2D versus 3D: The relevance of presentation media for valuing an Alpine landscape

Barbara Färber[1], Michael Getzner[1], Claudia Yamu[2]*

[1]Department of Spatial Planning, Center of Public Finance and Infrastructure Policy
Vienna University of Technology
Resselgasse 5, 1040 Vienna, Austria
ph. +43 1 58801 280320, fax +43 1 58801 9280320
e-mail: barbara.faerber/michael.getzner@tuwien.ac.at

[2]Department of Spatial Planning, Spatial Simulation Lab (SimLab)
Vienna University of Technology
Karlsgasse 13, 1040 Vienna, Austria
ph. +43 1 58801 430, fax +43 1 58801 9280430
e-mail: claudia.yamu@tuwien.ac.at

** corresponding author*

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Abstract

In order to value (hypothetical) landscape transformations, respondents in a survey are usually presented pictures of diverse landscapes in order to visualize differences in the appearance of a landscape. In the current paper, we present a class-room experiment ascertaining potential advantages and disadvantages, and differences, of 2D versus 3D presentations of landscape changes. The landscape to be valued was a typical alpine pasture in the Austrian Alps. Two alternative scenarios were tested; on the one hand, the landscape might change owing to changing agricultural uses, leading to natural afforestation (reforestation) and decay of existing infrastructure such as hiking trails. On the other hand, extensions of tourism infrastructure (renovation and extension of existing huts, new attractions for visitors) were presented. Respondents were divided into two groups; one was presented manipulated pictures (2D / non-stereoscopic), the other one was equipped with 3D glasses and asked for their perception of landscape changes in the spatial simulation lab. It turns out that significant differences between the two groups could be detected; respondents did announce different trip frequencies, i.e. respondents in the 3D stereoscopic group stated a higher frequency of trips given compared to the non-stereoscopic group. However, they did not state a significantly different willingness-to-pay to prevent disadvantageous landscape changes. The study thus provides some indication that the mode of presentation (non-stereoscopic vs. stereoscopic) may significantly affect the economic valuation of landscape changes.

Keywords: Alpine landscape, travel behavior, revealed/stated preferences, 3D vs. 2D (stereoscopic vs. non stereoscopic) presentation media.

1. Introduction and background

While remnants of pristine or wilderness areas can still be found in the Austrian Alps, the landscape has been transformed over centuries by human cultivation (agriculture, forestry). This is especially important for Alpine pastures which have led to a specific appearance of the landscape, as well as to a rich biodiversity of animal and plant species which are native to these pastures and which would not exist if human cultivation had left the original land cover of forests intact. The current appearance of the landscape provides the basis for Alpine tourism – a major sector of the Austrian economy. Alpine pastures and a diverse landscape form the typical and highly esteemed images and metaphors of intact ecosystems and sustainable agriculture and forestry. Alpine pastures are a significant element of the scenic beauty of Alpine landscapes; tourism marketing and tourist guides market the original pasture landscape as an essential element of enjoying a relaxed, natural environment. While hiking and other alpine activities during summer mainly take place during summer, pastures also provide the slopes for skiing during the winter season. However, it is less important for the tourism industries whether Alpine pastures as a key element of the landscapes in the Alps are natural from an ecological point of view. More important are the image and the metaphor transported by marketing agencies and destination management.

Tourism itself may have significant negative effects on Alpine pastures in terms of ecological degradation and overcrowding, but the structural change in agricultural production leads to abandonment of marginal pastures by reducing the intensity of cultivation. Re-forestation and the loss of biodiversity typical to pastures may therefore also lead to a changing appearance of the Alpine landscape. The positive external effects of high-alpine agriculture, e.g. by means of grazing cattle, has been a major argument in favor of subsidies for high-alpine farmers.

While the importance of the Alpine landscape *per se* is undoubtedly high, the economic value of recreation of Alpine pastures for visitors (domestic and international tourists) is still an open question. From and economic viewpoint, the landscape changes due to different agricultural practices may be valued by a wide range of economic valuation methods; one might ask for the tourists’ (or residents’) willingness-to-pay for different scenarios of the conservation of the Alpine landscape, or for the revealed and stated frequency of trips (vacations) in the Alpine tourism areas depending, among other factors, on different developments of the landscape. However, the practical implementation of economic valuation methods is often limited to presenting respondents several scenarios described verbally and by means of pictures of different Alpine landscapes. In some studies (e.g., Lienhoop and Ansmann, 2011; Getzner and Svajda, 2015), a picture is manipulated to show different stages of development. Nowadays, new techniques are available to present respondents such developments, for instance, three-dimensional (3D) presentations. While 3D models and their presentation are regularly used in urban and regional planning, e.g., for presenting different scenarios of urban developments to stakeholders, but less for valuing landscape scenarios. By now, it is unclear how a different presentation of a certain development of the appearance of a landscape might alter the respondents' perception and, subsequently, their valuation of landscape changes.

Against this background, the aim of this paper is to shed more light on the differences of the individual valuation of changes of an Alpine landscape characterized by pastures owing to two- (2D) versus three-dimensional (3D) presentations. In particular, the purpose of this paper is to find answers to the following questions:

- How are changes of a typical Alpine landscape (pasture) valued by respondents in an experimental setting?
- Are the revealed and stated travel frequencies different between scenarios?
- How does the form of presentation (3D vs. 2D) influence the respondents' answers?
- How do respondents perceive advantages or disadvantages of 3D vs. 2D presentations?

The structure of the paper is as follows: In Section 2 there is a brief overview of literature on presenting environmental, regional and urban development by means of different presentation media. In Section 3 the experimental setting is presented, and hypotheses are developed. In Section 4.1 the descriptive results of the study are discussed, and in Section 4.2 the econometric results with respect to the determinants of the respondents' willingness-to-pay and their revealed and stated travel frequency are presented. Finally, in Section 5, the results are summarized, and conclusions are drawn.

2. Valuing a landscape via visual presentation

Valuing landscape changes and transformations is usually done by presenting different management scenarios to survey respondents, or tourists. Very often, changes of landscapes are visualized through manipulating pictures and presenting these. On the one hand, valuation may be approached by assessing the recreation value of the current appearance of the landscape (e.g., by modeling trip frequency determined by travel cost and environmental and socio-economic attributes) in combination with hypothetical scenarios. This combination of revealed and state preference techniques has been recently made fruitful by a number of scholars (e.g., Whitehead et al., 2000; Hoyos and Riera, 2013). On the other hand, willingness-to-pay (WTP) to prevent deterioration or to enhance the quality of landscapes has widely been ascertained by means of visual representations (e.g., Lienhoop and Ansmann, 2011; Getzner and Svajda, 2015).

In spatial planning, new techniques have now been developed in order to visualize urban or rural landscapes more realistically, including the modelling of city landscapes with respect to urban development or urban sprawl. Spatial planning techniques include, of course, maps and plans, but also different forms of visualization (cf. Zech, 2013; Tisma et al., 2012). Visualization modeling has the aim to create an accurate context for development proposals and to explore possible future development scenarios. Visualizations are commonly used to overcome the lack of communication between different parties as they can translate conventional drawings and analyses into a format that may be more comprehensible (Pietsch, 2000). The lack of mutual communication can lead to inconsistencies in the planning and design process. Thus, 3D visualization often works as a communication tool for a decision-making process (Roupé and Johansson, 2010).

In the context of environmental valuation, Fiore et al. (2009) present the benefits of virtual experiments in a laboratory. They conclude that values elicited in virtual settings may reflect the respondents' beliefs that could be more close to the true beliefs compared to a standard survey situation, owing to the more realistic perception of respondents.

While environmental valuation techniques have only recently included experimental settings, urban and regional planning has used 3D simulations regularly. For instance, Grêt-Regamey et al. (2014) present an interactive simulation of city developments at Masdar City to present and highlight ecosystem services trade-offs with the aim to develop innovative sustainable urban strategies. Another application of 3D modelling for urban policies was published by Thill et al. (2011) who present applications of the "three dimensional city" for transport planning and mobility decisions. In energy policy, virtual experiments and simulations have been used, e.g., for siting wind power plants (Bishop and Stock, 2010).

Using digital visualization two kinds of displays can be used: (Auto-) Stereoscopic (3D) and non-stereoscopic (2D). Benoit et al. (2008) point out that the applications of 3D scenes are numerous as they range from entertainment (video, games) to more specialized applications such as educational ones or medical applications. The stereoscopic display increases visual authenticity due to the simulation of depth, based on the human brain and eye physiology (stereopsis). Stereoscopic images are using systems to display stereo images presenting two slightly different images to the right and left eye. Tauer (2010, p. 144 f.) points out that the stereoscopic display only produces a 3D effect due to two distinctive flat depth levels. The main advantage lies in the easy encoding of the images (Tauer, 2010). In contrast, a disadvantage is that owing to a fixed focal length of a stereoscopic display, e.g. the screen, results can conflict within our visual system. As a result, viewing stereoscopic images can have negative short-term consequences, including difficulty fusing binocular images and therefore reduced binocular performance (Hiruma et al., 1996; Liebold et al., 2013).

For viewing stereoscopic pictures, two systems are at stake, i.e. stereoscopic displays with glasses in contrast to autostereoscopic displays where no glasses are needed. The most cost-effective technique for stereoscopic display is by using anaglyphic lenses as viewing glasses to achieve the 3D effect. Different colored filters encode each eye's image. Thus, typically anaglyph images contain of two different complimentary colored images. Because of the colored filters in the glasses one colored image is only destined for one eye and the image is locked for the other one. This creates the 3D effect. The cost-effectiveness is juxtaposed by the disadvantage of color renderings as both images and the glasses are colored and thus can influence the quality of the image.

3. The experimental setting, and testable hypotheses

3.1 The class room experiment

In order to answer the basic research questions of the current study, 85 spatial planning students at the bachelor level were recruited for the classroom experiment. As an incentive to participate, students could earn points for the upcoming economics exam.

For producing the stereoscopic images for our classroom experiment, we faced the challenges described above in section 2. According to the size of the room, the position of participants and the size of the screen we identified a stereoscopic optimum with a distance of intersection for two images of 2.5 cm. We used the software "Free 3D Photo Maker" in order to produce the 3D image on the basis of the 2D picture of an alpine pasture.

Students registered for the experiment for certain time slots and were then randomly assigned to a group; in order to guarantee equal conditions of the experiment, we limited each group size to 15 respondents which is the maximum capacity of the spatial simulation laboratory. Prior to the experiment, students did not know whether they would be presented 2D or 3D images.

In the standard seminar room, students were verbally introduced to the survey, and then handed the self-administered questionnaire; the 2D image and the two development scenarios presented below were shown by means of an overhead projection. In total, 43 students were assigned to the 2D groups.

In the spatial simulation lab, the verbal introduction was equal to the 2D treatment, but students were in addition handed 3D glasses in order to watch the images of the original landscape and the two potential development scenarios. Figure *1* presents impressions from both the classroom and the simulation laboratory. Students then filled in the self-administered questionnaire after watching the 3D pictures.

<Figure *1* about here>

3.2 Development scenarios of alpine pastures, and testable hypotheses

As mentioned before, we presented respondents three pictures; the original one displayed an alpine pasture which proved to mirror the usual image, e.g. in tourism brochures, of a typical alpine pasture.[1] Based on this picture, two scenarios were introduced into this original picture by adding several components of landscape changes such as trees, hard-surfaced paths and roads, and tourism infrastructure. Scenario 1 mirrors a development that might reduce biodiversity typical to alpine pastures, and changes the landscape from the image of a landscape attractive for tourists to an area largely afforested owing to reducing or abandoning the traditional way of managing alpine pastures (scenario "Afforestation"). Scenario 2 also assumes a drastic change in the management of the pasture and intensively develops tourism infrastructure in terms of an alpine hut upgraded to a restaurant, with information panels, and other sports and leisure infrastructure (scenario "Tourism").

After having manipulated the original 2D picture to display the two potential scenarios, we then produced the corresponding 3D pictures. Figure *2* presents the original picture, and the two manipulated pictures displaying the scenarios 1 and 2.

<Figure *2* about here>

In order to test for differences in the perception, and consequently, in the economic valuation of the two scenarios, we structured our questionnaire as follows. First, a block of questions ascertained preferences of respondents and the frequency of vacations in alpine landscapes, including several dimensions to describe an alpine pasture. Second, the status quo of the appearance of the landscape, and the two scenarios, were valued by respondents, including their hypothetical frequency of vacations if one of the two scenarios were to be become reality. Third, respondents could state their willingness-to-pay for a landscape conservation funds to manage and maintain alpine pastures, and,

[1] Due to space restrictions, we cannot describe the procedure to test for similarities between pictures in detail. In a nutshell, we took several pictures of tourism brochures, analyzed them with respect to their content (forests, open spaces, alpine pastures, meadows, and blue sky) by breaking up the pictures in a 1x1 mm grid, and then took our own picture in high resolution in order to have a picture available that could be manipulated.

alternatively, to avoid scenario 1 or 2. Fourth, the questionnaire included statements regarding the 2D and the 3D presentation, respectively. The 2D group was asked about their opinions about a potential 3D presentation, e.g., whether they would expect more information if they would have had a 3D presentation instead. The 3D group was asked whether they thought that 2D pictures were enough for perceiving landscape changes. Both groups were also asked whether they thought that 3D could provide more information, or an improved spatial perception than 2D pictures. Finally, some socio-economic questions (e.g., income) were asked.

Our main six hypotheses to be tested are (for a list of variables, see Table *4*):

H1: $\text{Travelfrequency}_{\text{2D,Status quo}} \neq \text{Travelfrequency}_{\text{3D,Status quo}}$

H2: $\text{Travelfrequency}_{\text{2D,Scenario1}} \neq \text{Travelfrequency}_{\text{3D,Scenario1}}$

H3: $\text{Travelfrequency}_{\text{2D,Scenario2}} \neq \text{Travelfrequency}_{\text{3D,Scenario2}}$

H4: $\text{WTP}_{\text{2D,Scenario1}} \neq \text{WTP}_{\text{3D,Scenario1}}$

H5: $\text{WTP}_{\text{2D,Scenario2}} \neq \text{WTP}_{\text{3D,Scenario2}}$

H6: $\text{WTP}_{\emptyset\text{(2D,3D),Scenario1}} \neq \text{WTP}_{\emptyset\text{(2D,3D),Scenario2}}$

<Table *4* about here>

The first group of hypotheses tests whether travel frequency is different between the two groups (2D vs. 3D), depending on the scenario presented. The second group tests for differences of willingness-to-pay (WTP) with respect to the form of presentation, as well as the scenarios. As this paper answers the research questions and tests for the hypotheses in an exploratory approach, we do not have a priori assumptions about the direction of each test. For instance, if 3D presentation contain more information and offer a more comprehensive spatial perception of landscape changes, respondents may state a higher travel frequency and a higher WTP in the 3D group, as several studies showed that an increased level of information may also lead to a higher willingness-to-pay (e.g., Bergstrom et al., 1990; Ajzen et al., 1996; Getzner, 2012; Bartkowski et al., 2015).

Besides analyzing descriptive evidence regarding potential differences according to the hypotheses outlined above, this paper specifically tests the hypotheses by means of two equations which are estimated econometrically:

$$Travelfrequency_i=f(T_i,G_i,S_i,P_i) \quad (1)$$

$$WTP_i=f(G_i,S_i,P_i) \quad (2)$$

Equation (1) outlines the empirical model in order to estimate a ‘demand function’ for vacations in alpine areas, specifically with the focus on alpine pastures, on the basis of a travel cost model (cf., e.g., Phaneuf and Smith, 2005). The frequency of vacations in alpine landscapes, denoted by the variable ‘Travelfrequency’, should thus dependent on T_i (travel cost) consisting of both conservative estimates of transportation and travel time costs. As we do not aim to provide a representative study, nor measure recreation benefits in absolute terms, neither the choice of costs of travel time nor transportation costs influences the ordinal ranking with respect to scenarios or groups of respondents (Randall, 1994).

G_i contains a vector of grouping variables denoting the scenarios 1 and 2, and differentiating the sample of respondents between the 2D versus 3D presentations.

S_i denotes income of respondent i which can be reasoned by the standard assumption that travel frequency as a normal consumer good, as well willingness-to-pay for landscape conservation, is positively correlated with individual (or household) income.

P_i forms a vector of variables comprising the strength of agreement to a number of statements, e.g., regarding the role of alpine pastures for alpine landscapes, and the experience of respondents with developments at alpine pastures potentially considered unfavorable (e.g., afforestation, intensive tourism development).

With respect to equation (2) presented above, we basically assume comparable influences of the variables, and include all variables in our WTP function except for travel costs.

4. Empirical results

4.1 Descriptive survey results[2]

Owing to restriction of space, only selected descriptive results will be presented in this paper. Table *1* highlights respondents' preferences and viewpoint regarding vacations in alpine environments including alpine pastures. First of all, the most important reason for choosing alpine regions and pastures for vacations is the (appealing) appearance of the alpine landscape of which pastures are an essential element. As described in the introduction, tourism and destination marketing emphasize the landscape as one of the most important determinants of destination choice.

Other important motives of determining the destination of vacations include sports and recreation facilities, and reasonable prices.

Main sports activities of respondents during their vacations include swimming, hiking, cycling and mountaineering, all of which can be found in Austrian alpine regions.

<Table *1* about here>

Most respondents stayed about 1 to 2 weeks per year in alpine landscapes. The average length of stay was 10.23 days (standard deviation: 15.22 days; 2D group: 6.31 days; 3D group: 14.33 days). If scenario 1 ("afforestation") would become reality, respondents stated on average that they would reduce their length of stay to 4.52 days (std. dev. 11.34 days). However, respondents in the 2D group stated a reduced length of stay of 3.29 days, while respondent in the 3D group would reduce their stay to 5.78 days. If scenario 2 ("tourism") would be realized, the length of stay would on average be reduced to 4.17 days (2D group: 3.36 days; 3D group: 5.01 days). The stated reduction of the 3D group was thus much larger in relation to the stated length of stay before the scenarios would be realized.

[2] The entire questionnaire and further descriptions of the experiment, all the data and empirical assessments, including econometric estimations, can be obtained from the authors on request. Owing to limits of space only the most important results will be presented. Some more descriptive analysis can be found in Färber (2014).

Respondents also expressed their opinions concerning the functions of alpine pastures; as the Table *1* shows, respondents clearly thought that the conservation of biodiversity typical for alpine pastures, and the preservation of the landscape for recreation purposes were the most important functions.

Respondents were also asked to state their willingness-to-pay (WTP) for the prevention of either scenario 1 or scenario 2. As the results in Table *2* suggest, WTP of respondents was – on average – about EUR 10.74 (for the total sample, scenario 1), and EUR 10.35 (for the total sample, scenario 1), respectively. The very small differences suggest that willingness-to-pay was not different between the two groups.

<Table *2* about here>

Before turning to the econometric results with respect to travel frequency and WTP, *Table 3* presents the results of the perception of respondents with respect to the group (2D vs. 3D). As the results indicate, there are only slight differences. While around 85 to 88% of respondents in both groups thought that 2D photos would present the equally well, the 3D group stated that 3D presentations would be better to understand a problem of landscape change.

The other statements regarding 3D presentations were only slightly different between the two groups; a more pronounced, though not significant, difference occurred with the issue whether 3D presentation would contain more information.

<*Table 3* about here>

4.2 Travel frequency and willingness-to-pay for preventing landscape changes considered to be unfavorable

The first econometric estimations presented in this paper consider modeling the frequency of visits based on the actual frequency, and the potential frequency of trips depending on the two scenarios. Based on the hypotheses discussed in section 3.1, and the variables described in Table *4*, the dependence of travel frequency of respondents is tested with a specific focus on the landscape change, and the presentation media in terms of 2D versus 3D. Table *5* presents the results of two estimations; the left side of the table includes details of the basic travel cost model by accounting solely for travel costs, the two scenarios, the 3D versus the 2D group, and income of respondents.

First of all, the estimations show that – in line with theoretical expectations – travel frequency depends significantly on travel costs (variable ‘Travelcost’). Given the negative coefficient of -0.0023 which is stable in both estimations, we may also compute consumer surplus per trip to an alpine pasture (including the whole vacation during which the alpine pasture was visited). Consumer surplus in our case amounts to a total of about 432 EUR per holiday trip; owing to the strong rejection of both scenarios 1 (reforestation, variable ‘Scen1’) and 2 (intensive tourism, variable ‘Scen2’), respondents stated that they would change their travel frequency dramatically. As we discussed above, travel frequency might be significantly reduced from an average of 10.2 times in the last 5 years to about 4.5 times over the next 5 years. Considering all other variables – ceteris paribus – consumer surplus almost drops to one tenth of the original consumer surplus if the scenarios indeed are realized. This effect is only slightly smaller for the expanded travel cost model.

Furthermore, the group variable (variable ‘Group’) differentiating the sample regarding their treatment with 3D versus the 2D version of the pictures presented in the survey interestingly leads to a significantly higher trip frequency. As described above in section 4.1, the respondents in the 3D treatment stated a trip frequency of about 14 over the last five years, while respondents in the 2D treatment only said that they would have visited alpine pasture about 6.5 times. This significant difference is also indicated by the significant coefficient of 0.3501 in the basic travel cost model (left side of Table *5*) which leads to a welfare effect in terms of an additional consumer surplus of EUR 152 per vacation. However, the effect is again much smaller in the estimation of the expanded travel cost model; for this case, the additional consumer surplus attributable to the 3D version of the presentation amounts to EUR 95 per vacation.

Finally, the variable ‘Income1’ was also included in the basic estimation to ascertain the importance of socioeconomic variables. The estimation of both the basic and the expanded travel cost model suggest that – congruent with the theoretical expectations – travel frequency of respondents increases with income.

In order to ascertain additional determinants of travel frequency, and to control for potential influences of the perception of alpine pastures, Table *5* also shows the results of the expanded travel cost model. In this expanded model, more variables are included that may be closely connected to respondents' preferences for vacations in alpine environments. The estimation reveals that respondents who stated that alpine pastures would be essential for the appearance of the landscape indicate a higher travel frequency (variable 'Essential'). Furthermore, the variables 'Identity' (denoting respondents who thought that alpine pastures would contribute to the national identity), 'Experience1' (for respondents having experienced reforestation of alpine pastures) and 'Experience2' (for respondents having experienced intensive tourism on pastures) state stronger preferences for the alpine pasture presented in the experiment. Otherwise, respondents who stated that recreation would be an important ecosystem service of alpine pastures (variable 'Recreation') exhibit a below-average frequency of trips to such areas.

All in all, the travel frequency model, while it is – of course – not representative for the Austrian population, exhibits interesting results in terms of the popularity of landscape changes, and the importance of presentation media. There seems to be a strong preference of respondents for the appearance of alpine pastures corresponding to the usual "image" communicated by the tourism offices all over the Alps. In addition, it seems that travel frequency stated by respondents is influenced by the presentation media in the sense that 3D presentations motivate respondents to state higher trip frequencies than in the 2D treatment.

In order to explore the influence of 3D versus 2D presentations, Table *6* presents the results of a maximum likelihood estimation of the determinants of the respondent's willingness-to-pay for the prevention of the two scenarios. The table again shows two estimations, one with essentially three variables (variable 'Scen2' with the willingness-to-pay to prevent scenario 1 as the baseline), the variable 'Group' and the variable 'Income2'.[3] The simple estimation on the left-hand side of Table *6* only provides some indication that – as theory predicts – the respondent's willingness-to-pay is positively correlated with income. However, at first sight, there does not seem to be much difference with respect to the scenario for which a willingness-to-pay to prevent it was elicited, and to the presentation media (3D versus 2D).

[3] Regarding the variable ‚Income2', we used a different income variable for the estimation of willingness-to-pay; since the sample for this estimation is smaller than for the estimation of travel frequency in Table *4*, we had to use a simpler income variable with only two income classes (instead of the continuous income variable).

However, the right-hand side of Table *6* includes some additional variables which have already been used for explaining trip frequency. Enriching the picture with these variables leads to interesting results regarding the determinants of willingness-to-pay of participants in the experiment. While the coefficients and their significance of variables ‘Income2’ and ‘Scen2’ basically remain unchanged, the variable ‘Group’ is now weakly significant with small coefficient of -0.1224. This means that respondents in the 3D group in general stated a slightly smaller willingness-to-pay (on average, willingness-to-pay is about 10% lower in the 3D group than in the 2D group).

In addition to the explanatory variables already mentioned, it seems that preferences determine willingness-to-pay to a much higher degree that the way of presenting potential landscape changes. As expected, willingness-to-pay of respondents – ceteris paribus – increases with the acceptance of statements regarding the importance of alpine pastures for the landscape, for recreation, and with respect to the personal experiences of respondents.

5. Discussion, summary and conclusions

Based on a picture of an alpine pasture in the Austrian Alps, used as status quo for the rest of the survey, two hypothetical scenarios of landscape transformations were developed. These ought to illustrate potential qualitative changes of the current appearance of the landscape.

While in the first scenario, reforestation takes place, either naturally or artificially and as a consequence of the closing of farms in the alpine zones, the second scenario assumes an infrastructure expansion due to the increase of tourism. These scenarios were created through (digital) manipulation of the status quo picture.

Travel frequency, distance, and traveling time were used as indicators to determine the travel costs of the respondents, and combined with an estimation computing recreation benefits (consumer surplus). Furthermore the interviewees (in a class room experiment) were asked to state their estimated future visit frequency to the two modified scenarios within the next five years, as well as their willingness to pay in order to avoid each scenario.

A second aspect of this study focuses on the presentation of the landscape sceneries and their transformations. In addition to the already mentioned status quo picture and the two scenario photographs (2D), stereoscopic 3D-pictures of the various scenarios were produced as well. The aim of this experiment was therefore to identify the effects of these different presentations on the results. The survey participants were divided into two groups in a class-room experiment, one evaluating the landscape scenery using questionnaires with photographs (2D), the other using an almost similar questionnaire with stereoscopic 3D-pictures which were presented in the Department of Spatial Planning's spatial simulation laboratory.

Respondents of the 3D group state a significantly higher trip frequency than the 2D group; they also reacted to the 3D presentation of landscape changes differently, in the sense that they were more sensitive to disadvantageous transformations of the appearance of the alpine pastures.

The results show that the landscape scenery status quo was clearly preferred. Additionally, the modified scenarios have a significant negative impact on trip frequency. Furthermore, the consumer surplus drops enormously when the landscape scenery changes.

Concerning the different forms of representation (2D vs. 3D), significant differences between the two samples were found. This means that the different presentation methods of the hypothetical situations had a significant impact on trip frequency and, to a smaller extent, on the willingness to pay in the current experimental setting. While the 3D group stated a higher trip frequency compared to the 2D group – controlled for potential differences, e.g., regarding income, willingness-to-pay was marginally higher in the 2D group compared to the 3D group.

Interestingly, when asked for their evaluation of 3D versus 2D, the 3D group underestimated the influence of the presentation form as they did not expect additional information or a different perspective of the landscape. The 2D group had somewhat different expectations about 3D presentations in the sense that they expected an improved spatial perception of 3D versus 2D presentations.

All in all, the study thus provides some experimental evidence that the mode of presentation (2D vs. 3D) significantly affects the economic valuation of landscape changes by a different spatial perception of landscape changes. However, it has to be tested in additional (representative) experiments which reasoning may be developed for these effects.

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Figure 1: The classroom experiment: 2D lecture room and 3D presentation in the spatial simulation lab of the Vienna University of Technology

2D lecture room

3D spatial simulation lab

Source: Own pictures.

Figure 2: Alpine Landscape: status quo of pastures and possible future scenarios (“Afforestation”, “Tourism”)

Status quo: Typical alpine pasture	
Scenario 1: “Afforestation”	
Scenario 2: “Tourism”	

Source: Own pictures.

Table 1: Descriptive results: Vacations and alpine pastures

Main reason for choosing alpine landscapes with pastures as destinations of vacations	*Percentage of respondents (multiple answers)*
Appearance of the landscape	69.41%
Reasonable prices	47.06%
Possibilities for sports	44.71%
Recreation possibilities	42.35%
Nature experience	36.47%
Comprehensive provision of hotels, restaurants	18.82%
Solitude	12.94%
Accessibility to the area	10.59%
Sightseeing	9.41%
Contact with wildlife	5.88%
Friendly to families and children	3.53%
Main sports activities	*Percentage of respondents (multiple answers)*
Swimming	65.88%
Hiking	51.76%
Cycling	37.65%
Mountaineering	20.00%
Climbing	14.12%
Jogging	9.41%
Riding	3.53%
No sports	2.35%
Annual frequency and length of vacations in alpine landscapes	*Percentage of respondents*
More than 4 weeks	14.29%
Two to four weeks	28.57%
One to two weeks	26.19%
Less than one week	21.43%
No vacations in alpine regions	9.52%
Importance and functions of alpine pastures	*Mean on a 4-point Likert scale (4=most important)*
Sustaining and support for biodiversity	3.51
Preservation of cultural landscapes for recreation	3.52
Ecological farming of classical pasture products	3.46
Sustaining alpine pasture as ancient culture	3.17
Ecological, low-tech agriculture	2.93
Keeping the landscape open	2.38

n= 85.

Table 2: Willingness-to-pay to prevent scenario 1 or scenario 2

	2D group		*3D group*		*Total sample*	
	EUR (mean)	*n*	*EUR (mean)*	*n*	*EUR (mean)*	*n*
WTP to prevent scenario 1	10.58	43	10.9	41	10.74	84
WTP to prevent scenario 2	10.72	43	9.95	41	10.35	84

Table 3: Perception of 2D/3D presentations

	2D group		*3D group*		*Total sample*	
	(1)	*n*	*(1)*	*n*	*(1)*	*n*
3D presentations would have helped to understand the topic and the problems	23%	31				
Pictures present the issues and problems equally well as 3D presentations	85%	39				
3D presentations help to understand the topic and the problems			33%	36		
Pictures would have presented the issues and problems equally well as 3D presentations			88%	42		
3D presentations are more vivid, changes can be illustrated much better	3.56	43	3.74	42	3.65	85
3D presentations contain more information which makes valuation more easy	3.28	43	2.95	42	3.12	85
3D presentations are more modern and correspond to modern technology	3.44	43	3.79	42	3.61	85

(1) Percentage of respondents agreeing to a statement / mean on a 5-point Likert scale

Table 4: Variables of the empirical estimation

Variable name	*Description*
Dependent variables	
Travelfrequency	Frequency of travels to an alpine pasture landscape
WTP	Willingness-to-pay of respondents to prevent either scenario 1 or scenario 2 (EUR)
Explanatory variables	
T_i	
Travelcost	Travel costs of respondents for their visits to an alpine pasture landscape (EUR)
G_i	
Scen1	=1 for scenario 1
Scen2	=1 for scenario 2
Group	=1 for the sub-sample of the 3D treatment
S_i	
Income1	Income of respondent (net monthly income, per person, EUR, natural log)
Income2	=1 for respondents with a income higher than EUR 450 (per month, net of taxes)
P_i	
Essential	=1 for the respondent's view that alpine pastures are essential for the landscape
Identity	=1 for respondents agreeing to the statement that alpine pasture promote the national identity
Recreation	=1 for recreation considered to an important ecosystem service of alpine pastures
Experience1	=1 for respondents who have experienced the reforestation of alpine pastures
Experience2	=1 for the respondent's past experience with intensive touristic development on alpine pastures

Table 5: Determinants of the respondents' travel frequency

	Basic travel cost model			*Expanded travel cost model*		
Variable	*Coefficient*	*z-Stat*	*Sign.*	*Coefficient*	*z-Stat*	*Sign.*
Constant	0.1556	0.3273		1.2389	2.171	**
Travelcost	-0.0023	-3.2338	***	-0.0023	-3.0682	***
Scen1	-0.9835	-7.341	***	-0.9115	-6.6756	***
Scen2	-0.9541	-7.157	***	-0.8858	-6.5217	***
Group	0.3501	3.1551	***	0.2165	1.8194	*
Income1	0.3714	4.7842	***	0.1973	2.2962	**
Essential				0.4518	3.0162	***
Identity				0.5401	2.2008	**
Recreation				-1.3437	-4.8067	***
Experience1				0.5365	3.711	***
Experience2				0.3325	2.6367	***
Adj. R^2	0.1498			0.3065		
S.E. of regr.	7.8991			7.1341		
Log likelihood	-560.7406			-533.8609		
LR statistic	238.7263***			292.4857***		
n	203			203		

Dependent variable: Travelfrequency

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Count data model (negative binomial).

Table 6: Determinants of the respondents’ willingness to pay to prevent landscape changes considered to be unfavorable

Variable	*Coefficient*	*z-Stat*	*Sign.*	*Coefficient*	*z-Stat*	*Sign.*
Constant	2.2721	48.7988	***	1.9323	9.0088	***
Scen2	-0.0511	-1.0442		-0.0509	-1.0225	
Group	-0.0246	-0.5027		-0.1224	-2.3613	**
Income2	0.2805	5.6222	***	0.2865	5.3073	***
Essential				0.1096	1.7697	*
Identity				-0.2330	-2.7955	***
Recreation				0.5851	2.9496	***
Experience1				0.4570	8.0454	***
Experience2				-0.3519	-6.8151	***
Quasi-log liklh.	2,309.2520			2,401.6600		
LR stat.	33.3217***			218.1369***		
Deviance stat.	18.9026			18.3237		
n	165			165		

Dependent variable: WTP

*** p<0.01, ** p<0.05, * p<0.1

Baseline is the WTP for preventing scenario 1.

GLM (maximum likelihood) estimation (Poisson distribution assumed, log link).