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SKIER DEMAND AND BEHAVIOURAL ADAPTATION TO WEATHER, SNOW CONDITIONS AND CLIMATE CHANGE IN CENTRAL PYRENEES

Adaptación de la demanda de esquí y del comportamiento de los esquiadores a las condiciones meteorológicas, de nieve y al cambio climático en los Pirineos centrales

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ABSTRACT: This study used surveys to determine how skiers perceive weather and climate change, and their behaviour concerning ski practice in the Central Pyrenees. A mixed system was used to collect the surveys; in situ and online (n=205). The climate preferences show that 80% of the skiers did not go skiing on a rainy day, 58.5% on a day of excessive wind, 46% with poor visibility, and 41% did not go skiing in marginal snow conditions. 91% percent of respondents reported having been affected by snow shortages during a ski season. Regarding adaptation measures to climate change, 49% of respondents would continue skiing less often in their usual place, 21% would ski in the usual way even with bad snow conditions, 10% would replace to skiing with another mountain activity, 10% would travelled farther to find good snow conditions, and 8% stopped skiing during that season. A total of 77% of the respondents believed that climate change has a medium or high impact on snow conditions, but 76% consider that this is a problem to be faced in the future.

KEY WORDS: Survey; Skiers; Pyrenees; Weather; Climate change; Adaptation.

RESUMEN: Se ha realizado un estudio mediante encuestas para determinar cómo los esquiadores perciben el clima y el cambio climático, así como su comportamiento con respecto a la práctica del esquí en el Pirineo Central. Se uti-

lizó un sistema mixto para recopilar las encuestas; in situ y en línea (n = 205). Las preferencias climáticas muestran que el 80% de los esquiadores no fueron a esquiar en un día lluvioso, el 58.5% en un día de viento excesivo, el 46% con poca visibilidad y el 41% no esquió en condiciones de nieve marginal. El 91% de los encuestados informó haber sido afectado por la escasez de nieve durante una temporada de esquí. Con respecto a las medidas de adaptación al cambio climático, el 49% de los encuestados continuaría esquiando con menos frecuencia en su lugar habitual, el 21% esquiaría de la manera habitual incluso con malas condiciones de nieve, el 10% reemplazaría al esquí por otra actividad de montaña, el 10% viajaría más lejos para encontrar buenas condiciones de nieve, y el 8% dejaría de esquiar durante esa temporada. Un total de 77% de los encuestados cree que el cambio climático tiene un impacto medio o alto en las condiciones de nieve, pero el 76% considera que este es un problema al que se enfrentará en el futuro.

PALABRAS CLAVE: Encuestas; esquiadores; Pirineo; tiempo; cambio climático; adaptación.

1. Introduction

The tourism industry is highly linked to the natural environment, and it is an economic activity highly vulnerable to varying and changing weather and climate conditions. In particular, winter tourism activities are often dependent on elements such as sufficient snowpack, the possibility of snowmaking, precipitation, good visibility among others. (Gössling *et al.,* 2012; Scott *et al.,* 2012). Therefore, the winter sports sector is expected to be particularly vulnerable to changing climate conditions (Scott *et al.,* 2008a; Pütz *et al.,* 2011; Soboll & Dingeldey, 2012). There is relatively abundant literature that relate climate change with ski tourism from the point of view of offer. Much of this literature is reviewed in Gilaberte-Búrdalo *et al.* (2014). This literature is mainly focused on the vulnerability of the international ski industry due to the impact of increased average temperatures on snow quantity and quality for ski areas. These studies have consistently found the ski industry to be at risk to climate change, with a continued reduction in the number of operating ski areas or the additional need for artificial snowmaking technologies. In the majority of the analysed places, seasons are projected to become shorter on average and more variable due to a decrease in natural snow cover, which is expected to cause a decline in the number of visitors, mainly at low-altitude and low-latitude ski resorts.

Comparatively, there are fewer studies with respect to the influence of weather and climate on skier demand, including tourist behavioural responses to past or projected climatic variability, poor snow conditions, and ski resort closures. This gap is surprising, as it is the preferences of the skiers for ski destinations that will ultimately determine a destinations' future prospects (Elsasser & Messerli, 2001; Englin & Moeltner, 2004; Fukushima *et al.,* 2002; Pickering *et al.,* 2010; Shih *et al.,* 2009; Töglhofer *et al.,* 2011).

Within the studies that analyse the response of the tourists or skiers to environmental changes or simply to the interannual climatic variability are those that use the methodology of surveys or questionnaires. König (1998) examined how skiers in Australia might respond to hypothetically poor snow conditions expected in the future. 25% of respondents indicated they would continue skiing at the same place and frequency, 31% would ski less often, 38% would ski at another location and 6% would quit skiing. Similar surveys were also conducted by Behringer *et al.* (2000) and Elsasser & Bürki (2002) at resorts in Switzerland. The two studies reached very similar results. Behringer *et al.* (2000) found that 30% of respondents would not change their skiing behaviour, 11% would ski at the same location but less often, 28% would ski at a more snow-reliable resort at the same frequency, and 4% would give up skiing. Elsasser & Bürki (2002) found that the majority of skiers would ski at the same frequency (30% at the same resort, 28% at another snow-reliable resort), 32% would ski less often and 4% would stop skiing. Behringer *et al.* (2000) also examined the perceptions of tourists on the topic of climate change and the manner in which they might adapt their behaviour: they surveyed skiers and snowboarders in Switzerland and found that 83% of respondents believed that climate change would threaten ski tourism and almost half believed that this would occur between the year 2000 and 2030. Unbehaun *et al.* (2008) examined how climate change impacts may affect winter sports tourists, in terms of their activity levels as well as destination choice. When provided with scenarios of consecutive winters with snow deficiency, 68% of winter tourists would give up destination loyalty in favour of a more snow secure destination. Pickering *et al.* (2010) evaluated the attitudes towards climate change in the largest ski resort in Australia in 2007 using 351 questionnaires. The results showed that 90% of skiers would ski less often in the case of five consecutive snow poor years. The majority of respondents (78%) believed global warming will have an adverse effect on the Australian ski industry. Vivian (2011) obtained that the main factors that were found to have a strong influence when choosing a ski resort are the quality of snow conditions, the absence of crowded slopes and close proximity to their place of residence. Respondents were also asked about the importance of various weather aspects as well as ideal conditions to ski. It was found that the absence of rain was the most influential weather factor out of the six presented in this study for 66% of respondents. The second most important weather factor was having good visibility (61% of all respondents), followed by the absence

of strong winds. Furthermore, 87% would ski their usual frequency, with a lower total number of days, 11% would ski more often than normal to make up for a shorter season, and 1% would stop skiing for the entire winter. Dawson *et al.* (2013) asked skiers about how they behaved during seasons with bad snow conditions in the US Northeast. 38% of respondents indicated that they skied less often at some point in past seasons, which is only slightly higher than those who say that they intend to ski less often in the future (34%). When considering spatial substitution in past seasons with poor snow conditions, 60% of the individuals in this study indicated having at some point travelled elsewhere in the US Northeast to ski, and 67% had travelled outside of the region. Rutty *et al.* (2015) examined how skiers in Ontario (Canada) would change their participation patterns if their preferred ski resort were closed due to a lack of snow. The survey focuses on current behavioural responses, rather than decisions based on future scenarios of climate change. The results also indicate that beginner and infrequent skiers, as well as parents with children enrolled in ski lessons, were more likely to either ski less and/or stop skiing altogether, while experienced and core skiers were more likely to engage in spatial substitution. The largest share of respondents (48%) stated that they would engage in spatial substitution by skiing as often as they currently do, but at other locations until their resort opened. Almost half of the respondents would engage in temporal substitution, with 31% opting to ski less often and wait for the resort to open and 12% who would wait for their resort to open and ski more frequently in the shortened season. Steiger *et al.* (2015) conducted a skier survey at the end of the 2013/14 winter season in 22 ski areas in Western Austria, Southern Germany, and Northern Italy. Snow quality and snow reliability were rated as the most important factors for destination choice followed for the number of skiing days per season, good weather. When asked if certain weather conditions prevent respondents from going skiing, rain was rated the most important, followed by strong winds and fog.

Little is known about the perception and behaviour of the skiers of the Pyrenees to climate change, particularly in relation to how skiers may alter their behaviour in response to climate change. In fact, to our knowledge, there are only two studies about the perception of the effects of climate change in winter tourist areas of the Catalan Pyrenees (March *et al*, 2014) but that does not address in any case the behavior of the tourist in front of different climatic conditions. This study observed that the employment situation was a significant variable, with students, members of large households and the unemployed agreeing more that climate change would bring less precipitation in the Pyrenees. Age was significant, with young people and respondents with lower incomes being significantly more concerned about the negative effects of climate change on tourism employment in the area, on tourist infrastructure and in more general terms on its negative economic effects. Pons *et al*. (2014) explore the shift in tourist distribution amongst Pyrenean ski resorts taking into account the behavioral adaptation of individuals due to the impact of climate change on snow conditions. Their results show that, even more than a significant reduction in the ski market, the main effect of climate change will be a redistribution and consolidation of the current market, reallocating the visitors of more vulnerable ski resorts to the most resilient ones, able to offer longer ski seasons plus having a higher attractiveness factor.

The aim of the current study is to explore the following questions using online and on-site surveys: (1) how do snow and climate conditions affect the choice of a given ski day in the Pyrenees? (2) How do skiers react to bad weather or snow conditions in terms of frequency of skiing days or substitution of the original destination choice? (3) How does the perception of skiers change regarding present and future climate in the Pyrenees? (4) Do the different groups of skiers (age, expertise, times of practice) influence different behaviors to face weather and snow variability and climate change?

2. Methods

2.1. Study area

The Pyrenees is a mountain range located in the northeast of the Iberian Peninsula, bounded by the Mediterranean Sea to the east and the Atlantic Ocean to the west. The Pyrenees extends over 425 km from west to east and constitutes a natural border between Spain and France. The width (north–south) in the central part of the range is 150 km, and declines towards the west and east (López-Moreno & García-Ruiz, 2004). In the Pyrenees the lowest elevations for ski slopes typically range from 1500 to 1700 m a.s.l.: only 30% of these ski resorts have skiable areas above 2500 m, with 2800 m being the maximum (Gilaberte *et al.,* 2017). During the last season (2018–2019), the Catalan Pyrenees received approximately 1.4 million skiers, Andorra received 2 million and the Aragonese Pyrenees received almost 1.5 million. In all cases, the average number of tourists in the season surpassed the average number of the last years with an increase of around 10–20% (ATUDEM, 2017). The classic ski season in the Pyrenees runs from December to April.

2.2. Survey design and distribution

The design of the survey and the methodology has been developed following, in part, the methodology of Vivian (2011), Dawson *et al.* (2013), Rutty *et al.* (2015) and Steiger *et al.* (2015). The survey was structured in four sections: the first corresponds to the basic data of the respondent as well as the demographic profile; the second corresponds to the respondent's sports habits, in terms of the specific modality of skiing and the annual frequency of their practice; section 3 deals with the influence of weather and snow conditions on ski attendance; and section 4 asks tourists about their perception of climate change and how

they respond to adverse climatic and snow conditions. The total number of questions in the survey was 19. We used a multiple choice response because it is an efficient and effective measurement (Behringer *et al.*, 2000). Table 1 summarizes the questions that were distributed. The surveys were distributed during two non-consecutive ski seasons; 2014–2015 and 2016–2017.

To collect the surveys, a double methodology has been used: the first involved distributing the surveys online to different ski and alpine clubs and the second involved distributing surveys *in situ* in ski resorts in three different ski stations (Panticosa, Formigal and Astún). In one of the questions in the "sports habits" section, they are asked about which ski stations they choose to go skiing in first place, always limited to the Central Pyrenees area. Within the stations to be noted there are a total of 5 from the Aragonese Pyrenees (Astún, Candanchú, Panticosa, Formigal and Cerler), 4 from the Catalans Pyrenees (Baqueira Beret, Tavascán, Boí taüll and Espot Esquí), the 2 from Andorra (Grandvalira and Vallnord) and the stations of the French Pyrenees (in this case, none of them are specified in the survey). The interviewer approached everyone but only distributed the surveys to those who were an adult (18 years and older), had participated in skiing or snowboarding activities during that day and were willing to complete the survey.

We compiled a total of 205 valid surveys (136 on-line, 69 *in situ*). We think that the mixed data collection system is the most adequate to avoid some biases such as influencing the respondents' responses to the meteorological weather conditions that prevailed that day of the survey.

2.3. Data analysis

Descriptive analysis and graphical representation of the results were carried out for the four sections of the questionnaire. In addition, we used analysis of variance (ANOVA) to determine whether statistically significant differences in the means exist between different groups of skiers. An F-test was used to determine the significance of differences. When mean values are equal, F has a value of 1; if they differ, F has a value greater than 1. The value of the F statistic is presented with its level of significance (p-value.). A p-

Table 1. Questions distributed to the skiers.
Tabla 1. Cuestionario distribuido a los esquiadores.

SECTION 1: DEMOGRAPHIC PROFILE
1. Age
2. Gender
3. Place of origin
SECTION 2: SPORTS HABITS
4. Station you choose first to go skiing
5. Typology of skiing
6. Years of practice
7. Frequency of practice during a ski season
8. Possession of season pass
SECTION 3: INFLUENCE OF METEOROLOGY AND NIVOLOGY
9. Importance that the respondents give to meteorological and nivological conditions.
10. In which of the following (meteorological) situations would the respondent not go skiing.
11. The respondent has been affected by bad snow conditions in the last 10 years.
12. How they have adapted in a situation of snow shortage.
SECTION 4: PERCEPTION OF CLIMATE CHANGE AND ADAPTATION RESPONSES
13. Do you think that climate change affects the Pyrenees actually?
14. Do you think that climate change affects winter tourism in the Pyrenees actually?
15. Do you think that climate change will affect winter tourism in the Pyrenees?
16. What meteorological and nivological conditions do you believe will affect climate change?
17. If the station where you usually go presents bad snow conditions, would you pay more money to move to a station farther away to look for optimal conditions?
18. Would you be willing to pay a higher price for the ski pass at the stations you usually go to in order to compensate the resort for providing artificial snowmaking
19. If you could not ski/snowboarding as often as you currently do, what other mountain sports activities would you do?

value below 0.05 led to rejection of the assumption of similar means (Rubio-Hurtado & Berlanga-Silvente, 2012).

3. Results

3.1. Demographic profile

In this section, the demographic profile of the respondents was analysed (Figure 1). In the sample of surveys, 19.5% were female and 80.5% were male. Most of the respondents came from the community of Aragon, 33.5%, 17.5% Madrid, 14% País Vasco, 13.5% Cataluña and 7.5% from Navarra. All these regions are part or in the proximity of the Pyrenees, except Madrid. 14% came from other regions. The average age of respondents was 35.4 years, with the age group between 26 and 45 years being 54% of the total sample, followed by the 18–25 age group (23%). No response was obtained from skiers above 65 years.

3.2. Sports habits

In terms of typology of skiing in ski resorts, Figure 2a shows that most of them (65%) were alpine skiers, 18% were snowboarders, 12% were mixed alpine skiing and snowboarding and a minority were mountain skiers (5%). Regarding the years of experience (Figure 2b), we found that the majority of skiers who responded had long experience of skiing, with 63% of the people having more than 10 years of experience. For season passes, 80.5% of the respondents did not have a season pass, and the average annual number of skiing days was 13.2, although most people (61%) skied 1 to 10 times (Figure 2c).

3.3. Influence of meteorology and nivology

This section assessed the importance and actions that skiers took regarding snow and weather conditions. Skiers were asked to rate the importance they gave to the different snow and weather conditions from 1 to 5 (Question 8), with 1 being little or 5 very much. Figure 3a shows the results thereof. Skiers gave an importance of 4.3 points on average to the fact that there is rain, followed by 4.1 to windy conditions, 4.0 to the quality of snow, 3.8 to visibility, 3.7 to snow depth, 3.6 to the number of open ski lifts and 3.4 to the number of skiable kilometers. Skiers seem to be little concerned by cold conditions (2.4), preferring this to very warm (2.9), or snowfall days (3), or bad road conditions for accessing the ski area (3). These responses were analysed using ANOVA to determine different perceptions among different groups of skiers. Comparisons made between the different age groups showed significant differences for the "rain" factor. There were different opinions between the younger age group of 18–25 years in the score for the importance of rain (3.6) and the age groups of 46–55 and 56–65 (4.2). The difference of means yielded a value with F=2.87 and p-value=0.024. There was also a difference between different types of skiing for the variables of snow depth: snowboarders gave an average importance of 4.1 to the fact that there is sufficient snow, while alpine skiers gave 3.5 (F=3.09, p-value=0.036).

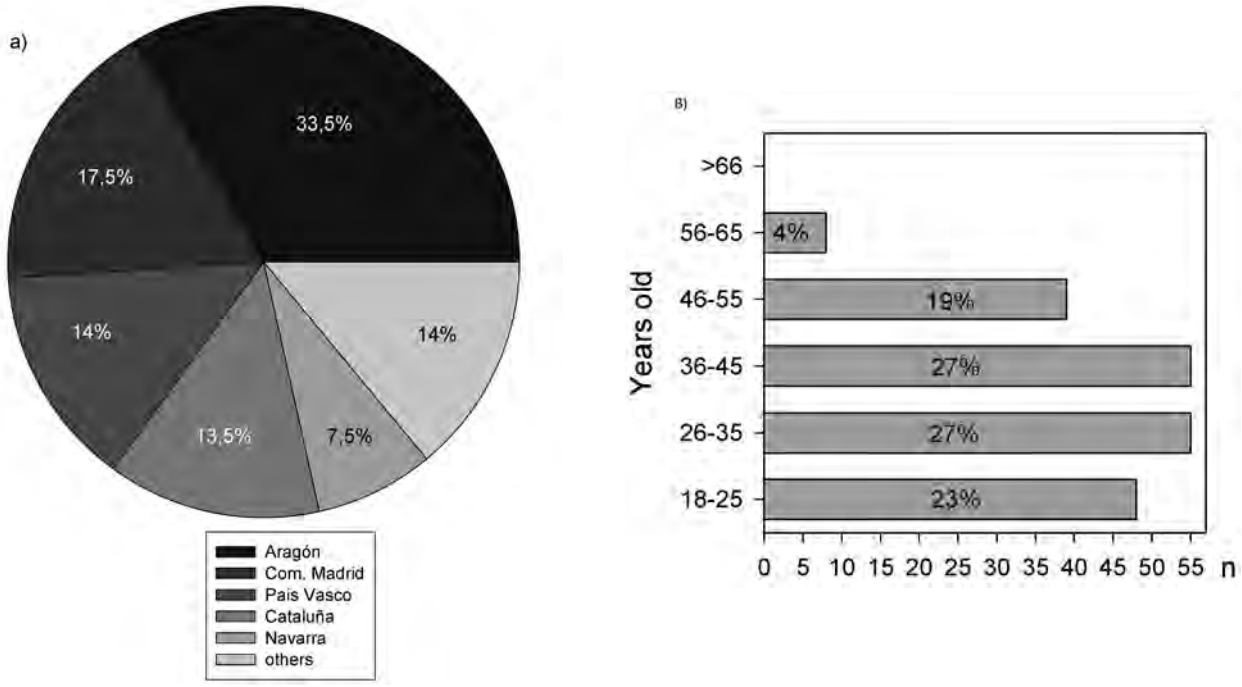

Figure 1. Demographic profile: a) origin place, b) age. *X* axis number of respondents.
Figura 1. Perfil demográfico: a) lugar de origen, b) edad. El eje X informa del número de encuestados.

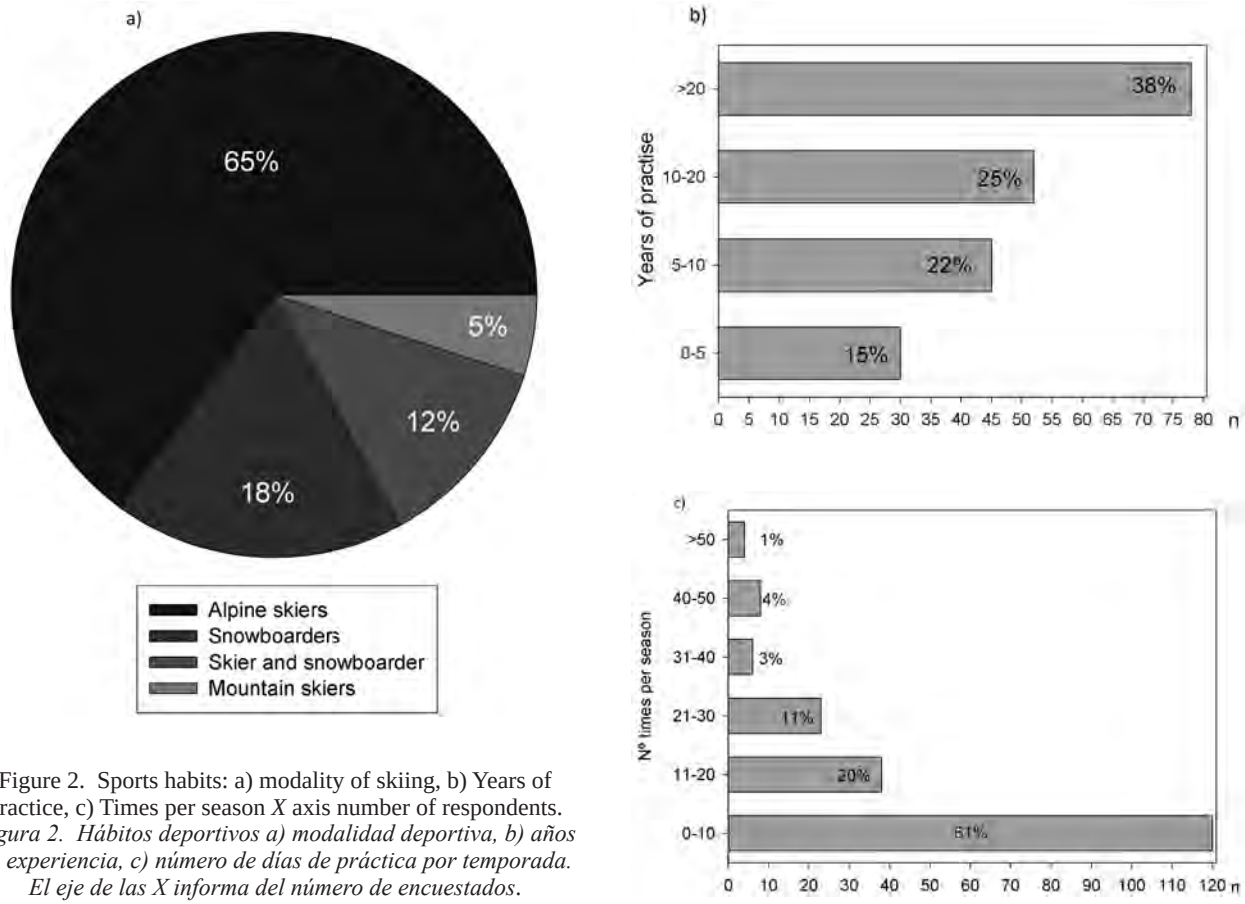

Figure 2. Sports habits: a) modality of skiing, b) Years of practice, c) Times per season *X* axis number of respondents.
Figura 2. Hábitos deportivos a) modalidad deportiva, b) años de experiencia, c) número de días de práctica por temporada. El eje de las X informa del número de encuestados.

Mean comparisons were also made for the different groups according to practice experience, but no significant differences were found.

The skiers were also asked about which meteorological and snow condition would lead to them refusing to ski in a day planned for this. Figure 3b shows that 80% of skiers would not go skiing on rainy days, 58.5% would not go on a day of excessive wind, and 46% would not go under poor visibility conditions. Furthermore, 41% would not go skiing when the snow depth is very low, and of these, 10% would not ski when this is only limited to ski runs and they cannot practice freestyle skiing. Comparisons were made between the different age groups, time of practice and place of origin, and no significant differences were found.

Overall, 91% percent of respondents reported having been affected by poor snow conditions in the past in their usual place of skiing, and they were asked what they did in these situations. A total of 49% of the answers indicated that they skied less often but whenever possible in the habitual place, 21% skied in the usual way despite poor snow conditions, 10% would not ski and looked for another mountain activity, 10% would travel farther to seek good snow conditions, 8% stopped skiing during the whole season and 3% responded "other" (Figure 4). Comparisons were made using ANOVA for the different age groups, degree of practice experience, number of times of practice and typology of skiing. Although no significant differences were found for any of these comparisons, skiers who practiced from 1 to 10 and 11 to 20 times per season mostly chose the option of skiing less often but whenever possible in their usual place of practice. An analysis has also been carried out to find out if depending on the place of origin they would show a different willingness to travel further as an adaptation measure in the face of the scarcity of snow. The 28.6% of the skiers in the community of Madrid would be willing, followed by 26.7% of the community of Navarra. On the other hand, Aragon shows the least willingness to change geographical location for skiing with a 13% of respondents. Also, mountain skiers were more likely to continue skiing in the usual way despite bad snow conditions, while snowboarders more often chose the option of skiing less often in the usual place (F=2.60, p-value=0.060).

3.4. Perception of climate change and adaptation responses

In the fourth section of the questionnaire, skiers were questioned about their perception of climate change and how they would behave, from a skiing perspective. Figure 5 shows that 77% of respondents are almost sure or probably that climate change affects the Pyrenees, but

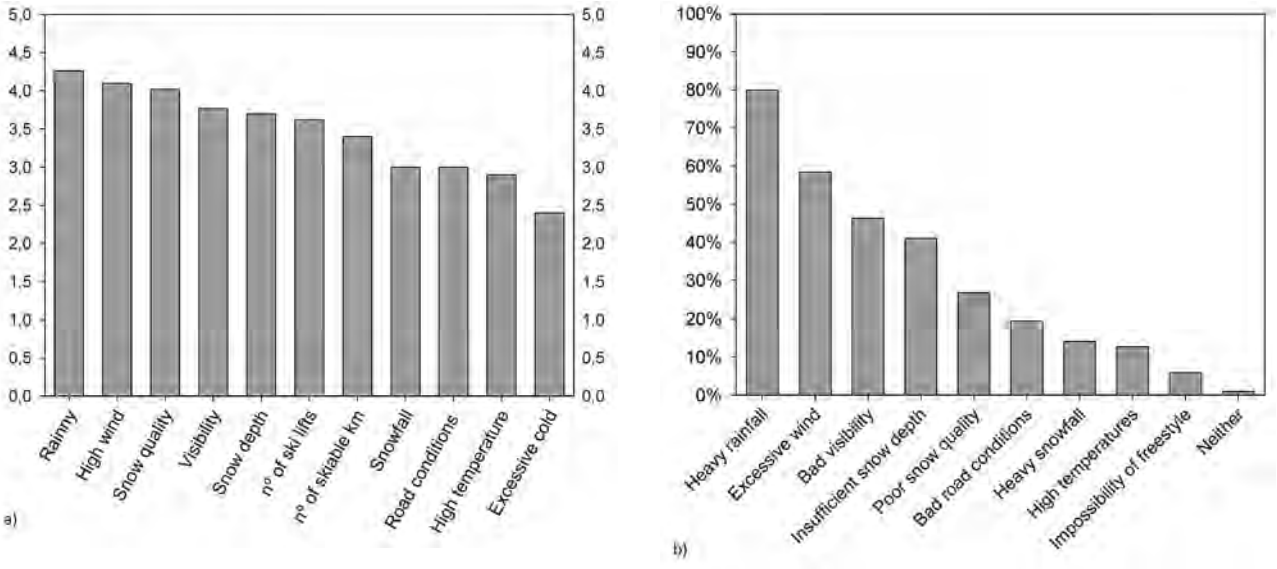

Figure 3. a) Mean values of the importance given by the respondents to different meteorological and snow conditions. b) Percentage of responses to situations that respondents would stop skiing a day that they had planned for it.

Figura 3. a) Valores medios de la importancia dada por los encuestados a las diferentes condiciones meteorológicas y de nieve. b) Porcentaje de respuestas en las que los encuestados dejarían de esquiar en un día que lo tuvieran planificado.

this perception falls drastically when asked if they believe that it affects ski tourism (48%), with only 15% who were sure of that. The number of people who think that climate change will impact ski tourism in the Pyrenees in the future (without specifying any stipulated time frame) rose to 76%. Nevertheless, a large percentage of respondents (18%) were not sure about this, and 7% of them were skeptical that climate change will affect skiing.

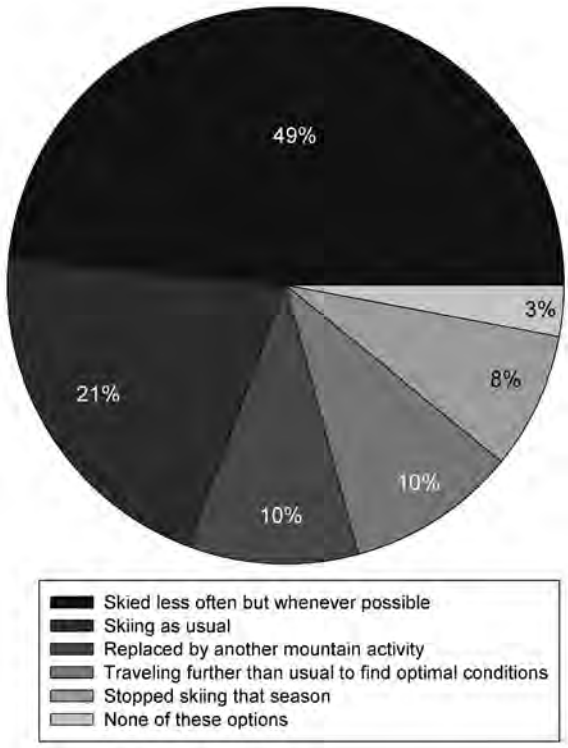

Figure 4. Adaptation of skiers to a past situation of bad snow conditions.

Figura 4. Adaptación de los esquiadores ante situaciones pasadas de malas condiciones de nieve.

Comparisons were made using ANOVA for the different age groups, degree of practice experience and typology of skiing for the three questions described above. Significant differences were found with regard to climate change already affecting the Pyrenees in a global way. People with short experience of skiing (0–5 years) believed that climate change affects the Pyrenees in a general way, while more experienced skiers (>20 years of practice) showed in the three questions that climate change affects the Pyrenees less or it does not affect them at all, with a great difference and a large number of respondents who say it does not affect anything, nor will it affect anything in the future. The post-hoc significance of ANOVA test showed differences between means of the two groups ($F=2.831$, p-value=0.039). There also exist differences between different typologies of skiing ($F=5.46$): while alpine skiers thought that climate change only affects "probably" in the Pyrenees, snowboarders (p-value=0.004) and mountain skiers (p-value=0.044) mostly thought that climate change has a substantial effect on the Pyrenees. Although the perception of climate change was not significant in terms of age, it was observed that skiers in the age groups of 18 to 45 years mostly believed that climate change affects the Pyrenees considerably, while older people mostly selected the option of only affects "probably".

Respondents who thought "almost sure" o "probably" that climate change will affect skiing were questioned

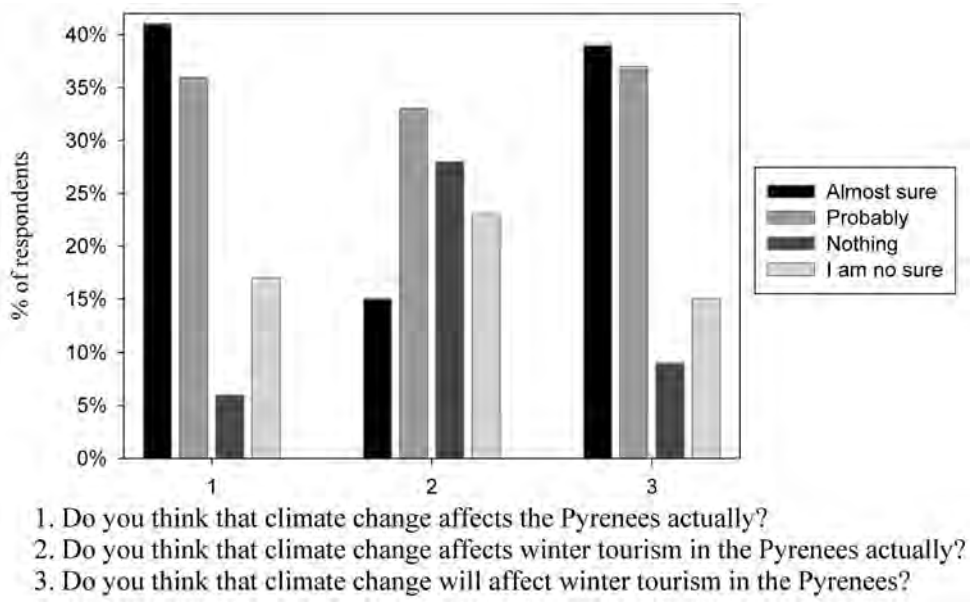

Figure 5. Perception of skiers on the condition of climate change in the Pyrenees.
Figura 5. Percepción de los esquiadores sobre la situación del cambio climático en el Pirineo.

about what weather and nivological conditions (Figure 6) they think will be most affected, scoring them from 1 to 5 (Q15). Temperature received an average score of 4.0 points, followed by the amount of snow (3.9), snow quality (3.6), snowfall (3.6), rainfall (3.5) and windy days (2.5).

The second part of this section explored adaptation measures adopted by the skiers for future bad snow conditions. To this end, different responses to adaptation measures were explored, such as how to replace the ski destination, the price of the pass or to shift to new activities. A total of 66% of respondents stressed their willingness to travel to farther ski destinations with better snow conditions. Only 36% of respondents would accept paying for a more expensive ski pass in order to compensate

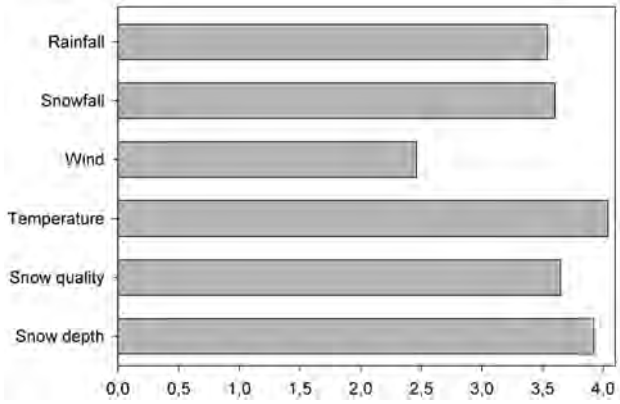

Figure 6. Scores about what weather and snow conditions will be more affected by climate change.
Figura 6. Valoración sobre qué condiciones meteorológicas y de nieve se verán más afectadas por el cambio climático.

the losses in the ski industry facing shorter ski seasons and the price of the increasing snowmaking expenses. Finally, they were asked what mountain activity they would do if they could not ski. The questionnaire gave the choice of multiple answers. The responses were n=64 affirmed that they would hike, n=35 would switch to mountain cycling, n=28 alpinism, n=26 climbing, n=22 snowshoeing, n=19 trekking, n=11 canyoning, n=10 trail running and n=6 snowsled.

4. Discussion and conclusions

This study aimed to deepen the attitude of skiers regarding snow and weather conditions, and about how climate change is affecting and will affect them. For this purpose, we used a novel mixed system approach of combining online and *in-situ* collection of surveys. The surveys were designed following previous studies (referenced in the Introduction) so that the results are highly comparable with other geographic areas. Despite the survey being distributed randomly, the final structure of the respondents exhibited a clear gender imbalance (80.5% males vs. 19.5% females). This contrasts surprisingly with the studies by Vivian (2011), Dawson *et al.* (2013) and Rutty *et al.* (2015), where most respondents turned out to be women. This could be explained because online surveys were provided in alpine and ski clubs in Spain, in which there is a very strong masculine composition. In addition, a recent study for all Spanish ski resorts carried out by ATUDEM, indicates that the majority profile of skiers is men between 35 and 45 years old (ATUDEM, 2019).

The dominant age group was from 26 to 54 years old (35.4 average); they were mostly experienced (or not)

skiers who practice skiing frequently (average 13 days per season), but do not have (80.5%) an annual ski pass. Most studies that analyze climate change and ski tourism focus on the thickness of snow or the possibility of making artificial snow as the key element for success in a season. However, as already stated in other studies, such as Gilaberte *et al.* (*under review*), rain or wind are decisive factors to reduce skiing attendance. In this study, respondents showed that rain, wind or poor visibility exceeds snow conditions in importance. The anticyclonic days, without excessive wind, were the ones with the greatest attendance, even if the snow cover did not present optimal conditions. In some ski stations the influx on sunny days was double or triple than on rainy days (during weekends), however these differences were smaller during the week. This result coincides with Scott *et al.* (2008b), Steiger *et al.,* (2015) and Vivian (2011), (who reported that the absence of rain, wind and good visibility were the most featured elements in skier preferences in Canada).

A total of 91% of respondents have recently suffered a year with poor snow conditions. Under such conditions, the majority (49%) continued attending the same ski destination but reduced the number of ski days in the ski season. Many respondents (21%) reported that they continued to ski as usual even though the snow conditions were bad. It is unrealistic to assume that all skiers will react the same to marginal snow conditions and a changing ski sector (Dawson & Scott, 2013). Some studies reviewed make distinctions between beginner and experienced skiers. According to some studies as Cocolas *et al.* (2016) for the winter tourism in Australia, expert skiers are disproportionately more likely to continue skiing despite poor snow conditions compared to beginners and occasional skiers. However, König, (1998) also for the Australian Alps differ in the last affirmation and show that experience skiers are more sensitive to the bad snow conditions. This goes in accordance with other studies as (Behringer *et al.,* 2000; Dawson *et al.* (2011) in Swiss Alpes and Dawson *et al.* (2013) in U.S. Northeast. In those works, the self-rated expert skiers indicated that they were more likely to exhibit substitution behaviour (activity, spatial and temporal) in comparison to intermediate- and beginner-level skiers – both currently and in prevision of future impacts of climate change. Steiger *et al.,* (2015) (for the Austrian and Italian Alps) found a highly significant negative relationship between skiing skills and the rating of all weather variables, meaning that beginners are more likely to not go skiing in case of unfavorable weather compared to intermediate and expert skiers. Although our study does not explicitly refer to any question of skiing proficiency, if the response is analysed according to the number of times a respondent went skiing in a season, it may result in more experienced skiers being the most likely to stop skiing in poor snow conditions, as in these cited studies.

As for the perception of skiers about climate change, 48% of respondents thought that climate change is almost sure to be already affecting skiing in the Pyrenees, while 76% think that it will be affected in the future. We found differences in the perception of climate change between the different age groups and consequently those that take more or less time practicing the sport. The meteorological factors that the skiers think will be most affected are the air temperature and the thickness of snowpack. The literature shows that one of the most frequent behaviors of skiers in the face of climate change is adaptive responses (Pickering *et al.,* 2010; Scott *et al.,* 2007). To more fully understand climate-induced behaviour change among alpine skiers, it is useful to draw upon Iso-Ahola's (1986) theory of recreation substitution. The theory of substitutability suggests that when individuals are no longer able to participate in an activity (e.g. due to poor snow conditions or the closure of local ski areas), they may substitute that activity with another (activity substitution), change the timing/intensity with which they participate (temporal substitution) or alter the location of practice (spatial substitution) (Dawson *et al.,* 2013).

Our results also show the adaptive behaviour of skiers, both in terms of movement, frequency of activity and substitution of skiing with other mountain activities. It is also interesting to note that the majority of the skiers are not, in principle, amenable to paying for more expensive ski passes to face the likely economic impacts derived from the increased expense of snowmaking and the maintenance of ski resorts for shorter ski seasons. In this sense, the most demanded activities were hiking, mountain biking and climbing, when it is not possible to ski.

The study of the impact of climate change from the point of view of demand has been less studied; however, it is fundamental to know the behaviour of tourists and the vulnerability of the ski sector to climate change. These types of approaches can also serve as useful tools for station managers or regional planners. The results of our survey are consistent with previous studies carried for the Alps, Australian Alps and Northem US mainly (Behringer *et al.,* 2000; Dawson *et al.,* 2011, 2013; König, 1998; Pickering *et al.,* 2010; Unbehaun *et al.,* 2008; Vivian, 2011). In the sense that we have seen that weather and climate are extremely important for skiers, and estimations based only on snow availability results are very limited (Rutty & Andrey, 2014). The different perceptions of the issue by the local population could indicate the best strategy for implementation of different adaptation and mitigation by the different stakeholders and levels of government involved. Despite more analysis being needed to apply to larger samples of respondents and other mountainous areas of Spain. Our results clearly point to the need for diversification of touristic activities around ski areas, aiming to reduce the seasonality on the tourist demand, and to increase the flexibility of ski resorts to offer different touristic products depending on the specific weather and snow conditions.

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