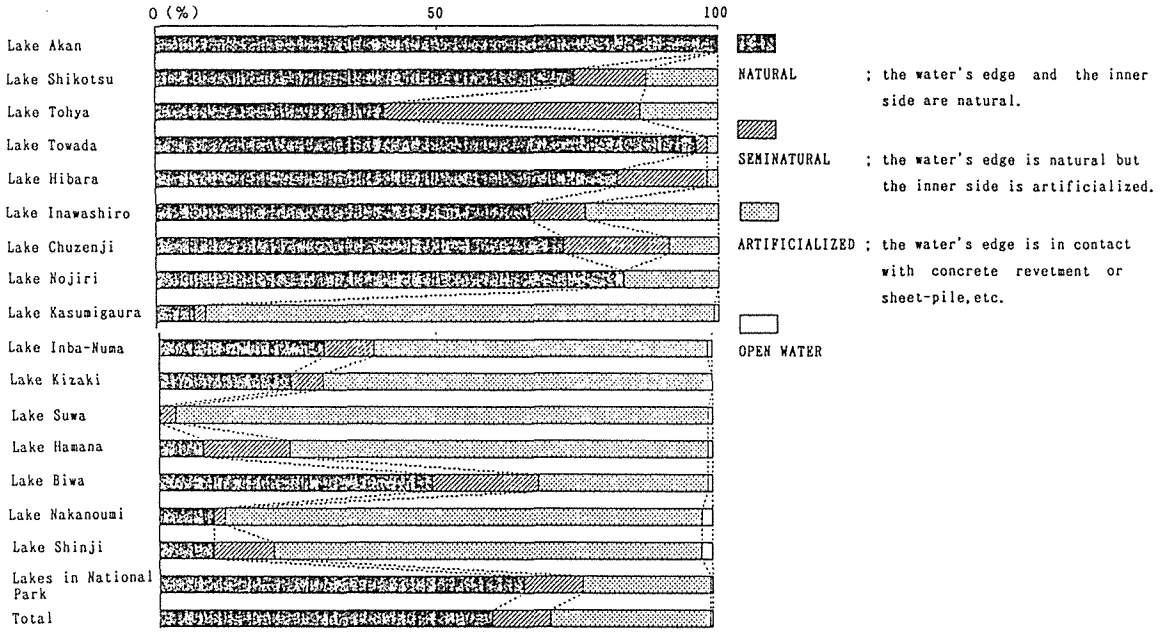

Figure 1. Present State of the Waterside of Main Japanese Lakes.(The Report of Second National Survey on the Natural Environment. The Environment Agency, Government of Japan. 1979)

Table 2. Changes of the Waterside of Main Japanese Rivers

Year of survey	Number of rivers investigated	Total length of riverbank (km)	Artificialized riverbank (km)	Percent artificialized (%)
1979	113	11,425	2,192.2	19.2
1985	113	11,412	2,441.5	21.4

The Report of Third National Survey on the Natural Environment.
The Environment Agency, Government of Japan. 1987.

Table 3. Artificial Structures across the Watercourse in Main Japanese Rivers.

River system	Number of artificial structure (A)	Total length of rivers (km) (B)	B／A (km)
Hokkaido-Sea of Okhotsk	11	325	29.5
Hokkaido-The Japan Sea	36	683	19.0
Hokkaido-The Pacific	29	488	16.8
Honshu-The Japan Sea	643	2,957	4.6
Honshu-The Pacific	513	3,738	7.3
Honshu-The Inland Sea	343	983	2.9
Shikoku-The Pacific	53	674	12.7
Shikoku-The Inland Sea	111	154	1.4
Kyushu-The Japan Sea	27	58	2.1
Kyushu-The Pacific	53	304	5.7
Kyushu-The Inland Sea	98	245	2.5
Kyushu-East China Sea	272	785	2.9
Okinawa-East China Sea	0	18	—
Total	2,189	11,412	5.2

The Report of Third National Survey on the Natural Environment. The Environment Agency, Government of Japan. 1987.

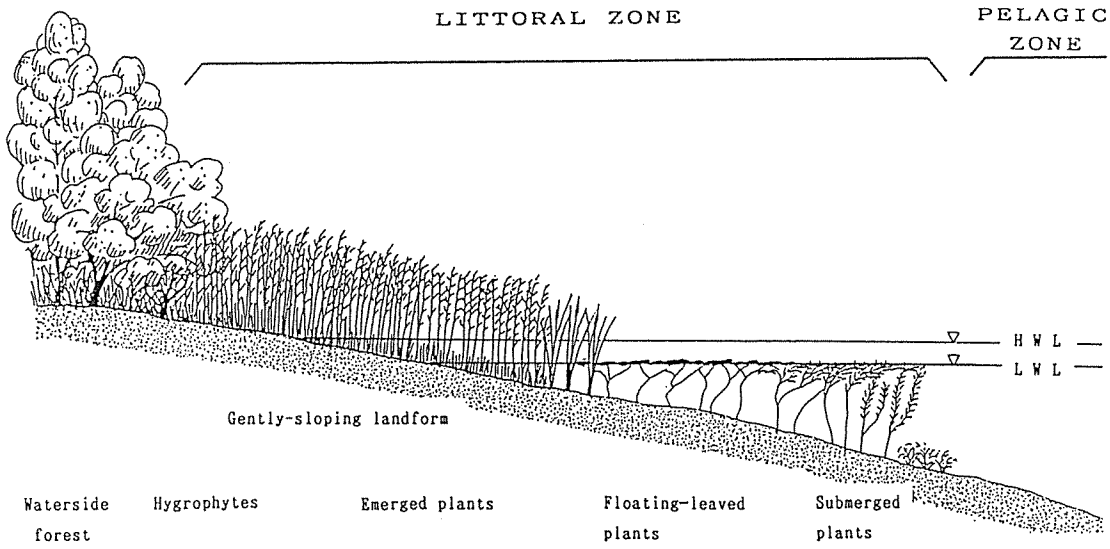

Figure 2. Littoral zone and its typical vegetation.

Table 4. Versatile functions of waterside vegetation.

	W	H	E	F	S
■ Improvement of water quality					
Catch of suspended solids	○	○	○	○	+
Decomposition of organic pollutants		○	○	+	+
Absorption of N and P from water and mud			+	○	○
Suppression of phytoplankton growth by shading			○	○	+
Oxygen supply to bottom mud		○	○	+	
Absorption of harmful substances		○	○	?	?
■ Contribution to wildlife					
Spawning and growing places of fishes and crustaceans	+		○	○	○
Nesting places, shelters and roost of birds	○	○	○	+	
Supply of foods for birds	○	○	○	○	○
Supply of foods and habitats for inects and amphibians	○	○	○	○	+
Supply of foods for molluscs and benthic animals	○	+	○	○	○
Supply of solid surface for epiphytic communities			○	○	○
■ Protection of lakeshore from erosion					
Reduction of wave force by dense vegetation	○	○	○	+	+
Fastening of soil by entangled root systems	○	○	○		
■ Supply of resources					
Supply of foods for men			○	○	+
Supply of raw materials for human life	○	○	○		
Supply of materials for agriculture	○	○	○	○	○
■ Contribution to the formation of waterside landscape					
Contribution to wide-scale landscape	○	○	○	+	
Contribution to local landscape	○	○	○	○	

Note , W : Waterside forest, H : Hygrophyte community, E : Emerged plant community, F : Floating-leaved plant community, S : Submerged plant community.

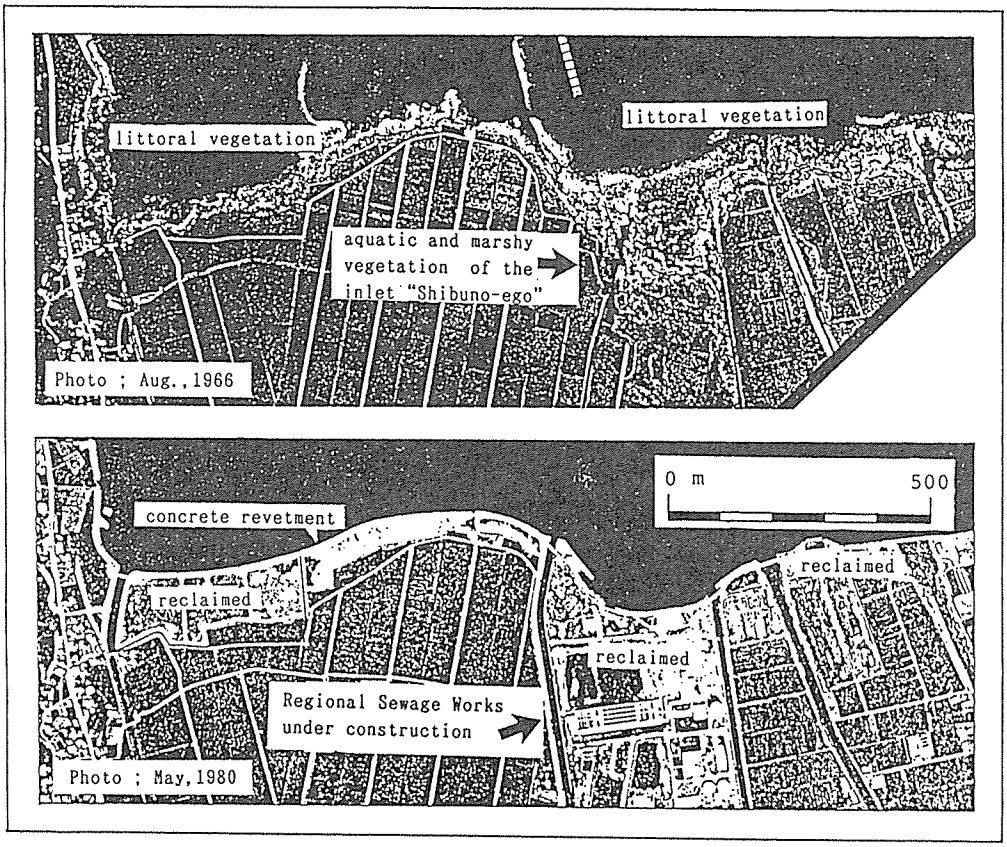

Figure 3. Extinction of littoral vegetation (avian habittat) caused by dredging and reclamation in Lake Suwa.

Table 5. Decrease in diversity of avian fauna after the extinction of littoral vegetation caused by dredging and reclamation in Lake Suwa.

(Number of species)

	Before construction Mar. to Oct.,1972 In "Shibuno-ego" area	After construction Apr.,1983 to Mar.,1984 In whole lake
Anatidae	20	12
Ardeidae	8	5
Scolopacidae	22	4
Charadriidae	8	3
Podicipidae	1	2
Laridae	-	2
Rallidae	2	2
Alcedinidae	-	1
Cinclidae	-	1
Sylviidae	2	2
Others	9	-
Total	79	34

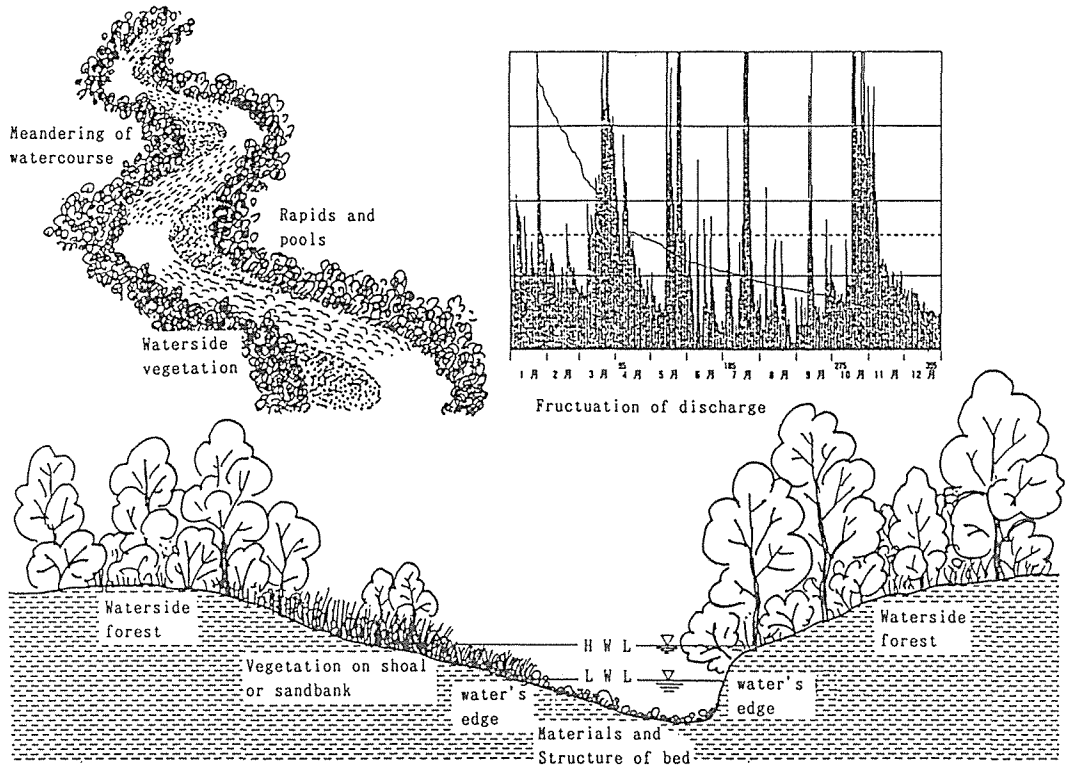

Figure 4. Structure of unartificial stream and riparian zone, and ecologically important factors on it.

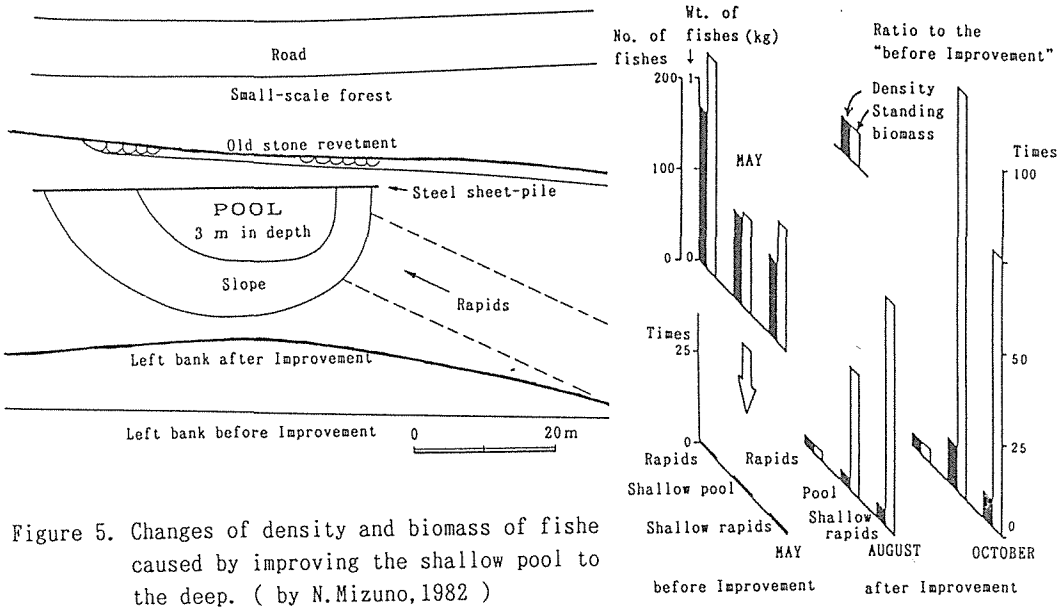

Figure 5. Changes of density and biomass of fishe caused by improving the shallow pool to the deep. (by N.Mizuno, 1982)

Table 6. Classified physiognomical components in 30 lake-shore landscapes shown in Figure 7.

【I】 Natural components :

1. Gentle slope including shoreline.
2. Vegetation of hygrophytes and emergent aquatic plants.
3. Vegetation of floating-leaved and submerged aquatic plants.
4. Woody vegetation on epilittoral area and hinterland.
5. Sandy beach.

【II】 Man-made components :

(A) 6. Steep or vertical man-made structure at the shoreline.
7. Enbankment of concrete or stone.
8. Building, harbour *etc.*
9. Colorful advertisement and structures.

(B) 10. Near-natural stone arragement.
11. Stone enbankment with gentle slope.

Note : Components II-(B) are intended to create near-natural landscape or amenities on the lake-shore.

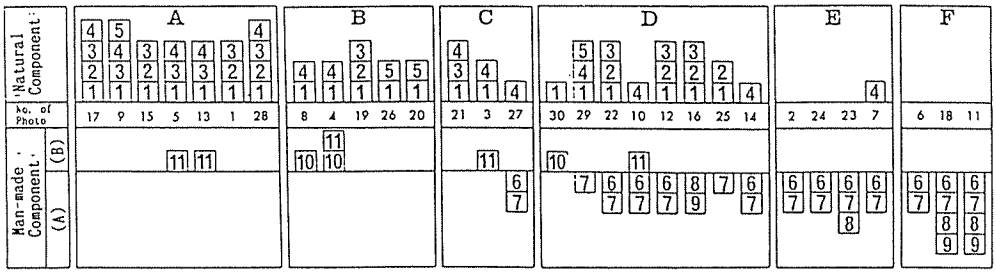

Figure 6. Relationship between the results of evaluation of desirability from opinion survey (A, most desirable to F, undesirable) and the physiognomical components of lake-shore landscape. Figures in boxes indicate the number of physiognomical components shown in Table 6, and the number of photographs are same as in Figure 7.

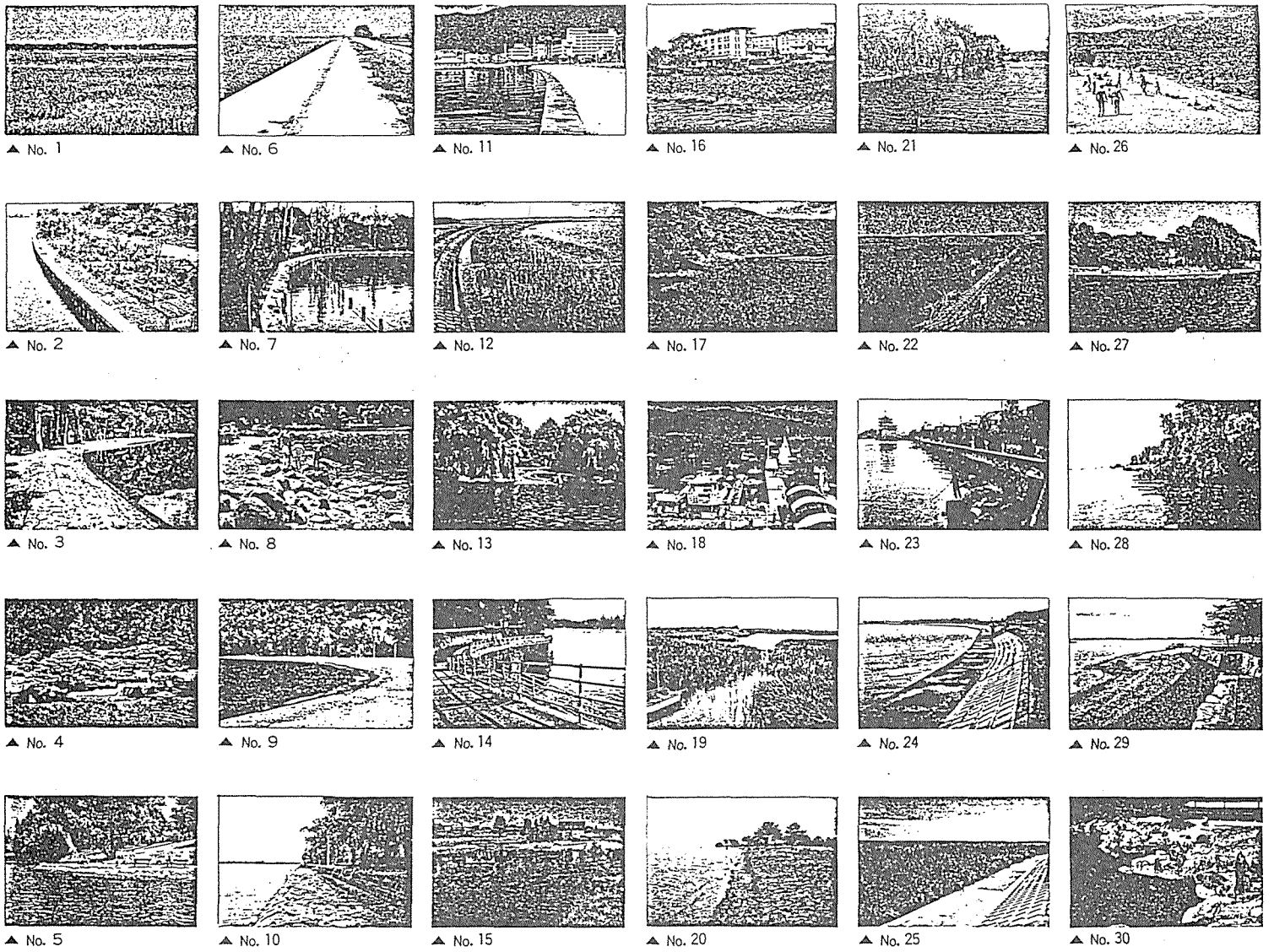

Figure 7. The chart of 30 Lakefront landscapes used for the evaluation of their desirability by means of the questionnaire. (The original is printed in color)