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Perception and evaluation of dead wood in streams and rivers by German students

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Abstract

Dead wood is a significant element of natural streams and rivers in temperate climate zones. Established stream management removes wood, whereas some scientists recently promoted the reintroduction of wood in stream rehabilitation and restoration. It is desirable to know if wood in streams and rivers would be accepted. A survey was therefore conducted in order to assess the spontaneous visual perception of 10 stream and 10 river scenes with and without wood in terms of naturalness, risk, aesthetics and need for improvement using visual analog scales. Three hundred and sixty-five German students from five subjects related to water management and from one subject without any professional association to running waters were surveyed before their first contact to teaching of aquatic ecology. They clearly perceived wood in streams and rivers as natural. Scenes with wood were most frequently associated with danger for sport activities while scenes without wood were most frequently associated with danger by flooding. When comparing scenes with and without wood, scenes with wood were clearly considered more positive as significantly more aesthetic, less dangerous and needing less improvement. The disciplinary groups showed variations in the absolute evaluation scores but the relative evaluation of scenes with wood versus scenes without wood was similar among all groups. The results indicate an acceptance for the reintroduction of wood in stream rehabilitation and restoration by young students who are potential future players in water management.

Keywords: River management; Survey; Perception; Woody debris; Restoration; Guiding principle

Introduction

In most natural streams and rivers, dead wood is an abundant substrate with major effects on the in-stream environment (Hering et al., 2000). It has significant

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influence upon channel processes and thus determines, for example, bed form, cross-sectional shape, sinuosity and valley bottom landform (Montgomery, Collins, Buffington, & Abbe, 2003) and even hydraulic exchange with the hyporheic and groundwater zones (Borchardt, Fischer, & Ibisch, 2001). Wood also provides refuge, habitat diversity and food for aquatic organisms and its presence enhances aquatic biodiversity (Dolloff & Warren, 2003; Hoffmann & Hering, 2000; Wondzell & Bisson, 2003; Zalewski, Lapinska, & Bayley, 2003).

Despite these benefits most running waters have only little to no wood at present (Elosegi & Johnson, 2003; Hering et al., 2000). In cultivated landscapes, long-term human impact on riparian vegetation reduced wood input and over recent centuries it is established practice to remove wood from streams and rivers for the reason of flood risk management (Elosegi & Johnson, 2003; Hering et al., 2000; Moulin & Piégay, 2004). The primary aims of water management in Germany currently shift from fast downstream discharge towards increasing retention of water in upstream reaches and towards stronger emphasis on good biological and structural quality of streams. The achievement of these objectives requires new vegetation maintenance practices (Boyer et al., 1998; Bragg & Kershner, 1999) and the re-establishment of natural wood as one cost-effective measure, at least in reaches where wood is no hazard to bridges or other infrastructure (Abbe, Brookes, & Montgomery, 2003; Gerhard & Reich, 2000, 2001; Launhardt & Mutz, 2003). The active placement of wood in stream rehabilitation and restoration would be an appropriate method to markedly improve the hydromorphological state of small streams (Reich, Kershner, & Wildman, 2003) as required by the EU Water Framework Directive. Such placement of wood could be applied to a large proportion of the streams in Central Europe (Kail & Hering, 2005). In discussion with stream managers these ideas are often rejected by the assertion that wood in streams and rivers is generally perceived as dangerous and abnormal by the public and hence not acceptable. However, no data on the perception of wood in streams and rivers in Germany are available, although results have been obtained for studies in New Zealand (Mosley, 1989) in the UK (Gregory & Davis, 1993).

Therefore, in coordination with colleagues from other countries, a survey was undertaken to assess how wood in streams and rivers is perceived by young Germans starting their academic education. The objectives were to assess the intuitive perception of wood in streams and rivers according to aesthetics, naturalness, danger, and need for improvement. The respondents had also to characterize their assessment when considering the danger perception and the need for improvement. We surveyed a student population because they could easily be approached and had similar ages, which reduced a potential bias. We then checked if six disciplinary groups (biology or ecology, civil engineering or hydraulic engineering, geography or environmental studies, agricultural biology, agricultural science, social science or economy) of which five represent potential future players in water management differ in their evaluation of wood.

In the first paper (Piégay et al., 2005), a general overview of the international comparison of wood evaluation from the collaborative surveys in nine countries is given. This international overview could not include the disciplinary groups agricultural biology and agricultural science, which are major stakeholders of water management in Germany, and moreover, none of the qualitative data assessed in Germany could be considered. One outcome of this international comparison was that the German respondents contrasted the perception of respondents from most other nations by perceiving wood as a beneficial element. Therefore, this paper focusses on the special perception of the German group, including data of all six disciplinary groups surveyed, and gives a deeper analysis of the qualitative data that could not be considered in previous overview (Piégay et al., 2005).

Methods

The perception of wood was assessed using a questionnaire that was based on visual perception of stream and river scenes. Participants were requested to rate 20 colour photographs that portrayed reach views of streams (channel width from 2 to 5 m) and rivers (channel width wider than 10 m) using a visual analog scale (Gift, 1989). The pictures comprised 10 river scenes (five with wood and five other scenes without) and 10 scenes of streams (again five with wood and five without). They reflected a variation of temperate stream and river types from mountain, piedmont, and lowland regions. The set of pictures is available on the web site http://cassiopee.univ-lyon3.fr/umr5600/questionnaire/tabmatriv.html. The pictures in a black and white format, information on the selection procedure of the photographs from a larger set of pictures, and information on the submission of the questionnaire are published in Piégay et al. (2005).

Participants were told the aim of the survey was to evaluate various river scenes. They did not know that the survey focussed on the perception of wood. Respondents were asked to mark their ranking on a analogous scale for each scene ranging from 0 (lowest degree of agreement) to 10 (highest degree of agreement) according to aesthetics, naturalness, danger and need for improvement. The type of danger perceived was further requested by selecting from ‘no danger’, ‘danger by flooding or inundation’, ‘danger because of bank erosion’, ‘danger for sport activity – hiking, boating, swimming’, ‘danger due to degraded water quality’ and ‘other’. The observers were also

requested to select the types of improvement they felt necessary from 'no improvement needed', 'improving of landscape quality', 'improving habitats for fauna', 'bank stabilization by engineering works', 'flood risk management by channel cleaning', 'flood risk management by civil engineering works' and 'other'. In addition to the perception of the stream or river scenes, we requested information about the proximity between place of residence and next stream or river and information about the frequency of visiting streams or rivers. The persons interviewed were undergraduate students from five degree subjects who will in future possibly be players in water management and graduate students from a degree without any professional association to running waters. Potential future professional players in water management were students of Civil Engineering having their main subject in water engineering (University Kassel), Landscape Planning (University Hannover), Environmental Engineering with main subject water management (Brandenburg Technological University, Cottbus), Agricultural Biology (University Hohenheim) and Agricultural Science (University Hohenheim). The group without any association to water management was the group of students of Social Work (Catholic University of Applied Sciences, Berlin). All students had no teaching regarding stream ecology and the significance of wood in streams and rivers, prior to the survey. Hence they represented a non-expert view of young people with high school education, who will be the coming generation of professional players in water management.

For each respondent, the mean score of scenes with wood (w) and without wood (nw) was calculated for stream and river scenes separately (N–5). These mean scores were used to review the differences in the perception between scenes with and without wood. Hence, differences in the evaluation of the scenes, due to other factors were not considered. Since some of the means did not follow a normal distribution (Kolmogorov–Smirnov), statistical differences were tested by non-parametric methods (Mann–Whitney U, Wilcoxon signed rank, SPSS). Variability of the characterization of danger perceived and improvement needed between streams and rivers and between scenes with wood and scenes without wood was analysed with contingency tables (Pearson χ^2, Cramers V, SPSS). The significance for differences of individual types of danger and individual types of improvement are estimated based on the standardized residuals (Bühl & Zöfel, 2000).

Results

Evaluation of respondents' ratings

Three hundred and sixty-five students were interviewed, but valid data for each of the measured means ranged from 356 to 364, since not all students answered all of the questions. Most participants (68.9%) lived close to a stream or river and visited streams or rivers frequently (30.7% 6–20 times per year; 44.7% > 20 times per year). The presence and lack of wood clearly affected the streams and rivers perception by students, although the significance of wood was stronger in streams. The participants considered scenes with and without wood dissimilar for all factors, except for aesthetics and need for improvement for river scenes (Wilcoxon $p<0.01$). They found stream scenes with wood more aesthetic (mean score $w = 5.9 \pm 0.08$, nw = 5.1 ± 0.06), more natural (mean score $w = 7.2 \pm 0.07$, nw = 4.7 ± 0.06), less dangerous (mean score $w = 3.8 \pm 0.09$, nw = 4.1 ± 0.08), and needing less improvement (mean score $w = 3.3 \pm 0.09$, nw = 4.0 ± 0.07), than streams without wood (Fig. 1). The observers assessed scenes of rivers with wood more natural (mean score $w = 7.0 \pm 0.07$, nw = 5.8 ± 0.06) and less dangerous (mean score $w = 4.1 \pm 0.08$, nw = 4.8 ± 0.08), than scenes without wood. The naturalness factor exhibited the largest differences in evaluation between scenes with and without wood for both streams and rivers. The lack or presence of wood had stronger significance in streams than in rivers for aesthetics, naturalness and needs for

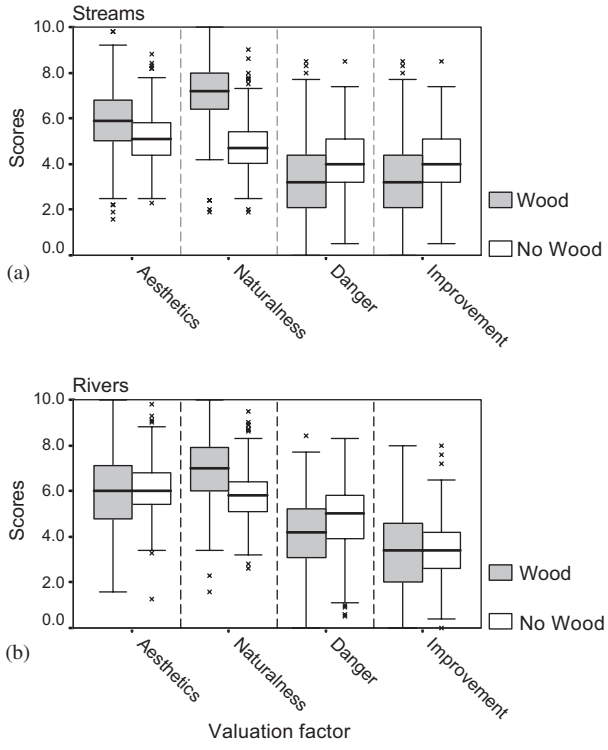

Fig. 1. (a) and (b) Distributions of scores of evaluation factors for scenes with and without wood for streams and rivers. Stars = outliers, whiskers = range of data, boxes = 25th and 75th percentiles and median. Scenes with and without wood were dissimilar for all factors, except for aesthetics and need for improvement for the river scenes (Wilcoxon $p<0.01$).

improvement. In contrast, the presence or lack of wood had a stronger significance for danger in rivers.

The type of danger perceived by the observers differed little between streams and rivers (Pearson χ^2, $p<0.001$, Cramers $V=0.12$) (Fig. 2). In 32% of the scenes for streams and 24% for rivers, the observers saw no danger. This difference also matched the higher danger scores given for the river scenes. Among the dangers perceived, danger caused by flooding was the most frequent and also the factor most clearly separating streams (23%) from rivers (31%) ($p<0.001$) followed by the category 'other dangers' (streams = 3%, rivers = 2%, $p<0.01$). Danger of bank erosion (streams = 9%, rivers = 8%), danger for sport activities such as swimming, boating or hiking (streams = 23%, rivers = 24%), and danger for water quality (streams = 10%, rivers = 11%) were similar among streams and rivers.

Wood affected the frequency in which different dangers were considered (Pearson χ^2, $p<0.001$) and this effect was stronger in streams (Cramers $V=0.24$) than rivers (Cramers $V=0.16$) (Figs. 3a and b). In streams, observers considered scenes with wood to cause less flood risk ($w=24\%$, nw = 42%, $p<0.001$) and less bank erosion ($w=10\%$, nw = 18%, $p<0.001$). Regarding sport activities scenes with wood were clearly considered more dangerous ($w=46\%$, nw = 21%, $p<0.001$). The danger for water quality ($w=15\%$, nw = 15%) and the category 'other' ($w=5\%$, nw = 4%) had similar frequencies with and without wood. In rivers, the risk of flooding ($w=37\%$, nw = 44%, $p<0.05$) and, contrary to the trend in streams, the danger for sport activities ($w=28\%$, nw-36%, $p<0.01$) were considered less often if wood was present. Danger for water quality was considered more often in presence of wood ($w=19\%$, nw = 9%, $p<0.001$). The risk of bank erosion ($w=12\%$, nw = 10%) and the category 'other' ($w=3\%$, nw = 2%) were similar with and without wood.

The types of need for improvement that were considered by the respondents was also clearly influenced by the presence of wood (Pearson χ^2, $p<0.001$) exhibiting the same trends in streams and rivers,

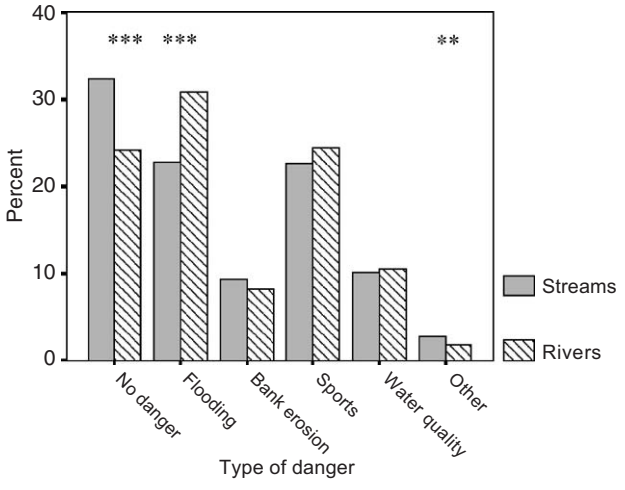

Fig. 2. Relative frequency of type of danger perceived for the individual scenes of streams and rivers. Sports = danger for swimming, boating, and hiking. Water quality = danger for water quality. Streams $N=3472$, rivers $N=3584$. Total frequencies were dissimilar between streams and rivers (Pearson χ^2, $p<0.001$, Cramers $V=0.12$); significance of differences for individual types of danger are given based on standardized residuals, $^{*}=p<0.05$, $^{**}=p<0.01$, $^{***}=p<0.001$.

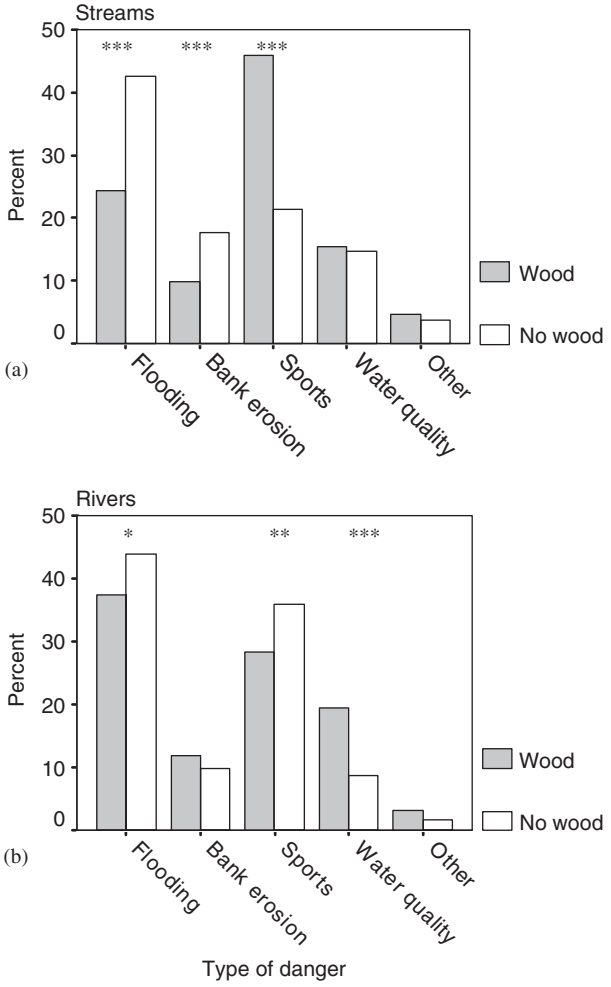

Fig. 3. (a) and (b) Relative frequency of types of danger considered by observers for individual scenes with and without wood for streams and rivers. Sports = danger for swimming, boating, and hiking. Water quality = danger for water quality. Type 'no danger' is not considered in the graphs. Streams $N=1146-1204$, rivers $N=1335-1385$. Total frequencies were dissimilar between scenes with wood and scenes without wood (Pearson χ^2, $p<0.001$, Cramers $V=0.24$ for streams and Cramers $V=0.16$ for rivers); significance of differences for individual types of danger are given based on standardized residuals, $^{*}=p<0.05$, $^{**}=p<0.01$, $^{***}=p<0.001$.

although these trends were stronger in streams (Cramers $V = 0.41$) than in rivers (Cramers $V = 0.34$) (Figs. 4a and b). Most participants considered no need for improvement (streams $w = 52\%$, nw = 37%; rivers $w = 43\%$, nw = 53%). The remaining observers, however, saw less need in scenes with wood for improving landscape quality (streams $w = 13$, nw = 25%, $p < 0.001$; rivers $w = 13\%$, nw = 14%, $p < 0.05$), habitats (streams $w = 7\%$, nw = 15%, $p < 0.001$; rivers $w = 7\%$, nw = 11%, $p < 0.001$) and flood risk management by civil engineering works (streams $w = 2\%$, nw = 5%, $p < 0.01$; rivers $w = 9\%$, nw = 9%, $p < 0.01$). The need for flood risk management by channel clearing was clearly seen more frequent in scenes with wood than in scenes without (streams $w = 17\%$, nw = 3%, $p < 0.001$; rivers $w = 17\%$, nw = 2%, $p < 0.001$).

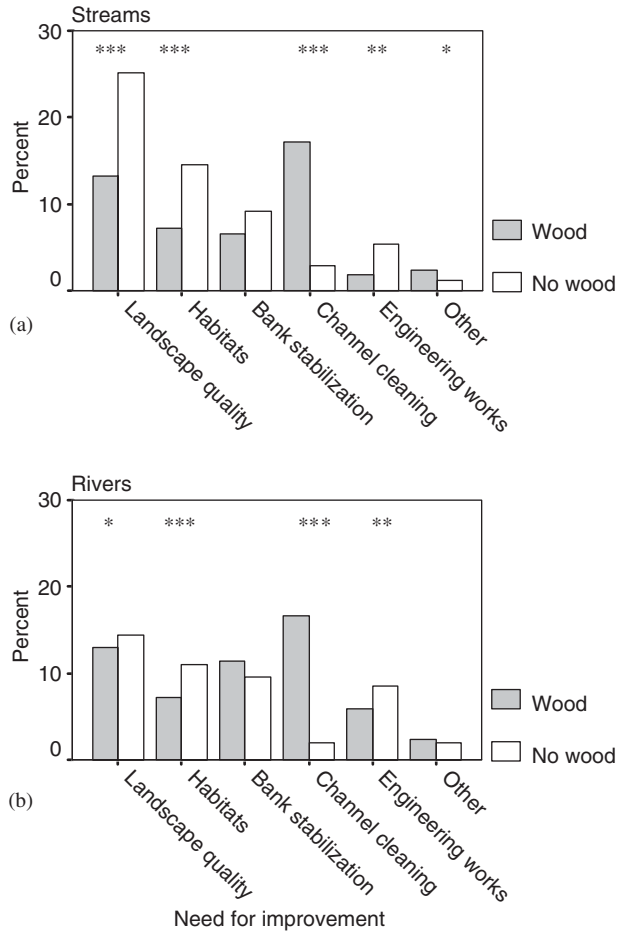

Fig. 4. (a) and (b) Relative frequency of types of improvement considered by observers for scenes with and without wood and for streams and rivers. Type 'no need for improvement' is not shown in the graphs. Streams $N = 1712-1727$, rivers $N = 1670-1676$. Total frequencies were dissimilar between scenes with wood and scenes without wood (Pearson χ^2, $p < 0.001$, Cramers $V = 0.41$ for streams and Cramers $V = 0.34$ for rivers); significance of differences for individual types of need for improvement are given based on standardized residuals, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$.

Comparison of disciplinary groups

The disciplinary groups differed in the scores of their evaluations except for the factors naturalness and danger in river scenes (Kruskal–Wallis, $p < 0.05$). Despite these dissimilarities of the absolute scores, the trend for the evaluation of presence versus lack of wood was comparable among the disciplinary groups for all factors except danger in streams (Table 1). In streams, scenes with wood were evaluated as more aesthetic by all groups except the civil engineers and the social workers, for whom this difference of scores was not significant. All disciplinary groups evaluated wood scenes in streams as more natural. The need for improvement was considered lower by all groups except by agricultural biologists and social workers, for whom these differences of scores were not significant. Regarding danger in streams, the perception of wood was contrary among the groups. Civil and environmental engineers and agricultural scientist saw no difference between scenes with and without wood, landscape planners and agricultural biologists considered scenes of the streams with wood less dangerous, whereas social scientists considered them more dangerous.

In rivers, no significant difference was considered for aesthetics and scenes with wood were seen as more natural in all six disciplinary groups. Contrary to our expectations, five groups considered rivers with wood less dangerous than scenes without wood and only for the agricultural scientists the difference of danger scores was not significant. No difference between wood and no wood scenes was seen for the need for improvement except by the civil engineers, who considered higher need for improvement in river scenes with wood.

The relative frequencies of the types of danger and types of improvement needed that were considered in the scenes showed small differences between the educational groups (Figs. 5 and 6). Although the dissimilarities were significant (Pearsons χ^2, $p < 0.001$) the effect of educational group was weak (Cramers $V = 0.05$ for type of danger and type of improvement). Hence, observers from all groups perceived similar dangers and improvement needs related to the scenes.

Discussion

Respondents' ratings

Static photographs, as used in this study, cannot fully give the dynamic appearance of streams and rivers. Despite this restriction, there is good confidence for

Table 1. Mean scores of evaluation factors of the disciplinary groups for scenes with and without wood

	Aesthetics		Naturalness		Danger		Need for improvement	
	Wood	No wood	Wood	No wood	Wood	No wood	Wood	No wood
Streams								
Civil engineering	5.4	5.1 n.s.	7.1	4.7**	4.0	4.5 n.s.	3.9	4.8*
Landscape planning	5.8	4.8**	7.0	4.6**	3.6	4.5**	3.2	4.6**
Environmental engineering	6.2	5.2*	7.3	4.7**	3.8	3.7 n.s.	3.1	3.9*
Agricultural biology	5.8	5.1**	7.1	4.6**	3.9	4.2*	3.3	4.1 n.s.
Agricultural science	6.4	5.4**	7.1	5.0**	3.4	3.6 n.s.	3.0	3.8*
Social work	5.7	5.5 n.s.	7.5	5.3**	4.4	3.8*	3.4	3.6 n.s.
Rivers								
Civil engineering	5.7	6.0 n.s.	7.1	5.8**	4.4	4.9*	4.1	3.6*
Landscape planning	6.1	5.9 n.s.	6.9	5.7**	4.0	4.8**	3.4	3.5 n.s.
Environmental engineering	5.5	5.9 n.s.	6.8	5.7**	4.5	5.2*	3.6	3.8 n.s.
Agricultural biology	6.2	6.2 n.s.	7.0	5.6**	3.7	4.8**	3.1	3.3 n.s.
Agricultural science	6.3	6.6 n.s.	7.1	6.2**	3.9	4.2 n.s.	3.0	2.7 n.s.
Social work	5.8	5.9 n.s.	6.9	5.7**	4.1	4.7*	3.6	3.6 n.s.

The significance of the difference between scenes with (wood) and without wood (no wood) are marked (n.s. = not significant, * = significant ($p<0.05$), and ** = highly significant ($p<0.01$) (Wilcoxon test). $N = 356-364$.

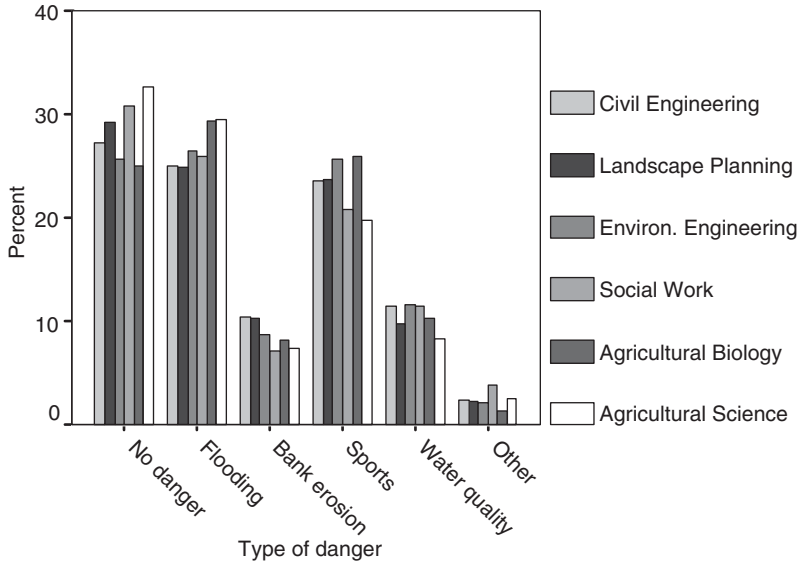

Fig. 5. Relative frequency of 'type of danger' for disciplinary groups. Sports = danger for swimming, boating, and hiking. Water quality = danger due to water quality. $N = 902-1599$.

appropriate use of photographs as an environmental presentation medium in land- and waterscape studies (Shuttleworth, 1980; Vining & Orland, 1989; Zube, Simcox, & Law, 1987). In particular when applied in a comparative approach testing relative differences, this practical technique is suitable and has been previously applied (Brown & Daniel, 1991; Gregory & Davis, 1993; Mosley, 1989).

Although wood was not mentioned as the target of the survey to the participants, its presence or absence clearly affected the evaluation of the scenes. The stronger awareness of wood in the stream scenes than in the river scenes corresponded to the relative dimensions of trees or other wooden objects in the stream or the river channels. In the smaller scaled stream scenes wood was more visible than in the larger scaled river scenes.

Even though most participants of the survey visited streams or rivers frequently (30.7% 6–20 times per year; 44.7% > 20 times per year), they had hardly personally experienced a natural wood-rich stream. Despite this fact, they clearly evaluated scenes with wood as more natural. We assume this judgement might result from being familiar with the wilderness appearance of natural forests with a high degree of dead wood (Kölbel, 1999).

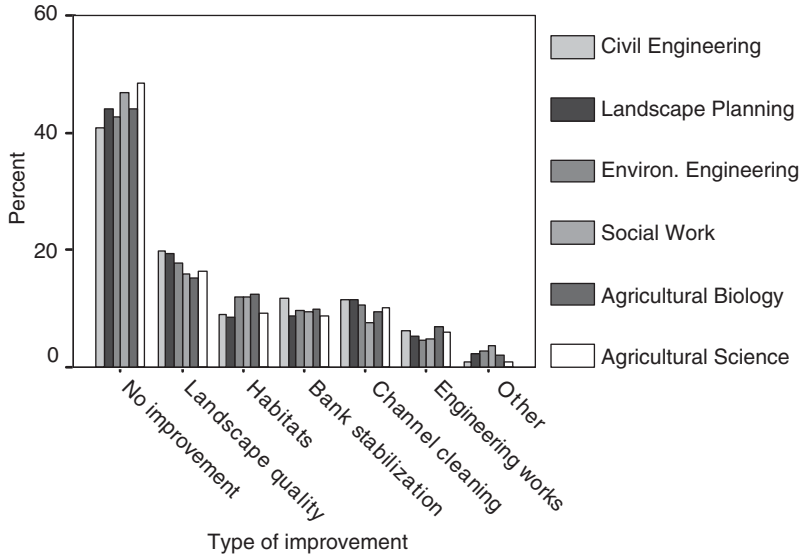

Fig. 6. Relative frequency of types of 'improvement needed' for disciplinary groups. $N = 860-1580$.

A number of such forests have been established in Germany during the past decades. Furthermore, general environmental education by mass media was and still is imparting the appearance of natural forests and wilderness, e.g. in the intensive public discussions on nature conservation or on the dieback of European forests (Waldsterben). Furthermore, the significance and the ecological value of natural upstream reaches with high retention potential for water was promoted in the public discussion on the causes of the floods of large German rivers such as Rhine, Elbe and Oder throughout the past years. This might also have contributed to the opinion of wood-rich streams and rivers as being natural.

The majority of German citizens have in general a high opinion of nature (Kuckhartz, 2000). Hence, it is not surprising that the streams and river scenes with wood in the survey perceived as being more natural were also constantly perceived more aesthetic. The participants obviously followed the aesthetic guiding principle of wilderness. This matches the attitude of 77% of the German citizens who believe that 'if men were to leave nature alone, peace and harmony would prevail' (Kuckhartz, 1997).

The scores for both perception of danger and need for improvement were below average score of 5, showing that stream and rivers were in general not seen as particularly dangerous or as hotspots with urgent demand for improvement. Moreover, contrary to our expectations wood scenes were perceived less dangerous or at least not more dangerous than scenes without wood and consequently more need for improvement was seen for scenes without wood. The ranking of the potential types of danger with flooding in first place indicates that participants were well aware of the type of potential danger of wood and moreover, that participants might have been influenced by the discussion on flood prevention. However, all the student groups apparently also evaluated the danger on the background of their personal relation to streams with danger for sport activities mentioned more frequently than bank erosion.

Comparison of disciplinary groups

There was almost no difference among the evaluation of the disciplinary groups. This shows that despite the variation among the intended professions, from orientation to environmental protection (Environmental Engineering, Agricultural Biology) to technical control of the environment and design perspective of channels (Civil Engineering), students considered wood in streams and rivers alike.

One exception to this was that landscape planners and agricultural biologists considered scenes with wood less dangerous than scenes without wood contrary to the social workers. Since the relative significance of the danger types for scenes with and without wood was identical in all groups, the contrasting evaluation of danger associated with wood indicated a different relative importance of danger types among the groups. Landscape planners and agricultural biologists, who study disciplines related to landscapes and environmental principles, obviously considered flooding most important for the estimation of the danger score, while social workers, whose relation to streams is just a leisure time activity, considered danger for sport activities as most important.

If we compare the German wood perception to those of students from nine other countries, who were also

surveyed with the identical method (Piégay et al., 2005), the positive perception of the Germans was close to students from USA-Oregon and Sweden. In contrary, the groups from France, India, Italy, Japan, Poland, Russia, Spain, USA-Texas considered streams and rivers with wood to be less aesthetic, more dangerous, and needing more improvement than scenes without wood. It is surprising that perception of Germans, who live in a densely populated and highly cultivated landscape, was in accordance with countries that have much more forested and less populated landscape. This accordance was also reflected by the frequency of visiting a stream or river. It was highest in USA-Oregon (57% > 20 times per year) followed by Russia (49% > 20 times per year), Germany (45% > 20 times per year) and Sweden (45% > 20 times per year), while for all the other countries the visiting frequency was considerably lower (13–33% > 20 times per year). We assume that both the relative positive perception of natural wood and the high frequency of visiting running waters reflect the positive attitude towards nature (Kuckhartz, 1997) and recent environmental educational efforts in Germany promoting the guiding principle of naturalness and wilderness.

From the clearly positive perception of wood by young German students we doubt that wood is being generally perceived by the public as abnormal and dangerous in streams and rivers, such as is often argued by river managers. Young students at the beginning of their academic education do not represent the German public in general. However, they are 36% of the age group in 2003 and the proportion of this educational group in the German population is still increasing (OECD, 2003). Most of the students will continue their professional careers as hydraulic engineers, water resource managers, environmental managers, landscape planners, or farmers and, hence, will be players in the water management of the near future. It is unclear if their perception of wood will change during their education. Risks and benefits of wood in streams and rivers will then be seen from an expert's view with disciplinary background. Therefore, there is further need for a survey among the educated professional pressure groups of water management. Studies related to these groups may be more difficult and expensive compared to surveying students and respective funding is needed. However, we think that the positive attitude of the young people will open up perspectives for reintroducing ecologically beneficial wood to streams at least at sites where it cannot cause any harm (e.g. in low-energy lowland streams).

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