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Variations in cross-cultural perception of riverscapes in relation to in-channel wood

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Human perception of riverscapes with and without large wood (LW) has been investigated with a photo-questionnaire submitted to 2250 students in ten countries, capturing reactions to 20 pictures in terms of naturalness, danger, aesthetics and need for improvement. Principal component analysis performed on average scores per country per item showed that the primary discriminating factors are human modification, turbulence and extent of water shown in the scenes. Wood discriminated the perception of student groups, but other factors are also critical. Features associated with human activity (channel deepening and straightening, rip-rapping) were perceived to be less aesthetically pleasing than wood. Perception of the most dangerous riverscapes is not specifically affected by wood, but by turbulent flows and wide rivers. The presence of wood clearly discriminated the need for human intervention. Perceptions differed among countries, reflecting different cultural contexts. Students from Germany, Sweden and Oregon perceived LW more positively as a natural and wild component of watercourses. These perceptions are linked to positive attitudes towards natural riverscapes. Other students, such as those from China, Russia or India, perceived rivers with wood as needing regulation and maintenance. Whatever the socio-cultural context, large wood elicits an emotional influence on how one perceives riverscapes.

keywords in-channel wood, large woody debris, public perception, riverscape evaluation, channel improvement, naturalness, cross-cultural comparison

Introduction

Throughout the world before the 1970s, large woody debris (termed in-channel wood in this paper and abbreviated as LW) was generally considered a nuisance or hazard to be avoided because of its hydraulic effects and consequential associated risks (Le Lay and Moulin 2007; Le Lay and Piégay 2007).

As a result, LW was systematically removed from channels. Due to growing recognition of the ecological benefits of wood in rivers, LW has become a common component of restoration projects in some areas of North America, Germany and Austria, as well as Australia and Japan (Reich *et al.* 2003). Recognising this change in attitude, participants at the First International Conference on Wood in World

Rivers (held in Oregon in October 2000) agreed that the expression 'woody debris', commonly used over the last two decades, now appeared inappropriate and negative (Gregory *et al.* 2003). The term 'in-channel wood' was suggested as an alternative.

By the 1990s, river managers began to promote a new discourse of river and floodplain restoration to complement the long-established flood defence emphasis (Adams *et al.* 2004). Restored watercourses are highly valued by local residents (Tunstall *et al.* 1999), who attach importance to public involvement and expect to be consulted about river-restoration works (Rhoads *et al.* 1999; Tunstall *et al.* 2000; Wade *et al.* 2002; Petts 2006). The success or failure of restoration projects reflects the range of opinions from stakeholders, as well as the diversity of relevant management institutions (Adams *et al.* 2005; Carter and Howe 2006).

Water is one of the most important and attractive visual elements of the landscape (Burmil *et al.* 1999) and is closely associated with landscape assessments made by individuals (Real *et al.* 2000). When asked to categorise a set of landscapes, participants strongly rated the presence/absence of water (Zube 1973; Zube *et al.* 1983; Blankson and Green 1991). Water features generally received favourable ratings because of their association with scenic beauty (Zube 1973; Blankson and Green 1991; Scott and Canter 1997). In spite of water as a key element of riverscapes, however, Mosley (1989) and House and Sangster (1991) found that observers appeared to be more strongly influenced in their evaluation of riverscape attractiveness by the character of the riparian environment than by characteristics of the river channel. Herzog (1985) studied preferences for four categories of waterscapes – (1) mountain waterscapes, (2) swampy areas, (3) rivers, lakes and ponds and (4) large bodies of water – and concluded that mountain waterscapes were the most preferred category and swampy areas by far the least preferred. Concerning riparian vegetation, Mosley (1989) established that the amount of natural forest in a scene is the best single variable to predict riverscape preference. House and Sangster (1991) defined several trends, particularly an overwhelming desire for trees and a preference for vegetation diversity (in terms of plants, trees and grasses). Riverscape attractiveness is increased by an open deciduous forest, with a mixture of grass and plants, or grass and trees overhanging the banks.

As regards water characteristics, movement and appearance must be distinguished. Scores based on

visual examination of photographs showed that people prefer open waterscape, waterfalls and running waters (Herzog 1985); they dislike stagnant water (Kaplan 1984). Considering five kinds of water features (still, flowing, falling, jet and combination), Nasar and Lin (2003) reported that observers have higher preferences for jets. As expected, they rate still water as most calming and moving water as more exciting. Brown and Daniel (1991) described the relationship between flow quantity and scenic quality for the Cache La Poudre River in Colorado: beauty increases as flow increases up to about 31–42 m³/s, then falls as flow continues to increase.

Dirty polluted waters are perceived negatively. Smith *et al.* (1995a) established that water appearance (clarity and colour) and swimming are closely related. Blue water is preferred to yellow water, which may be acceptable when it is perceived as being natural. Brown, turbid water is not positively evaluated by swimmers who are concerned about safety and whose ability to see the bottom depends on water clarity (Smith *et al.* 1995b). In contrast, Nasar and Li (2004) highlighted the attractiveness of reflecting water. Reflection increases the variety of visible objects, the waterscape naturalness (Kaplan and Kaplan 1989), and the restorative effects of the environment (Ulrich *et al.* 1991; Kaplan and Kaplan 1989; Herzog *et al.* 1997; Parsons *et al.* 1998).

Culture structures riverscapes and riverscapes inculcate culture (Nassauer 1995), so that public perception influences the improvement of watercourses (Shrader 1995). Preferences for natural environments are remarkably consistent when cultures are similar (Zube 1984). Studies have found high agreement, for instance, comparing Scottish and American samples (Shafer and Tooby 1973), or among Yugoslavian students, Italian American, and various other American ethnic groups (Zube and Pitt 1981). By contrast, preferences differ when dissimilar cultural groups were examined (Zube and Pitt 1981; Kaplan and Herbert 1987; Hull and Revell 1989). Moreover, variations may occur among members of the same culture, so that some experimental studies have focused on the observers' characteristics. Many variables have an effect upon descriptive and evaluative responses: personality and socio-economic attributes (Zube and Pitt 1981; Carp and Carp 1982a 1982b), professional experience in terms of resource and environmental management (Zube 1973; Buhyoff *et al.* 1978; Feimer 1984; Gregory and Davis 1993), as well as familiarity with a particular environment or a type of environment (Pedersen

1978; Zube and Pitt 1981; Buhyoff *et al.* 1983; Kaplan and Herbert 1987; Hull and Revell 1989).

The effect of discrete features in river channels, such as boulders or wood accumulations, has not yet been considered. Following the Corvallis conference, a study was designed to test whether spatial variations in public perception of LW in streams and rivers relate to social, cultural and historical characteristics. A preliminary paper (Piégay *et al.* 2005) described the survey and reported results indicating average differences in public perception among respondents. It established that LW-rich channels are generally considered more natural, less aesthetic, more dangerous and needing more improvement than riverscapes without LW. The study also showed that cross-cultural variations are more significant than variations among the four different academic disciplines surveyed. Although this preliminary analysis indicated that large wood is a useful discriminator of riverscape evaluations, it did not assess the importance of wood in relation to other characteristics of the riverscape. This study builds upon the previous analysis by examining other factors in detail, such as the human and water characteristics (spatial extent and turbulence) that may affect how one perceives rivers. To further explore cross-cultural variations, additional responses from China are included in this analysis, as well as information on types of perceived dangers and suggested improvements to the river environment identified by respondents in different geographical areas.

Methods

The survey of perception of riverscapes is based on the experimental (or perceptual) approach to landscape assessment: environment is considered a source of information influencing individual attitudes according to observer characteristics (Zube *et al.* 1982; Dakin 2003; Le Lay *et al.* 2005). Such a study requires a set of photographs and a questionnaire. Students in universities provided a convenient sampling pool because of their relatively uniform age structure. Several studies of scenic beauty show close agreement between the judgements of students and those of the general public (Brown and Daniel 1991). Responses were assumed to represent non-experts because the students selected had not received specific training in the ecological role of in-channel LW prior to the survey. Because there is no influence of disciplinary training in the sampling

design, each group being composed of four distinct disciplines without differences between them in terms of how these students perceived wood (Piégay *et al.* 2005), the student groups are appropriate for cross-cultural comparisons. Even if student perceptions are not identical with the perception of the entire population of each country, the relative differences are still valuable for demonstrating how perceptions vary for a particular group of individuals within the different countries.

Selection of riverscapes

The method of presenting visual scenes is a key issue in landscape preference research. During site visits, observers' responses are not biased by any riverscape surrogates because direct experience is capable of stimulating all the senses in real-world situations. Faced with logistical difficulties of presenting an adequate number of landscape views to an unrestricted sample of respondents, this study used the well-established procedure of photographic displays (Mosley 1989; Brown and Daniel 1991; Gregory and Davis 1993). On-site survey of the environment can create empirical and analytical problems, such as the control of observational strategy and access of a large number of participants to the several sites they are to evaluate. For this international study, we used colour slides as a substitute presentation medium, since it was the only practicable method (Mosley 1989). Despite the fact that the surrogate environmental displays may involve perceptual distortion, comparisons between responses obtained *in situ* and responses obtained through photographs have given ample evidence that supports the validity and effectiveness of photographs in representing landscapes (e.g. Shuttleworth 1980; Kellomäki and Savolainen 1984; Zube *et al.* 1987; Vining and Orland 1989; Stamps 1990; Hull and Stewart 1992). Few significant differences exist between the observer reactions to and perceptions of landscapes, either when viewed in the field or as photographs. Although the photograph is a two-dimensional image whose content does not convey the dynamic qualities of water such as sound and movement (Huang and Tassinary 2000), and differs, therefore, from on-site experience, it satisfies the requirement for such an analysis, namely the equivalence of presentation to the respondents.

Photographs were selected by the participants using a website for Internet discussion. Each contributor sent a set of riverscapes to the webmaster. From 300 pictures originally identified, individual

suggestions provided by the authors were summarised and finally a series of 20 photographs was agreed upon by all of the scientists. Because local features are the main objects of interest, the field of vision and the vertical range are deliberately restricted, so that attention is directed to channels and the valley landscape has minimal influence on the evaluation of scenic attractiveness (Mosley 1989).

The selected scenes gave a suitable range of scenic variation, including a sufficient variety of riverscape types (Gregory and Davis 1993). These photographs consisted of ten examples of LW-rich channels and ten that have no wood. They also represent various physical environments to include uplands, piedmonts and lowlands. These riverscapes show different degrees of human influence, embracing channels considered as undisturbed (no recent evidence of human modification), maintained (riparian vegetation is selectively cut and the wood is removed to prevent flooding) and regulated (the channel geometry has been modified). The photographs comprised ten streams (channel width from 2 to 5 m) and ten rivers (channel width wider than 10 m). Therefore, two sets of ten photographs were submitted randomly to respondents, labelled in two sets from A to J for streams and K to T for rivers (Figure 1a).

Procedure and instruction

The most appropriate way to obtain input from respondents to these carefully selected photographs is to utilise a questionnaire. To quantify how respondents perceive each photograph, they were asked to assess four metrics: aesthetics, naturalness, danger and need for improvement. For each metric, the 20 colour photographs were rated on Visual Analog Scales (VAS), in which the respondent marks his rating along a line segment having endpoints of 0 (lowest degree of agreement) and 10 (highest degree of agreement) (Figure 1b). This approach allows freedom of response (no specified division of the assessment scale). VAS scores were determined using a graduated scale to measure the position of the respondent's mark relative to the total length of the VAS. Such a continuous scale avoids the operational problems inherent in methods that involve sorting photographs into order of preference. Other commonly used scales, such as methods of summated ratings, the method of equal-appearing intervals, and the method of semantic differential scaling, or the simple 5-point scale were not chosen, in order to allow use

of statistical analyses of continuous variables (Gift 1989).

The questionnaire further included two qualitative variables for the characterisation of perceived danger (6 modalities: 1: no danger, 2: flooding/inundation, 3: danger to land/house because of bank erosion, 4: danger when practising leisure activity (swimming, boating, hiking), 5: danger due to degraded water quality, 6: other) and motivation for improving riverscape (7 modalities: 1: no improvement, 2: improvement of scenic beauty, 3: improvement of habitats for fauna, 4: bank stabilisation by works, 5: channel cleaning for flooding risk mitigation, 6: engineering measures for flooding risk mitigation, 7: other). Background information about personal residence (urban versus rural, proximity to a watercourse), visit frequency to a watercourse, leisure activity, gender and age were also requested from each respondent.

After translation into the national language of each country, each scientist conducted a pilot test on a sample of ten persons to appraise the reliability of the survey. This test confirmed the validity of selected photographs and demonstrated the effectiveness of VAS and of the modalities provided for the categorical variables. On the basis of the experience gained from these tests, the study was undertaken using the same protocol in 11 geographic areas from the United States (Corvallis in Oregon and College Station in Texas), Europe (Lyon in France, Cottbus, Hannover, Kaissel and Berlin in Germany, Florence and Bologna in Italy, Krakow and Varsow in Poland, Moscow in Russia, Bilbao in Spain, Umea in Sweden), and Asia (Guangzhou, Beijing, Foshan, in the Guangdong Province of China, and Pune, 140 km to the north-east of Bombay in India) (Table I). These areas reflect a diversity of socio-cultural environments. The respondents were not informed that wood was the topic under scrutiny. After a short preliminary introduction and the distribution of paper copies of the questionnaire, the photographs were projected one by one to students who completed the survey in a classroom. The students graded each picture independently of the others.

Data analysis

The VAS scores from photographs with LW were distinguished from those without LW. We performed all statistical procedures with R, a program for data analysis and graphics (Ihaka and Gentleman 1996). As each photograph was graded on a specific VAS, the scores can be averaged and compared in various

(a)

STREAMS (A to J)

RIVERS (K to T)

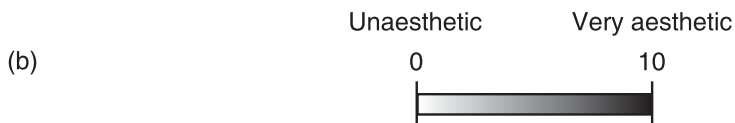
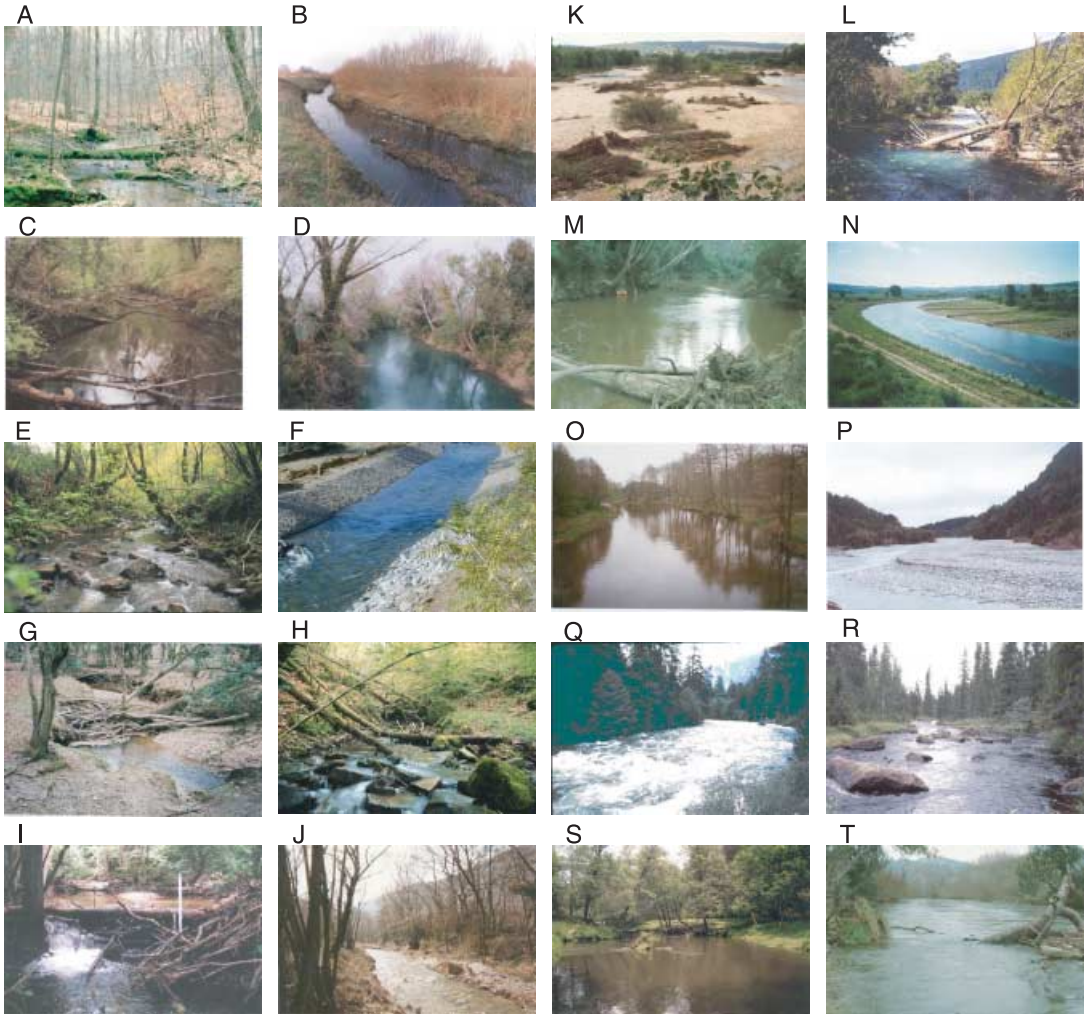


Figure 1 (a) Photographs with and without wood used by the respondents to evaluate their riverscape perceptions in terms of naturalness, aesthetics, danger and need for improvement (from Piégay *et al.* (2005), with permission of Springer Verlag). (b) The Visual Analog Scale (VAS) used for quantifying the riverscape aesthetics

Table I General information characterising the sampling and the geographic area surveyed

	<i>Geographic area</i>	<i>Number of respondents</i>	<i>Density (population/km²)</i>	<i>Forest cover (% of land area)^a</i>
1	China	364	136.6	17.5
2	France	200	107.0	27.9
3	Germany	230	235.3	30.7
4	India	200	335.7	21.6
5	Italy	200	195.0	34.0
6	Oregon (USA)	120	12.7	48.3
7	Poland	215	127.3	29.7
8	Russia	196	8.7	50.4
9	Spain	115	79.4	28.8
10	Sweden	204	21.6	65.9
11	Texas (USA)	206	27.9	10.2

^aSource: Food and Agriculture Organization of the United Nations (2003)

ways. As a result, for each of the four variables (naturalness, aesthetics, danger, improvement), we considered the average scores for photographs with and without wood, taking into account potential differences between the 11 geographic areas.

We computed correlation coefficients of Bravais-Pearson from scores of aesthetics, naturalness, danger and need for improvement to measure the strength of the associations between these four quantitative variables. These coefficients also identified the attributes of riverscape quality which determined the decisionmaking factor. Regression analysis further explored the motivation for improvement.

We arranged contingency tables for the four perceived riverscape variables (aesthetics, naturalness, danger and need for improvement) using mean VAS scores per area for each photograph. Thus, each table contained 11 columns corresponding to the 11 areas and 20 rows corresponding to the 20 slides. To investigate the cross-cultural variation between geographic areas, we performed a normalised Principal Component Analysis (nPCA) on each of the four quantitative attributes describing riverscape perception. We provided the inertia ratio of each of the significant factors to statistically validate the procedure.

Concerning the categorical variables, we performed a Factorial Correspondence Analysis (CA), a well-established method for analysing contingency tables, to evaluate the variation in perceived danger (or need for improvement) between respondents in different geographic areas. External information on the riverscape was provided using the following categorical variables: presence or absence of LW,

degree of human management (natural, maintained or regulated riverscape), and reach position in the river continuum (upland, piedmont or lowland).

Results

The influence of the presence of in-stream wood on riverscape perception

When data from all 11 geographic areas were grouped together, clear statistical differences were found in the overall perception of channels. As shown in Piégay *et al.* (2005), students considered scenes with wood to be less aesthetic (p -value of t -test < 0.0001), more natural ($p < 0.0001$), more dangerous ($p < 0.0001$) and needing more improvement ($p < 0.0001$) than the riverscapes without wood. Nevertheless, the bar charts show that some photographs contributed more strongly to the differences than others (Figure 2). Only a few of the scenes without wood (E, Q and R) are rated as the most aesthetically pleasing, whereas others (e.g. B and F with regulated channels) scored lower than most of the pictures with wood. When considering naturalness, the highest scores are also observed for riverscapes without wood (E, Q and R), but scenes with wood cluster around a relatively constant value of naturalness, compared to the high variability of scenes without wood. The least difference between rivers or streams with and without wood is associated with perceived danger. The highest score is a riverscape without wood (Q) with white turbulent water and a large, deep channel; however, wood obstructions in flowing deep water (e.g. picture T) are also considered dangerous. In terms

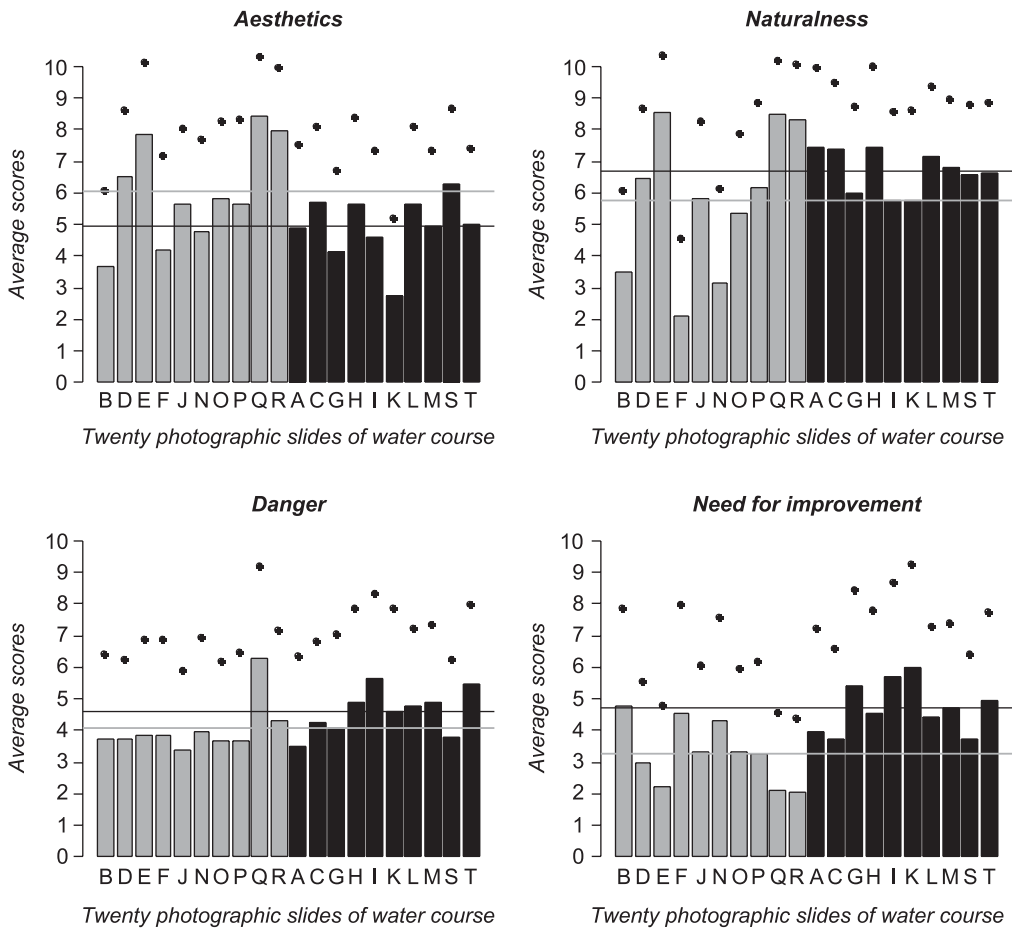


Figure 2 Average scores for each slide with wood (from A to J, black bars) and without wood (from K to T, grey bars) according to the aesthetics, naturalness, danger and need for improvement from appraisal of 1970 respondents (black line: average score of the scenes with LW; grey line: average score of the scenes without LW). The black points above the bars correspond to standard deviations. See scenes A to T in Figure 1

of the need for improvement, the presence of wood is clearly a critical issue with channels containing wood scoring consistently higher than those without wood. No improvement is perceived as needed in natural and aesthetic riverscapes without wood (e.g. E, Q, R) even if they are dangerous (Q). Conversely, the regulated channels, even if they have no wood, are perceived as requiring improvement (B and F).

Results of the correlation analysis show two significant positive relations between naturalness and aesthetics ($r = 0.50, p < 0.0001$), and between danger and need for improvement ($r = 0.40, p < 0.0001$). Two significant negative relations

were also found: between aesthetics and need for improvement ($r = -0.47, p < 0.0001$), and between naturalness and need for improvement ($r = -0.30, p < 0.0001$). The presence of LW tends to strengthen the relation between danger and need for improvement ($r = 0.46, p < 0.0001$ instead of $r = 0.32, p < 0.0001$). LW also appears to reduce the relation between naturalness and aesthetics ($r = 0.43$ instead of $r = 0.64, p < 0.0001$) (Tables II and III).

Riverscape types and cultural contrast

Results of the four normalised Principal Component Analyses (nPCA) present some common aspects (Figures 3–6). The positions of photographic

Table II Correlation matrices (in bold, significant values for $p < 0.0001$) of the four perceived riverscape variables (aesthetics, naturalness, danger and need for improvement) for the scenes without LW

	<i>Aesthetics</i>	<i>Naturalness</i>	<i>Danger</i>	<i>Improvement</i>
<i>Aesthetics</i>		0.64	-0.05	-0.46
<i>Naturalness</i>			-0.01	-0.39
<i>Danger</i>				0.32
<i>Improvement</i>				

Table III Correlation matrices (in bold, significant values for $p < 0.0001$) of the four perceived riverscape variables (aesthetics, naturalness, danger and need for improvement) for the scenes with LW

	<i>Aesthetics</i>	<i>Naturalness</i>	<i>Danger</i>	<i>Improvement</i>
<i>Aesthetics</i>		0.43	-0.22	-0.44
<i>Naturalness</i>			-0.14	-0.30
<i>Danger</i>				0.46
<i>Improvement</i>				

slides are shown on the $F1 \times F2$ factorial map, and the position of each geographic area along the components is shown on a $F1 \times F2$ correlation circle. The two first axes of an nPCA performed on the aesthetic quality accounted for 93 per cent of the total variability (78% and 15% for the first and the second axis, respectively; Figure 3A insert). The respondents found clear differences between the scenes (Figure 3A). The first axis corresponds with overall perception of aesthetic quality. Photographs labelled E, Q and R were perceived as the most aesthetic riverscapes. These scenes are characterised by visible evidence of turbulent flow (whitewater) and scattered large boulders. The least attractive scene, K, shows extensive gravel bars with a narrow band of water and large amounts of LW. Slides B, F and N show three regulated channels and thus emphasise the influence of human modification on aesthetics (Figure 3A, D). Upland slides had positive attributes and were perceived as generally more scenic than the lowland and, especially, the piedmont ones (Figure 3E). The second axis corresponds to the 'degree of wood' in the channels, with channels containing wood lying below this axis and those without wood lying above it

(Figure 3C). Given this grouping, the influence of in-stream LW on perceptions of aesthetics is clear, but this factor is not the dominant influence on such perceptions. Five geographic areas are well accounted for by the first axis (France, Italy, Poland, Spain and Texas; Figure 3B). The F2 axis is defined by two opposing groups, respondents from China, India and Russia who do not appreciate riverscapes with LW, and respondents from Germany, Oregon and Sweden who find LW aesthetically pleasing (Figure 3B and C).

The two first axes of an nPCA performed on the perception of naturalness accounted for 96 per cent of the total variability (88% and 8% for the first and second axis, respectively; Figure 4A insert). Responses to naturalness of scenes were comparable to those for aesthetics. Attractive scenes were also perceived as natural (Figure 4A), but the degree of channel regulation clearly influenced the results. Scenes from regulated watercourses (B, F and N slides) cluster on the left end of the F1 axis (Figure 4A, D). Consequently, perceptions of naturalness appear to be associated both with 'beauty' and 'degree of management' across all geographic regions. The F2 axis indicated a clear secondary influence of LW (Figure 4C) on perceptions of naturalness. Chinese, Indian and Russian students gave responses clearly distinct from the others, suggesting that landscapes with wood (e.g. mainly pictures K, I and G showing important obstructions or wide accumulation of wood) are not viewed as natural.

The two first axes of an nPCA performed on the perception of danger accounted for 85 per cent of the total variance (63% and 22% for the first and second axis, respectively; Figure 5A insert) and had more contrasted responses than those for aesthetics and naturalness (Figure 5). Photo Q, showing a fast flowing river without wood, was considered the most dangerous by respondents from all geographic areas (Figure 5A). Photos I and T, but also H, L, K and M, had high values of perceived danger, probably because these pictures exemplify obstructed channels. The F1 axis appears to be associated with evidence of turbulent flow and degree of blockage by wood. However, the amount of wood is not a strong discriminator along the F2 axis (Figure 5C). Three groups of geographic areas were distinguished (Figure 5A): (a) a first group composed of Germany, Oregon, Poland and Sweden, areas for which respondents perceive some channels with wood (e.g. A, G, S scenes) as not dangerous, (b)

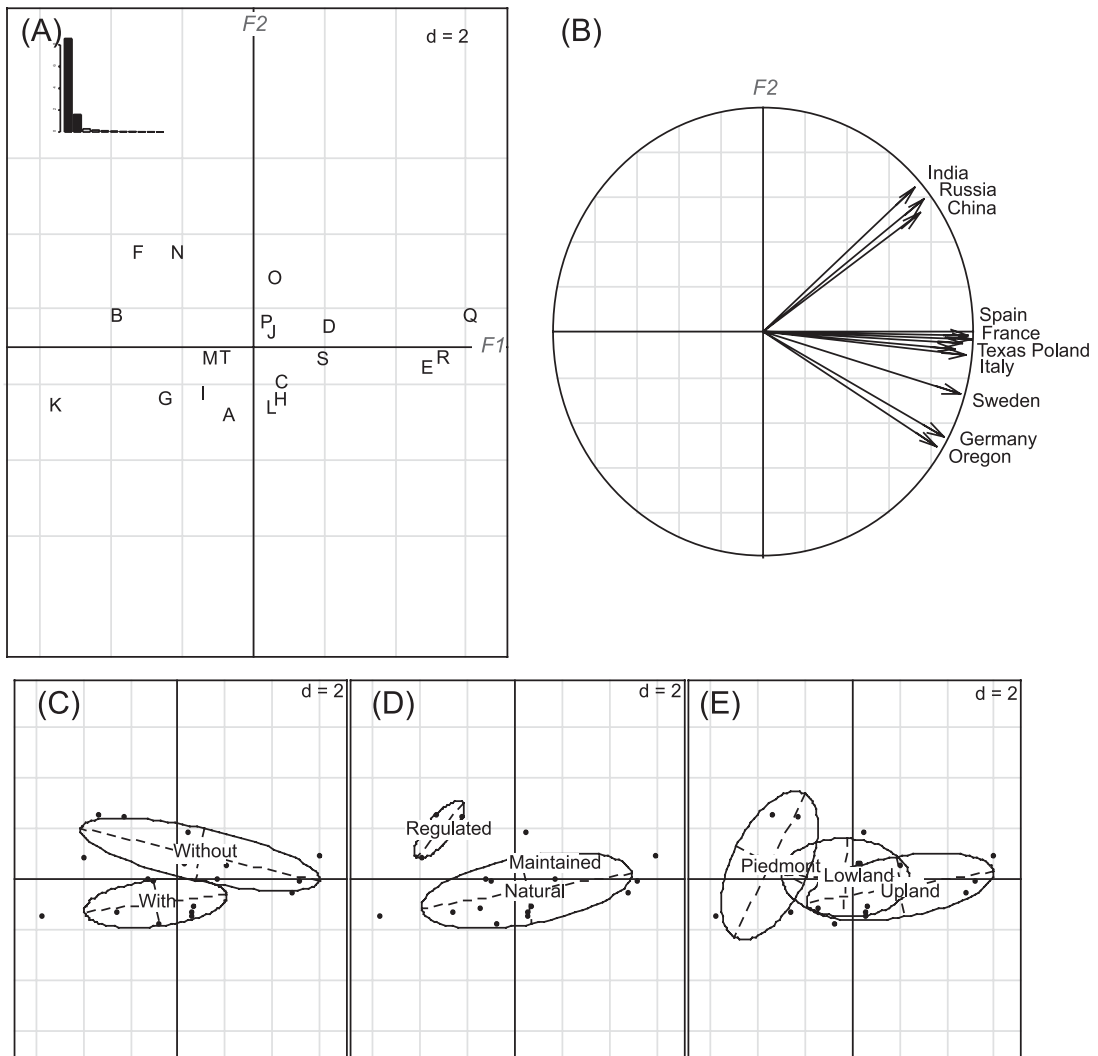


Figure 3 Results of a principal component analysis performed on the perception of aesthetic quality. (A) First factorial plane showing the positions of the 20 slides. Insert presents the histogram of eigenvalues. (B) Correlation circle identifying the positions of the 11 geographic areas on the first two PCA axes. Allocation of slides (as positioned in A) to (C) the presence/absence of large wood, (D) the degree of human management and (E) the landform type. In C, D and E, each ellipse encompasses 67 per cent of the scenes along each axis for clarity and labels are situated at the centre of gravity of each group

a second group, consisting of participants from France, Italy and Spain, who consider landscapes with wood as being particularly dangerous (e.g. I, T, L, M, K), and (c) a third group that includes students from China, India, Russia and Texas, who perceive regulated channels (N, F and B scenes) as being less dangerous.

The two first axes of an nPCA performed on the perception of the need for improvement accounted for 91 per cent of the total variance (69% and 22% for the first and second axis, respectively; Figure 6A insert). Responses to photographic slides with LW had the highest scores. The factorial map (Figure 6A) shows that the need for improvement concerns

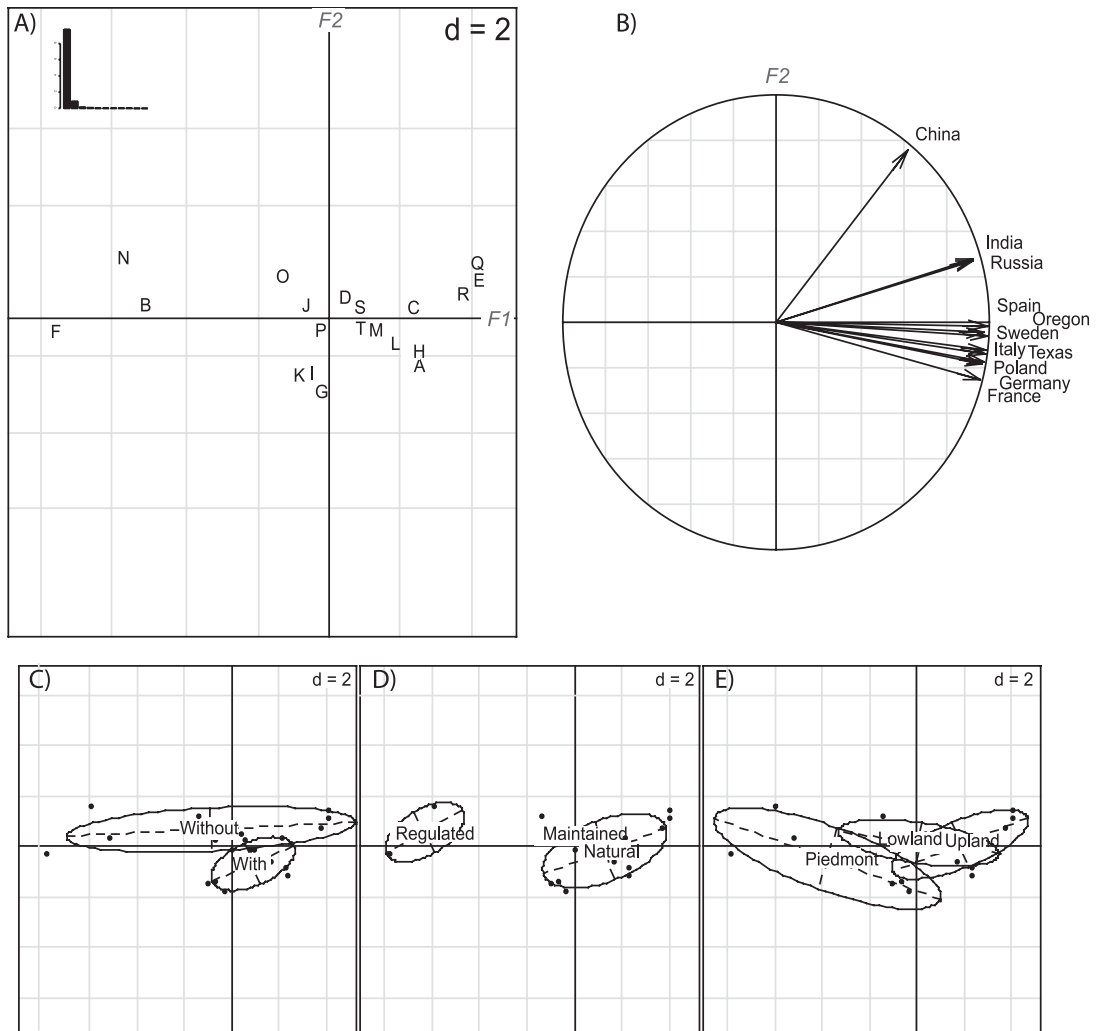


Figure 4 Results of a principal component analysis performed on the perception of naturalness (see Figure 3 for further details)

not only the removal of LW but also restoration of regulated channels (B, F and N scenes). The F1 axis appears to be associated with the presence of wood (Figure 6C), whereas the F2 axis is structured by the naturalness of the channel (Figure 6D). Respondents from Germany, Oregon and Sweden expressed a need for improving regulated channels (Figure 6B, D), whereas Chinese, French, Indian and Russian students perceived LW-rich channels as in need of improvement (Figure 6B, C). The most attractive scenes (E, R, Q) are considered as needing the least improvement.

Characterisation of danger and need for improvement

Multiple Correspondence Analyses were performed on the characterisation of the danger and the need for improvement. Results of the MCA are presented as five sub-factorial maps arranged by each of the variables to better link and interpret geographic areas of students and photographs (Figures 7 and 8). The positions of each geographic area (Figures 7A and 8A) and the photographic slides (Figures 7B and 8B) are shown on the factorial maps. The results

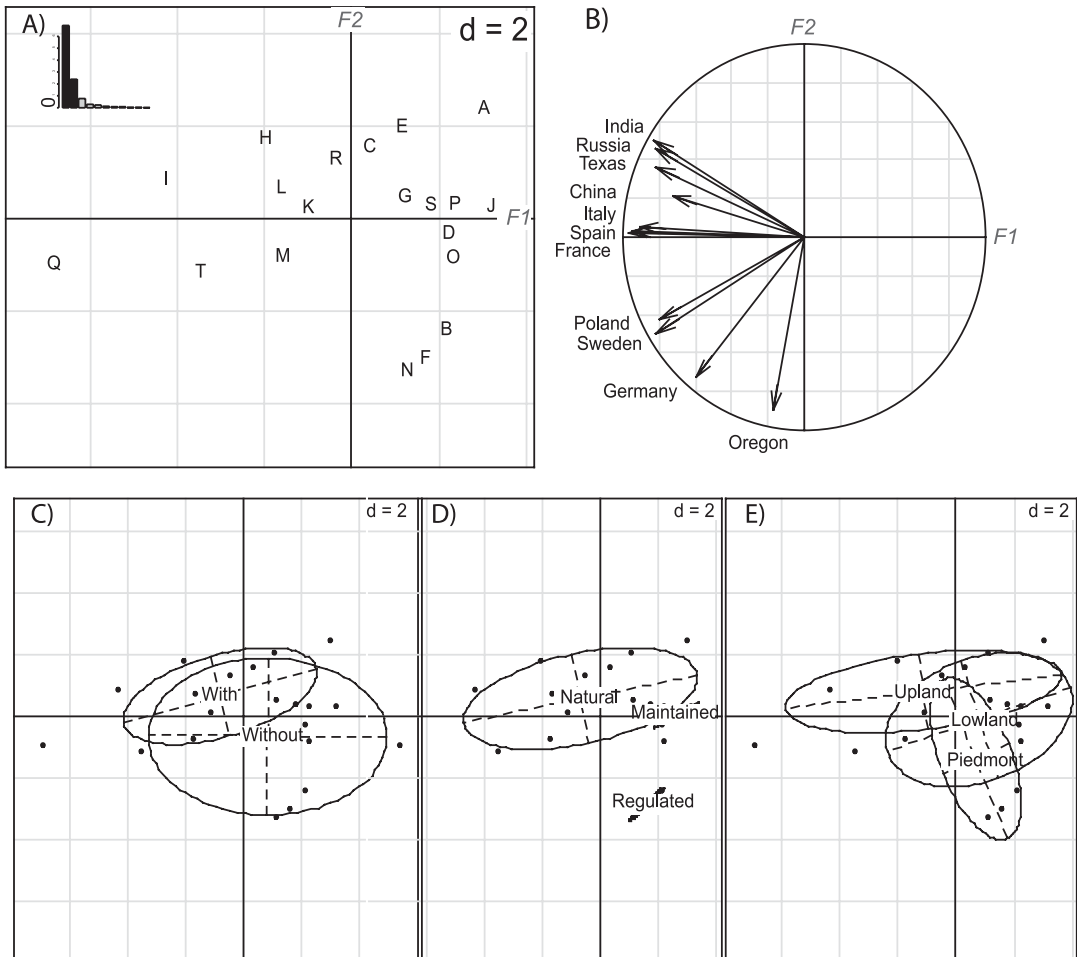


Figure 5 Results of a principal component analysis performed on the perception of danger (see Figure 3 for further details)

present one common feature: LW-rich channels elicit responses systematically less variable than those associated with channels without LW (Figures 7C and 8C).

Results show that danger is associated with the presence/absence of LW across all regions (Figure 7C), but there are strong differences in the perception of danger. Students from Oregon, Germany, Sweden and Poland tend to perceive ‘no danger’ when river channels contain some LW (I, C, H, L and A scenes). Respondents from India, Russia and France, on the other hand, more often considered regulated channels to be less dangerous (B, F and

N scenes). Students from China and Oregon also perceived fast flowing channels, with some boulders and little wood (R, E and Q scenes) as not dangerous. As shown for the modality ‘flooding’, Spanish, German, Swedish, French and Texan students recognised a risk when the riverscapes show evidence of protection measures: embankment, channelisation or maintenance (F, N and B scenes). The presence of LW but also turbulent flow seem to influence more strongly participants from India, Russia and China. When observing riverscapes with relatively large channels with falling or leaning trees (M, S, D, G and O scenes), students from

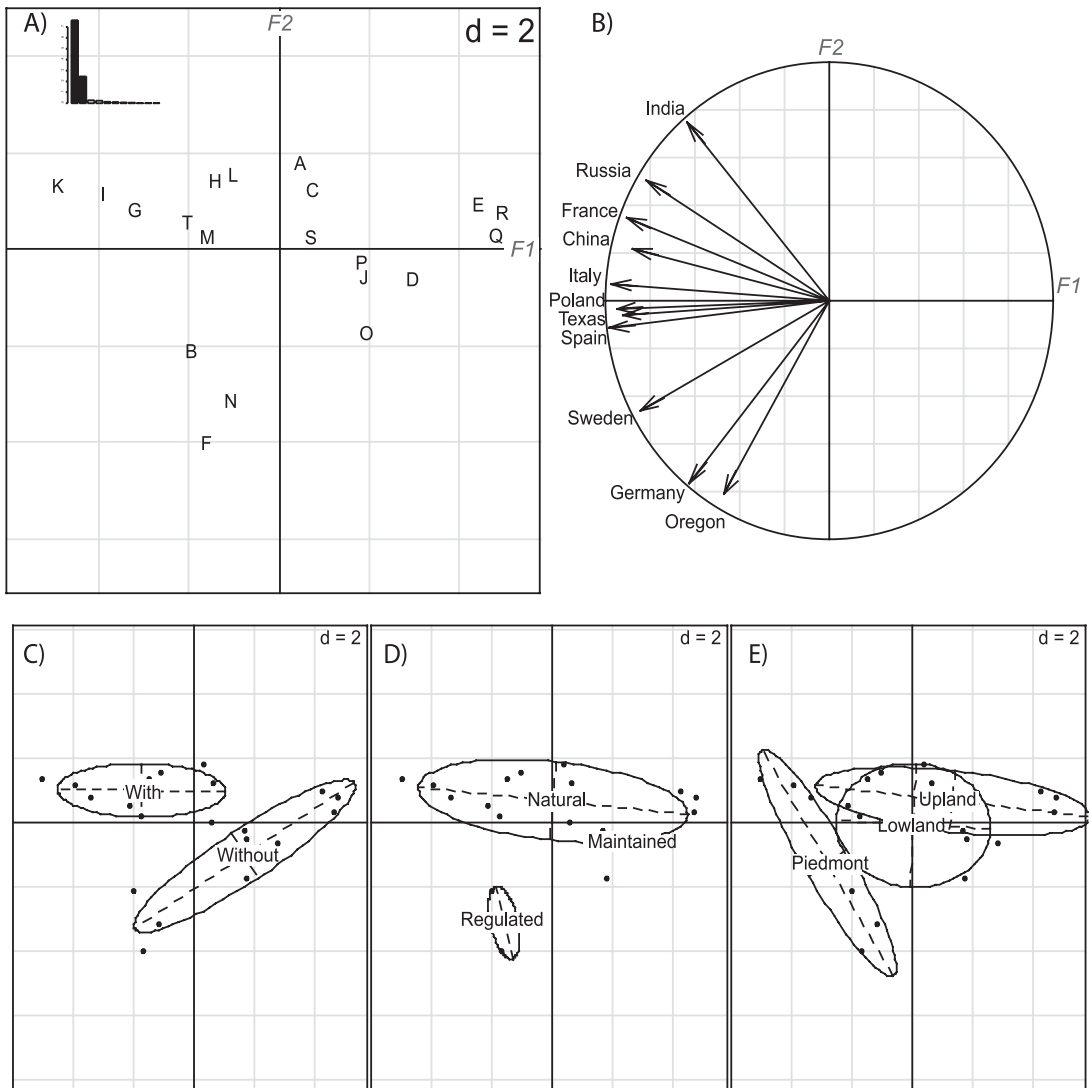


Figure 6 Results of a principal component analysis performed on the perception of the need for improvement (see Figure 3 for further details)

France and Oregon tend to choose the modality 'bank erosion'. Chinese and Russian participants are more influenced by the nature of the bed and the bank (e.g. a lot of gravel, no vegetation on K, N and F scenes). Moreover, Polish observers are more affected by the channel gradient and water turbulence (R, E and Q) when considering bank erosion risk. As regards the modality 'for leisure activities', responses to channels without LW are heterogene-

ous. Scenes with deep water (e.g. O, N, S and M) are considered dangerous for leisure activities by Indian, Russian and Chinese students, whereas students from Oregon and Sweden focused on pictures B and F with steep banks. LW does not seem to be a concern in relation to leisure activities. Finally, when selecting the modality 'in terms of water quality', many student groups, particularly from Oregon and Germany, considered the water

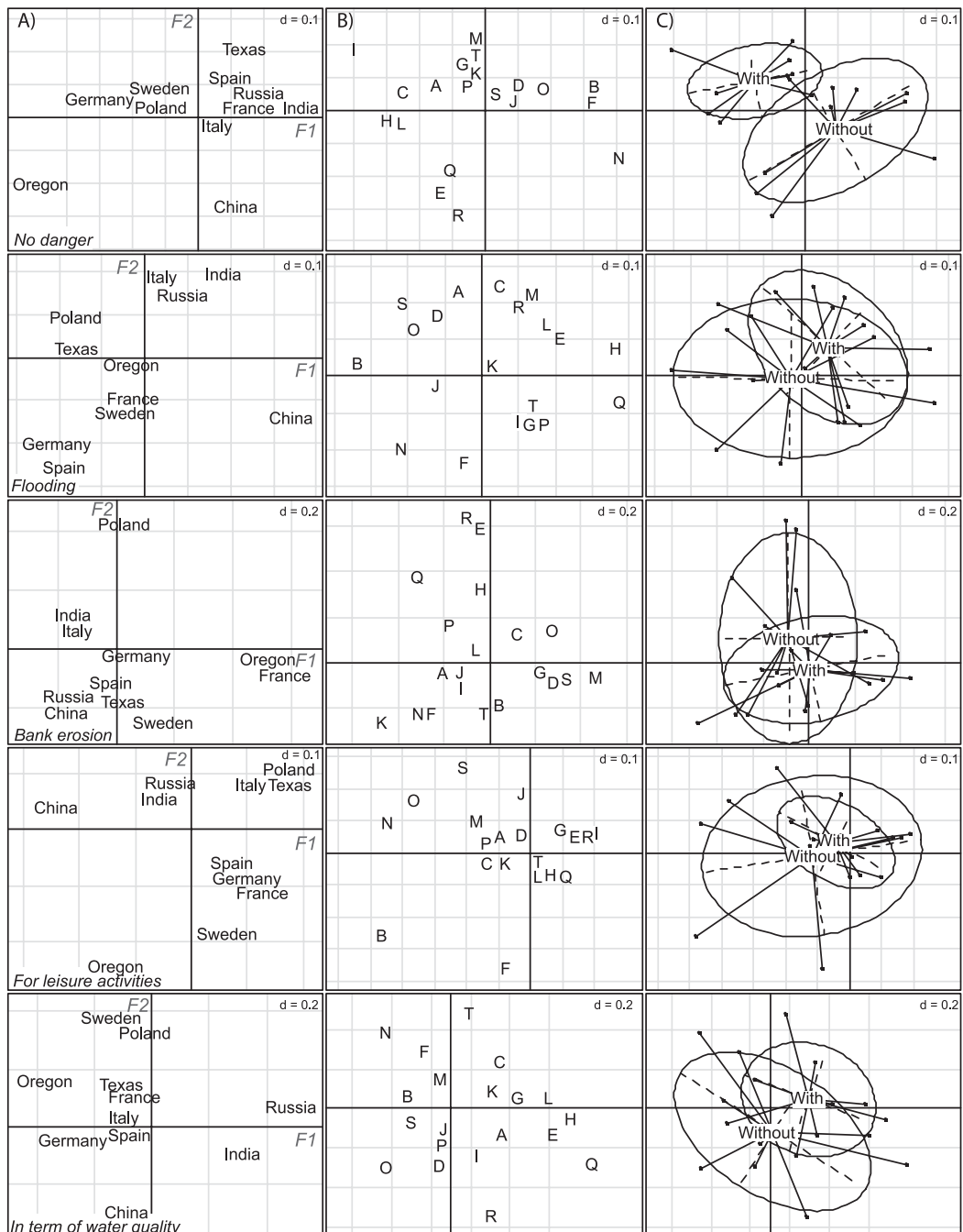


Figure 7 Results of a multiple correspondence analysis performed on the characterisation of danger assigned by respondents to the slides. (A) First factorial plane showing the positions of the 11 geographic areas. (B) First factorial map identifying the positions of the 20 slides. (C) Allocation of slides (as positioned in A) to the presence/absence of large wood. Each ellipse encompasses 67 per cent of the scenes along each axis for clarity and labels are situated at the centre of gravity of each group

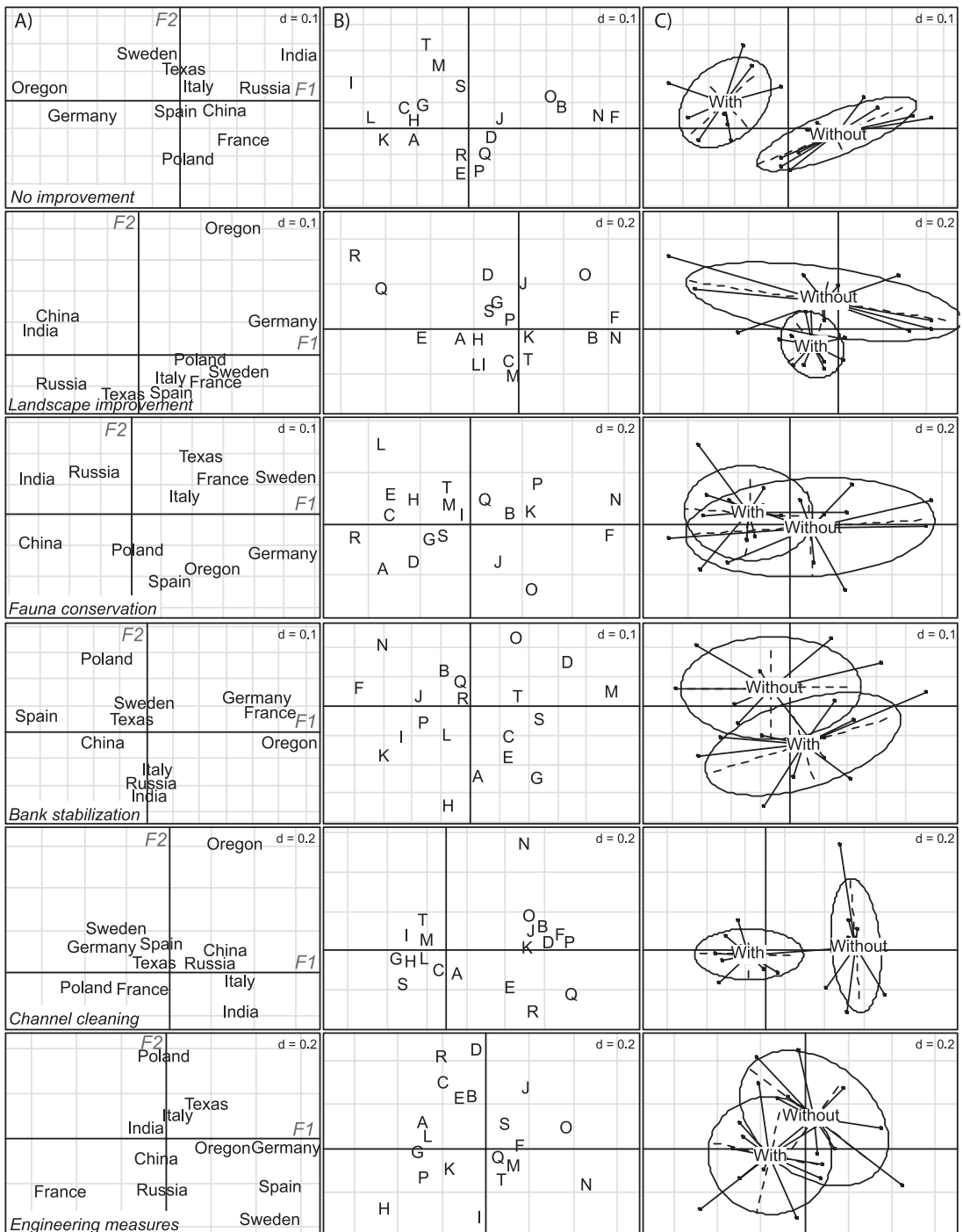


Figure 8 Results of a multiple correspondence analysis performed on the characterisation of the need for improvement assigned by respondents to the slides (see Figure 7 for further details)

colour and smooth water surface on N, O, B and S slides as being a potential danger in terms of water quality, independent of the presence of wood. The modality is selected for LW-rich channels (H, E and L scenes) by Russian and Indian students. Except for the students from Russia, China and India, who characterised the danger of wood presence mainly in terms of flooding risk and water quality, the others considered riverscapes with wood as being dangerous (e.g. Italy, France, Spain mainly) but did not identify specific reasons.

Students from Oregon, Germany and Sweden tended to prefer no need for improvement of LW-rich channels, whereas the participants from India, Russia, France and China preferred no improvement of riverscapes without LW (Figure 8). Students in Oregon opted for 'landscape improvement' when photographs did not contain LW. Those in Germany viewed regulated rivers (B, N and F scenes) as least in need of improvement. Those in India, China and Russia viewed rivers with turbulent flow over boulders (R, Q and E scenes) as not needing improvement. This last group of countries suggests some improvement measures in terms of 'fauna conservation' with respect to riverscapes showing water disruption such as boulders (R, E and H scenes) or LW (L, C, A and H scenes). Improvement of fauna is also suggested by Swedish and German students in the presence of artificial geometry (F and N scenes) and lack of water (K and P scenes). When observing LW in streams (H, A and G scenes), respondents from India, Russia and Italy recognised a need for 'bank stabilisation'. Students from Oregon, France and Germany focused on other aspects independent of the presence of wood, such as high steep banks with leaning trees. Moreover, responses concerning 'channel cleaning' are well discriminated by the presence/absence of wood in channels. Polish, German and Swedish students seemed to be motivated to clean LW-rich channels, whereas participants from Oregon are distinctive: they selected this modality for regulated rivers (especially concerning scene N). Finally, observers from France and Russia often chose 'engineering measures' in the presence of LW and gravel bars (K and P). On the contrary, German, Oregon, Spanish and Swedish students selected this modality more frequently for the maintained or regulated riverscapes.

The results described above indicate that perceptions of rivers with wood can be improved by watercourse maintenance, and notably by vegetation

clearing. In some countries, such as in Russia, China and France or Italy, strong actions such as engineering measures and bank stabilisation are also suggested for riverscapes with wood. The results also show that students' responses are both similar and different across cultural and historical contexts, as discussed below.

Discussion

Consensual riverscape perception

The results show different attitudes to riverscapes for which the wood is not the most critical factor, but is one amongst a set including water character (turbulence, spatial extent), other local features, such as boulders and evidence of human activity. The students all expressed a clear aesthetic preference for mountain flows (Q, R and E features) with turbulent water and boulders. Similar consensual criteria are drawn upon to identify natural riverscapes and degree of danger (wide rivers, turbulent flow, wood obstructions). The need for improvement is the least consensual item, but wood removal is the most prevailing response.

A broad inter-cultural consensus on the perception of riverscapes is evident. Our results provide confirmation of previous investigations concerning riverscape perception and evaluation. Shafer and Brush (1977) indicated that water, in combination with forest vegetation either in the intermediate or the distant zone, strongly enhances scenic quality. Many studies, based on the physical attributes of landscapes (Shafer *et al.* 1969; Zube 1973; Schroeder *et al.* 1986) and on the comparison between responses from different experimental populations (Purcell and Lamb 1984), have demonstrated the significance of perceived naturalness in terms of environmental evaluation. Winding rivers with natural banks and channels are preferred, particularly if the riverscape presents tree and vegetation diversity (House and Sangster 1991).

The presence of in-channel LW influences students' perceptions, not only in terms of perceived beauty and naturalness of scenes, feeling of danger or inclination towards improvement, but also in terms of characterisation of risks and measures needed for improvement. The results highlight a generally negative perception of LW by respondents that influences their attitudes towards river management. It is important to note that LW removal is a first reaction for many respondents (e.g. Italy,

France, Texas, Spain); channel clearing can then be a useful choice to improve the landscape. Even if channels cluttered by LW are perceived as being the most natural, Gregory and Davis (1993) had previously recognised that riverscape attractiveness tends to increase with the percentage of trees shown in the scene and the number of visible tree trunks. Conversely, it reduces with the increasing amount of in-channel debris. Similar results were obtained in forest environments (Daniel and Boster 1976; Arthur 1977). Clearly, the public prefers a landscape without vegetation in or on water (Calvin *et al.* 1972; Wilson *et al.* 1995). This is exemplified by the results where photographs E, Q, R are most appreciated. It is possible that observers perceived the overabundance of aquatic vegetation (algae and plants) as indicative of stagnant water (Kaplan 1984), because flowing waters are preferred to still waters (Herzog 1985; Nasar and Lin 2003).

Cross-cultural variations in riverscape perception

Students from India, China and Russia do not consider wood as being aesthetically pleasing and do not perceive wood as being an indicator of naturalness (K, I and G scenes). Rather, they consider it a problem because danger is reduced when the channel is regulated. In Sweden, Germany and Oregon, the students do not appreciate regulated rivers, which they view as needing improvement. Wood is seen as a natural indicator and is not considered dangerous. In contrast to the previous group, they perceive danger along regulated channels.

To some extent, a general attitude towards natural features conflicts with the distinction between these two groups. One group works against nature (students from China, India and most of those from Russia), whereas the other accords with nature (students from Germany, Sweden and Oregon) so that two opposite development options are highlighted. On the one hand, there is a preference for natural landscapes to man-made landscapes (Calvin *et al.* 1972; Hodgson and Thayer 1980). On the other hand, there is a desire to control rivers (Mosley 1989; House and Sangster 1991; Gregory and Davis 1993). Cross-cultural variation can, therefore, be associated with differences in decisionmaking philosophy, in land-use context and in environmental education.

Despite recent progress towards a management with nature approach for river channels (Downs and Gregory 2004), the imperative of development as a technological process may explain the negative perception of LW in India, China and Russia.

The long-standing technocratic, hard-engineering approach to river management may have affected people's perceptions through opinions expressed on television, with reference to dam construction or channelisation structures, inculcating a commonly held opinion that humans can subjugate rivers. Such a technocratic approach, working on rivers instead of working with rivers, is usually associated with statements directed to the public commending such activities undertaken for the benefit of the society. In China, in spite of the syncretism between man and nature boosted by Taoism, Confucianism and Buddhism, since the 1950s the relation with rivers has been more one of domination than cooperation (Haifang 2004). Overall, land-use context is not so meaningful here as the three surveyed groups are located in very different geographic settings, from tropical to continental temperate.

When looking at other geographic areas, land-use context and familiarity with wood and rivers may provide some explanation for differences in regional response. People living in traditional forested landscapes such as in Oregon and in Sweden are more familiar with wood in rivers as a natural component. This hypothesis is supported when looking at the clear differences in perception between students from Texas (unforested) and Oregon (forested) who live in the same country, but in states with different vegetation condition. Habituation to see and experience in-channel LW makes its evaluation more positive, which suggests that land use patterns and environmental characteristics may contribute to the formation of landscape perceptions and values as noted by Zube (1987). Moreover, risks that are perceived to be familiar are more readily accepted than risks perceived to be unfamiliar and exotic. New risks tend to be more frightening than those risks that we have lived with for some time so that our experience helps us to put the risk in perspective. However, comparison among the extent of forest cover (Table I) raises the question as to whether this factor strongly influences LW perception and attitudes. Students from Russia, which has a dense forest coverage and a long forestry tradition but a very low population density, do not respond similarly to students from Sweden and Oregon. However, the students selected for this study were located in Moscow and the traditional agricultural areas of eastern Europe (Table I). When considering students from Germany, whose reactions to riverscapes are similar to those from students in Sweden and Oregon, it is meaningful to see that

the population density is high and the forest cover relatively low. The responses of German, Oregon and Swedish students may instead reflect the significant role of environmental information, communication and education.

Conclusions

In conclusion, results of our analyses indicate that the presence of wood in river channels influences how one perceives the quality of landscapes. The degree of blockage by LW is a secondary discriminator, however. Evidence of human modification (channel regulation), water character (spatial extent and turbulence via whitewater), physical environment (upland, piedmont and lowland), local features (presence of gravel bars or boulders) and characteristics of riparian vegetation also play significant roles in influencing the perception of students. The most aesthetic and natural riverscapes show whitewater and scattered large boulders, whereas the least attractive are characterised by extensive gravel bars, narrow bands of water and large amounts of LW. Channels obstructed by LW are clearly considered dangerous, implying a need for improvement through removal of LW. Unobstructed channels are apparently most acceptable to the general public.

Attitudes towards improvement and danger vary across cultural settings. Students from China, India and most of those from Russia expressed similar feelings when scoring the different photographs. Students from Germany, Sweden and Oregon shared similar attitudes towards the scenes, notably concerning the need for improvement, but also the perception of danger and the aesthetic value. Students from Spain and Texas were often similar in their scoring, whereas American students from Oregon and Texas expressed clearly different reactions. Thus, living and working with nature, which is supported as a development strategy, contrasts with another model where development is possible if nature is controlled.

Variability in attitudes towards riverscapes reflects the difficulties of applying the sustainable development concept at a global scale without considering the geographical complexity of human thinking. In many countries, laws prohibit LW addition and require landowners and public agencies to remove driftwood, floating debris, debris dams and log jams. Nevertheless, sustainable management of LW requires its recognition by the public

and river managers as a natural and attractive component of the fluvial system and balanced consideration of threats and benefits resulting from its presence in watercourses (Le Lay 2006). Local residents must be more involved in watercourse management (House 1996; Petts 2006), implying that campaigns of environmental education promote a greater environmental awareness and understanding by the public through public debates, consensus conferences or local forums (Nunneri and Hofmann 2005). Environmental transformations must be considered in an integrative perspective according to the intertwining of natural and human actors (Eden *et al.* 2000). The process of watercourse restoration is a scientific, practical and social endeavour to reconcile the expectations of restoration and policy workers with those of their local public (Eden and Tunstall 2006).

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