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AN ASSESSMENT OF THE CRACOW LANDSCAPE FROM THE LEVEL OF THE VISTULA RIVER WITH THE USE OF THE URBAN RIVERSIDE LANDSCAPE VALUATION MODEL

OCENA KRAJOBRAZU KRAKOWA Z POZIOMU WISŁY Z ZASTOSOWANIEM MODELU WALORYZACJI MIEJSKICH KRAJOBRAZÓW NADRZECZNYCH

Abstract

The objective of this article is to present the results of a Cracow landscape valuation from the level of the Vistula river. The paper presents and verifies the urban riverside landscape valuation model based upon five classification functions. The study covers a thirty-kilometre section of the Vistula river within the administrative boundaries of Cracow. 144 valuation points were designated at which the landscape was assessed based upon eight parameters. The presented results indicate the dynamics of the Cracow Vistula river landscape value and allow the assessment of application possibilities of the model developed for the landscape of Wrocław.

Keywords: *model*, *landscape valuation*, *riverside landscape*, *Kraków*, *Wisła*

Streszczenie

Celem artykułu jest przedstawienie wyników waloryzacji krajobrazu Krakowa widzianego z poziomu Wisły. W pracy zaprezentowano i zweryfikowano model waloryzacji miejskich krajobrazów nadrzecznych oparty na 5 funkcjach klasyfikacyjnych. Badaniami objęto 30-kilometrowy odcinek Wisły w administracyjnych granicach Krakowa. Wyznaczono 144 punkty waloryzacyjne, w których oceniano krajobraz na podstawie 8 parametrów. Przedstawione wyniki badań wykazały dynamikę wartości krajobrazu nadwiślańskiego Krakowa, a także pozwoliły ocenić możliwości zastosowania modelu opracowanego dla krajobrazu Wrocławia w aspekcie uniwersalnym.

Słowa kluczowe: *model*, *waloryzacja krajobrazu*, *krajobraz nadrzeczny*, *Kraków*, *Wisła*

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1. Introduction

Since ancient times, human life has been centred around river banks. As civilisation developed, the economic, spatial and landscape functions of rivers changed. The landscape qualities of the urban space located by a river, given historical, economic and cultural transformations, have acquired a new meaning over recent decades – they emphasise the individuality and uniqueness of riverside towns, becoming highly important spaces for the urban development of towns [16].

The issues related to landscape, its assessment and valuation are the topic of research papers in various fields, such as landscape architecture, environmental psychology, biology, spatial planning, law, aesthetics, sociology and geography. In this article, the 'value' mean visual value of the landscape. Until recently, little attention was devoted to the aesthetic qualities of landscape. The attention of the authors was mainly directed towards the assessment of the ecological values of landscapes and the indicators that describe them. Owing to the European Landscape Convention (2001) [3], promoting an integrated approach to landscape, combining social, cultural and visual aspects with ecological functions, the need to include aesthetic aspects, apart from the ecological ones, in landscape research increased. This fact is also emphasised by numerous studies conducted around the world [5, 14, 26, 27].

In research papers to date on the subject of riverside valuation methods, the trend has been based upon the valuation of the physiochemical and biological properties of water – the so-called ecomorphological methods [6, 7, 17, 18]. The underlying objective of the abovementioned methods is to determine the level of the watercourse's naturalness. The division into categories is based upon the total scoring of the selected physical, chemical and biological parameters of the water catchment area, river valley, river bed and biocoenosis [6].

There is a group of methods that show an interest in riverside landscape aesthetics, based mostly on the assessment of preferences of various social groups [1, 8–11, 19].

The contact of urban fabric and the natural environment in the form of a river, the multitude of landscape types along the open space of the river make riverside landscapes extremely valuable and at the same time susceptible to implemented changes. This problem has been observed by researchers worldwide when making attempts to develop a method of the assessment of urban riverside landscape value in order to properly manage such spaces. One of the largest international ventures of an interdisciplinary nature n this regard is the initiative of the group named URBEM (Urban River Basin Enhancement Methods) [20–25].

Issues of urban riverside landscape assessment have also become the research interests of Polish scholars in recent years. Methods with a very broad theoretical spectrum, the boundaries of which touch subjective methods, are appearing [19] with some methods [2, 12] if requently using modern computer tools, and some methods employing psychophysical methods [15][1].

The objective of this article is to present the results of Cracow landscape valuation as seen from the level of the river and to appraise the possibilities of applying the urban riverside

[1] The division of methods adopted after [28].

landscape classification method [15], which was developed for the landscape of Wrocław, to investigate conditions in Cracow.

2. Methods

2.1. Field studies

Field studies were conducted on the Vistula river in Cracow on a thirty-kilometre section (15 km upstream and 15 km downstream) between the Kościuszko Barrage and Dąbie Barrage. The purpose of the field studies was to register the landscape of Cracow as seen from the level of the Vistula river. To accomplish this, a motor boat was hired from the Cracow Water Rescue Service. The image was recorded using a professional Sony DCR-VX2000E camcorder between 10 am and 2 pm during stable lighting conditions. The camera was attached at the front of the boat in such a manner as to ensure a fixed viewing angle in relation to the level of the river. At 200 m distance 77 points were established (a total of 144 – Fig. 1), at which the assessment of individual parameters underlying the model was performed:

1. parameters concerning the river (Table 1) – *width of the river bed* [RB], *flora* [F];
2. parameters concerning the city (Table 2) – *landscape dominants* [LD], *destructive elements* [DE], *historical value* [Hv] (sum of points);
3. parameters concerning perception (Table 3) – *colour* [C], *horizontal complexity coefficient* [HCC], *vertical complexity coefficient* [VCC].

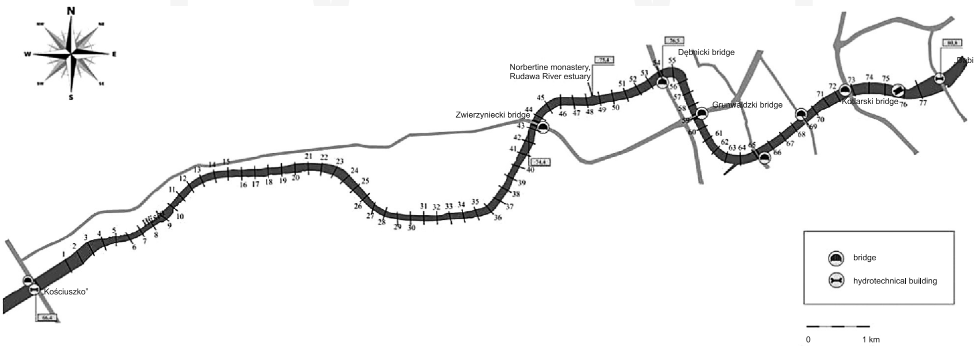

Fig. 1. The research area (author study)

Table 1

Number grading of the parameters concerning the river

<table>
<tr><td colspan="9">Parameters concerning the river</td></tr>
<tr><td rowspan="3">1.</td><td colspan="8">WIDTH OF THE RIVER BED [RB]</td></tr>
<tr><td colspan="3">description of factor</td><td colspan="2">narrow 0–5 m</td><td>medium 5–20 m</td><td>wide 20–100 m</td><td>very wide > 100 m</td></tr>
<tr><td colspan="3">number grade</td><td colspan="2">1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td rowspan="9">2.</td><td colspan="8">FLORA [F]</td></tr>
<tr><td colspan="4" rowspan="3">description of factor</td><td colspan="4">**number of species**</td></tr>
<tr><td>0</td><td>1–3</td><td colspan="2">≥ 4</td></tr>
<tr><td colspan="4">number grade</td></tr>
<tr><td rowspan="4">**structure**</td><td>lack of flora</td><td colspan="2" rowspan="4">number grade</td><td>0</td><td>–</td><td colspan="2">–</td></tr>
<tr><td>flora covers the stripe of the width from 0–12 m (single specimens or small groups)</td><td>–</td><td>1</td><td colspan="2">2</td></tr>
<tr><td>flora covers the stripe of the width from 12–20 m</td><td>–</td><td>2</td><td colspan="2">3</td></tr>
<tr><td>flora covers the stripe of the width over 20 m (compact structure)</td><td>–</td><td>4</td><td colspan="2">5</td></tr>
</table>

Table 2

Number grading of the parameters concerning the city

<table>
<tr><td colspan="7">Parameters concerning the city</td></tr>
<tr><td rowspan="6">1.</td><td colspan="6">**LANDSCAPE DOMINANTS [LD]**</td></tr>
<tr><td colspan="3" rowspan="3">description of factor</td><td colspan="3">**occurrence**</td></tr>
<tr><td>plan I</td><td>plan II</td><td>plan III</td></tr>
<tr><td colspan="3">number grade</td></tr>
<tr><td rowspan="2">**size**</td><td>small</td><td rowspan="2">number grade</td><td>4</td><td>2</td><td>0</td></tr>
<tr><td>large</td><td>5</td><td>3</td><td>1</td></tr>
<tr><td rowspan="6">2.</td><td colspan="6">**DESTRUCTIVE ELEMENTS [DE]**</td></tr>
<tr><td colspan="3" rowspan="3">description of factor</td><td colspan="3">**occurrence**</td></tr>
<tr><td>plan I</td><td>plan II</td><td>plan III</td></tr>
<tr><td colspan="3">number grade</td></tr>
<tr><td rowspan="2">**size**</td><td>small</td><td rowspan="2">number grade</td><td>4</td><td>2</td><td>0</td></tr>
<tr><td>large</td><td>5</td><td>3</td><td>1</td></tr>
</table>

3.	HISTORICAL VALUE [Hv] – sum of points (classification on the basis of effective legal acts in Poland)	
	description of factor	number grade
	visible whole architectural units of the 1st preservation zone	4
	visible whole architectural units of the 2nd preservation zone	3
	visible single specimens of the 1st preservation zone	1
	visible single specimens of the 2nd preservation zone	1
	visible buildings included in the register of monuments	1

Table 3

Number grading and the method of determining the parameters concerning perception

Parameters concerning perception				
1.	**COLOUR [C]**			
	description of factor	number of colours		
		≤ 5	6–8	≥ 9
	number grade	1	3	5
2.	**HORIZONTAL COMPLEXITY COEFFICIENT [HCC]**			
	description of factor	the ratio of horizontal line length to sectional view length		
	method of parameter determining	**HCC = hl/s** where: HCC – horizontal complexity coefficient hl – horizon line length s – sectional view length		
3.	**VERTICAL COMPLEXITY COEFFICIENT [VCC]**			
	description of factor	the ratio of the sum of the length of flora line, the length of architectural line and the length of coastal line to the length of sectional view		
	method of parameter determining	**VCC = (al+cl+fl)/s** where: VCC – Vertical complexity coefficient al – length of architectural line cl – length of coast line fl – length of flora line s – length of sectional view		

2.2. Urban riverside landscape valuation model [15]

This was developed for the Wrocław landscape as seen from the level of the Odra river. It was built from five classification functions describing five classes of landscape quality calculated according to the following formulas:

$$0.8392 \times Hv + 12.8670 \times RB - 0.1717 \times LD + 1.2957 \times F + 1.5694 \times DE + 10.0521 \times VCC + 2.4827 \times C - 2.4635 \times HCC - 36.6202 = \mathbf{VL}$$

$$-0.8403 \times Hv + 14.9771 \times RB + 0.3887 \times LD + 1.6550 \times F - 0.1802 \times DE + 11.8779 \times VCC + 1.9210 \times C - 2.6846 \times HCC - 41.1003 = \mathbf{L}$$

$$-0.8897 \times Hv + 17.3897 \times RB + 0.4635 \times LD + 2.3918 \times F - 0.0129 \times DE + 11.6220 \times VCC + 2.5640 \times C - 2.2115 \times HCC - 50.4446 = \mathbf{M}$$

$$1.5832 \times Hv + 18.7132 \times RB + 1.1165 \times LD + 2.6668 \times F - 0.3168 \times DE + 13.6641 \times VCC + 3.4565 \times C - 2.6464 \times HCC - 74.9210 = \mathbf{H}$$

$$3.055 \times Hv + 19.409 \times RB + 1.815 \times LD + 3.408 \times F - 0.485 \times DE + 16.022 \times VCC + 3.772 \times C - 4.764 \times HCC - 102.050 = \mathbf{VH}$$

where:

Hv – historical value
RB – width of the river bed
LD – landscape dominants
F – flora
DE – destructive elements
C – colour
VCC – vertical complexity coefficient
HCC – horizontal complexity coefficient
VL – class – very low value of landscape
L – class – low value of landscape
M – class – medium value of landscape
H – class – high value of landscape
VH – class – very high value of landscape

Each case is classified into the given landscape value class for which it obtains the highest classification value.

3. Results

The conducted field studies and **research allowed** the development of a database of 144 cases. Values were calculated for each case classification (Table 4). The distribution of Cracow landscape qualities along the Vistula river is presented in Fig. 2. The Cracow landscape as seen from the level of the Vistula river may be divided into two fragments. The first being from the Zwierzyniecki bridge to the Kościuszko barrage – this is of a homogeneous, quite monotonous character, obtained mean landscape quality values. The second goes from the Zwierzyniecki bridge to the Dąbie barrage and is characterised by a fairly high dynamics, variability with the lowest landscape quality values over the section from the Kotlarski bridge upstream. The highest landscape value classes were observed for the section between the Zwierzyniecki, Grunwaldzki and Kotlarski bridges.

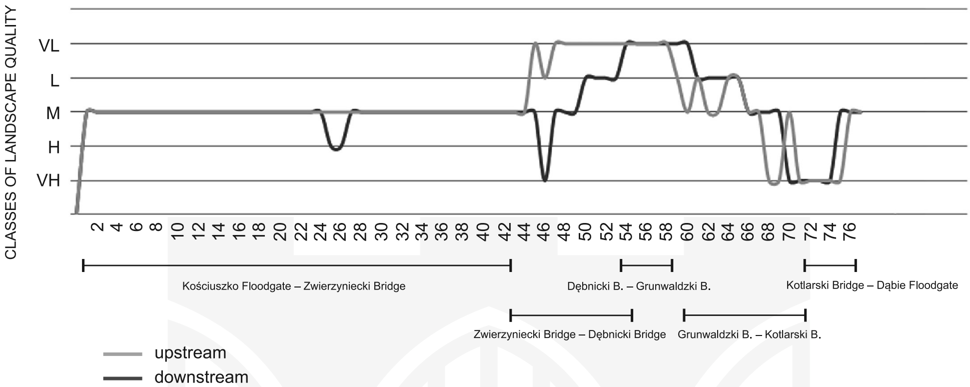

Fig. 2. Cracow landscape classification from the level of the Vistula river

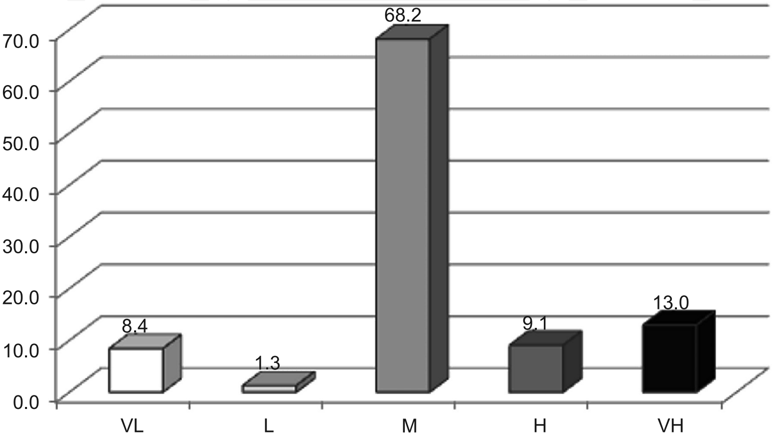

Fig. 3. Percentage share of Cracow landscape quality classes as seen from the Vistula level

The largest number, as much as 68.2% of the studied cases, were classified as medium landscape quality. Over 22% of the cases obtained either high or very high scores of landscape quality. Whereas 8.4% of the studied points were classified as the lowest class of landscape quality (Fig. 3).

4. Discussion

The model applied in the paper finds the relationships between the studied landscape parameters and its value class. The effectiveness of the model in the studies of the Wrocław landscape as seen from the level of the Odra river was estimated to be at alevel of 77% [15]. The issues related to landscape and its evaluation are extremely complex – this fact was also stressed by Feimer N.R. et al (1979), claiming that the desired level of reliability in landscape research amounts to 0.70 or more.

Analysis of the classification values obtained by the model shows that twenty – nine cases (20.14%) obtained similar function values for the two classes of landscape quality (marked red in Table 4). Twenty – one cases are related to the N class, eight cases to the W class and one to the S class.

Similar results were achieved in the studies conducted in Wrocław, where the lowest prediction of the model was observed for the N and W classes – 64.2 and 61.9 percent of the correctly classified cases, respectively [15]. One may also note that similar classification values belong to neighbouring classes. This fact may indicate to the researcher the probability of wrong model prediction or that the value of the given landscape is between two classes.

Unfortunately, it is difficult to find studies that would allow a direct comparison of the obtained results in the literature of the subject. The research conducted by scholars from the Cracow University of Technology is mainly related to the landscape of the river's section in the vicinity of Wawel Castle, as this is the most valuable landscape.

5. Conclusions

The research conducted in this paper indicates that the underlying idea for the model and the used indicators are universal and objective in nature; therefore, the model may be used for the assessment of the landscape of medium – size European rivers such as the Odra or the Vistula. The applied model is one of the voices in the discussion concerning the search for objective methods of landscape quality assessment. This may be a starting point for the development of a supporting tool for making decisions related to the location of investments within the riverside areas without adversely affecting the landscape. Regarding the results obtained in the study, there is a need for further research on this topic.

Table 4

Database fragment. The obtained classification values are marked grey. The values closest to the highest classification values are marked red

Valuation points.	PARAMETERS													Class of landscape
	HCC	VCC	RB	F	LD	DE	Hv	C	VL	L	M	H	VH	
1	1.127012	3.426241	4	2	5	0	0	3	55.69332	67.49557	71.23469	65.05137	52.31915	S
2	1.127012	3.336489	4	2	3	0	0	3	55.13453	65.65211	69.26459	61.59199	47.25114	S
3	1.293308	3.013706	4	2	0	0	0	1	47.02991	56.36358	58.62694	46.47887	28.29828	S
4	1.293308	2.842061	4	2	0	0	0	1	45.30451	54.3248	56.63208	44.13349	25.54818	S
5	1.781597	3.083518	4	2	0	0	0	1	46.52877	55.88195	58.35845	46.14058	27.0906	S
6	1.781597	3.083518	4	2	0	0	0	1	46.52877	55.88195	58.35845	46.14058	27.0906	S
7	1.781597	3.083732	4	2	0	0	0	1	46.53092	55.88448	58.36093	46.1435	27.09402	S
8	1.989208	3.655698	4	2	0	0	0	1	51.76893	62.12089	64.54919	53.40948	35.26901	S
9	1.920462	3.540633	4	2	0	0	0	1	50.78164	60.93871	63.36393	52.01915	33.75294	S
10	1.634668	2.838116	4	2	0	0	0	1	44.42392	53.36153	55.83132	43.17622	23.85874	S
11	1.634668	2.838116	4	2	0	0	0	1	44.42392	53.36153	55.83132	43.17622	23.85874	S
12	1.920462	3.540633	4	2	0	0	0	1	50.78164	60.93871	63.36393	52.01915	33.75294	S
13	1.634668	2.838116	4	2	0	7	0	1	55.40972	52.10013	55.74102	40.95862	20.46374	S
14	1.634668	2.838116	4	2	0	7	0	1	55.40972	52.10013	55.74102	40.95862	20.46374	S
15	1.365036	3.183739	4	2	0	5	0	1	56.4094	57.28966	60.37994	47.0284	28.25583	S
16	1.365036	3.183739	4	2	0	3	0	1	53.2706	57.65006	60.40574	47.662	29.22583	S
17	1.170128	2.826173	4	2	0	0	0	1	45.44826	54.46677	56.71984	44.24238	25.88045	S
18	1.340551	3.151085	4	2	3	0	0	1	47.77937	59.03462	61.50958	51.5805	35.71929	S
19	1.298725	2.573362	4	2	0	0	0	1	42.59018	51.11868	53.49728	40.44763	21.21728	S
20	1.208457	3.167387	4	2	3	0	1	1	47.42946	58.74258	61.10147	53.73603	39.66478	S
21	1.340551	3.151085	3	2	3	0	1	3	39.03857	47.05922	48.35818	41.3635	26.90929	S
22	1.208457	3.167387	3	2	3	0	1	3	39.52786	47.60748	48.83977	41.93583	27.79978	S
23	1.140483	3.828992	3	2	3	0	1	3	46.34583	55.64845	56.67927	51.15596	38.72385	S
24	1.140483	3.828992	3	2	3	0	1	3	46.34583	55.64845	56.67927	51.15596	38.72385	S
25	1.158913	3.776425	3	0	3	0	1	3	43.18062	51.66459	51.24398	45.05531	30.97783	N
26	1.159861	3.890057	3	0	3	0	1	3	44.32053	53.01175	52.56251	46.60547	32.79392	N
27	1.317443	3.93995	3	3	3	0	1	3	48.32095	58.14633	59.96927	54.87059	43.06658	S
28	1.159861	3.890057	3	3	3	0	1	3	48.20763	57.97675	59.73791	54.60587	43.01792	S

29	1.544868	3.664439	3	3	3	0	1	1	40.02583	50.42129	51.13634	43.59113	30.02489	S
30	1.618639	3.343619	3	3	0	0	0	1	37.97348	46.08678	46.74382	34.07948	16.03327	S
31	1.618639	3.343619	3	3	0	0	0	1	37.97348	46.08678	46.74382	34.07948	16.03327	S
32	1.618639	3.343619	3	3	0	0	0	1	37.97348	46.08678	46.74382	34.07948	16.03327	S
33	1.705406	3.014341	3	3	0	0	0	1	34.44979	41.94271	42.72507	29.35058	10.34422	S
34	2.940658	4.10889	3	5	5	0	0	1	44.14216	56.88099	59.81525	51.95372	37.88734	S
35	1.792302	3.983589	3	5	5	0	0	1	45.7116	58.47556	60.89859	53.28061	41.35053	S
36	1.369848	2.710228	3	5	2	0	1	1	33.62826	42.47843	44.75365	35.23296	20.57132	S
37	1.609759	3.083286	3	5	2	0	1	1	36.78726	46.26551	48.55877	39.69557	25.40552	S
38	1.609759	3.083286	3	5	2	0	1	1	36.78726	46.26551	48.55877	39.69557	25.40552	S
39	1.503947	2.613651	3	5	0	0	0	1	33.50971	41.03419	43.29737	29.74224	11.70011	S
40	1.695477	3.182467	3	5	0	0	0	1	38.75567	47.27635	49.48459	37.00774	19.90124	S
41	1.728256	2.79368	3	5	0	0	0	1	34.76679	42.57037	44.89361	31.60856	13.51593	S
42	1.436394	2.489128	3	5	0	0	0	1	32.42441	39.73647	41.99956	28.21952	10.02683	S
43	1.728256	2.79368	3	5	0	0	0	1	34.76679	42.57037	44.89361	31.60856	13.51593	S
44	1.878277	3.644315	3	2	5	0	0	1	38.20229	49.24989	49.59002	40.41682	25.28111	S
45	1.425303	3.655257	3	2	5	5	0	3	52.24058	53.53691	55.78244	47.09408	32.73339	S
46	2.035886	3.712255	3	2	0	8	0	3	56.87605	50.09065	52.73836	39.72415	20.20778	NN
47	1.889694	4.19774	3	2	4	1	1	5	54.56994	62.06756	64.88657	61.92455	49.93668	S
48	1.657062	4.068289	4	2	4	1	1	5	66.70878	76.13159	81.28627	79.48456	68.37989	S
49	1.74086	3.73411	4	2	4	1	1	5	63.14314	71.93727	77.21712	74.69654	62.62645	S
50	1.760912	3.970518	4	2	4	1	5	3	57.14794	67.48828	71.23351	77.29358	70.99466	W
51	1.777982	3.806996	4	2	6	4	5	5	64.79234	69.57895	75.3116	83.20962	78.01238	W
52	1.706244	3.430912	4	2	6	4	5	5	61.18864	65.30445	71.0994	78.26062	72.32853	W
53	1.762805	3.490068	4	2	1	0	8	5	53.70725	62.11166	66.72683	79.35356	75.03687	W
54	2.535158	4.921672	4	2	5	0	11	5	62.99078	76.07655	80.84177	106.0868	110.7195	WW
55	1.620552	4.461098	4	2	5	0	11	5	60.61418	73.06124	77.51163	102.2139	107.6974	WW
56	1.512026	5.753345	4	2	13	0	11	5	72.49772	91.81137	96.47812	129.0904	143.4388	WW
57	1.482711	5.064595	4	2	16	0	8	5	67.64906	87.39617	92.59791	118.3568	128.8233	WW
58	1.517222	5.041102	4	2	16	0	8	5	67.32788	87.02447	92.24855	117.9444	128.2825	WW
59	2.377934	5.207056	4	2	20	0	5	5	68.70651	90.76069	96.7969	117.6507	124.936	WW
60	1.321168	4.026604	4	2	13	0	4	5	61.48493	77.6958	83.05993	94.91879	95.29721	WW
61	1.321168	3.875659	4	2	11	0	4	5	60.31102	75.12549	80.37865	90.62326	89.24877	W

62	1.320301	3.86	4	2	11	0	4	5	60.15575	74.94182	80.19858	90.41158	89.00201	W
63	1.485187	3.339244	4	2	11	0	4	5	54.51485	68.31367	73.7817	82.85956	79.87293	W
64	1.485187	3.339244	4	2	1	1	4	3	52.83585	60.40447	64.0058	64.46476	53.69393	W
65	1.523244	3.659911	4	2	5	3	4	3	58.41748	65.30555	69.47663	72.57807	64.94036	W
66	1.570373	4.058249	4	1	5	0	0	3	59.65841	72.15725	75.20759	69.84708	56.92501	S
67	1.343401	3.608003	4	1	3	0	0	3	56.03504	66.64121	69.54978	62.06254	47.16246	S
68	1.470244	3.529053	4	1	1	5	0	3	63.11934	63.68451	67.3602	56.83107	39.23824	S
69	2.490358	4.549166	4	1	8	5	0	3	69.65868	75.78362	80.20448	75.88588	63.42767	S
70	1.364508	3.178606	4	0	8	11	0	3	66.7759	59.7905	64.29644	55.57025	40.5141	NN
71	1.271017	2.360436	4	0	8	20	0	3	72.90649	48.70156	54.87834	41.78692	23.48579	NN
72	1.239725	2.594732	4	0	6	20	0	3	75.68215	50.7911	56.74353	42.83817	23.75875	NN
73	2.271017	3.594732	4	1	3	11	0	3	70.87986	62.0111	67.20222	55.94156	37.19568	NN
74	1.908261	3.446599	4	1	5	7	0	3	63.66346	62.72364	67.26146	58.37765	42.12046	NN
75	1.908261	3.340877	4	1	3	7	0	3	62.94413	60.69049	65.10576	54.70006	36.79658	S
76	2.65925	3.352673	4	1	8	3	0	3	54.07654	61.4788	65.95114	59.72352	44.42286	S
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
144	1.918895	3.903521	4	1	8	2	0	3	59.86818	70.18946	74.00328	69.52644	57.26059	S

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