

# What drives flushing distance? Understanding human disturbance of alpine chamois in Tyrol, Austria.

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# 1 Abstract / Zusammenfassung / Riassunto

**English:** Over the summer of 2018, one hundred herds of alpine chamois (*Rupicapra rupicapra rupicapra*) in Karwendel and Pitztal were approached by the researcher in order to understand their behaviour when disturbed. Both study areas are subject to large quantities of hiking tourists in the summer months. A GIS model built by the Tyrolean Forest Service was used to categorise herds by the level of recreational pressure that they experience in the areas they were found. Herd flushing distance was a useful measurement for understanding animal timidness, and was found to be 124m on average. It was rare for animals to produce running escape responses, as sight lines were maintained throughout the approaches. Linear regression modelling revealed that the main drivers of flushing distance were recreational pressure, location, and the distance a hiker is from the trail. There was a negative relationship between recreational pressure and flushing distance, and a positive relationship between the hiker distance from the trail and flushing distance. Herds in Pitztal were found to flush at greater distances than those in Karwendel. Chamois were concluded to be least disturbed by hikers who behave predictably and stay on trail. Management recommendations to limit the disturbance of chamois herds are given.

**Deutsch:** Im Sommer 2018 wurden einhundert Herden Gämse (*Rupicapra rupicapra rupicapra*) im Karwendel und Pitztal von dem Forscher beobachtet, um ihr Verhalten bei Störungen zu verstehen. Beide Untersuchungsgebiete sind in den Sommermonaten sehr stark von Wandertouristen frequentiert. Mit Hilfe eines GIS-Modells der Tiroler Forstverwaltung wurden die Herden aufgrund des Erholungsdrucks, welchen sie in den gefunden Gebieten erfahren, kategorisiert. Die Fluchtdistanz war ein nützliches Maß um die Schüchternheit von Tieren zu erforschen und wurde mit durchschnittlich 124 m festgestellt. Es war selten, dass Tiere laufende Fluchtreaktionen hervorriefen, da die Sichtlinie während der gesamten Annäherung beibehalten wurde. Lineare Regressionsmodelle ergaben, dass die Haupttreiber der Fluchtdistanz der Erholungsdruck, die Lage sowie die Entfernung eines Wanderers vom Weg waren. Es gab einen negativen Zusammenhang zwischen Erholungsdruck und Fluchtdistanz, und einen positiven Zusammenhang zwischen dem Abstand des Wanderers vom Weg und der Fluchtdistanz. Im Pitztal fliehen Herden bei größeren Entfernungen als im Karwendel. Es wurde festgestellt, dass Gämse am wenigsten von Wanderern gestört werden, die sich vorhersehbar verhalten und auf Wegen bleiben. Zuletzt werden Managementempfehlungen gegeben, um die Störung von Gämsherden einzuschränken.

**Italiano:** Nell'estate del 2018 cento mandrie di camosci alpini (*Rupicapra rupicapra rupicapra*) a Karwendel e Pitztal sono state avvicinate dal ricercatore per capire il loro comportamento in caso di disturbi. Entrambe le aree di ricerca sono soggette a grandi quantità di turisti ed escursionisti nei mesi estivi. Un modello GIS costruito dal servizio forestale tirolese è stato utilizzato per classificare le mandrie in base al livello di pressione ricreativa che subiscono nelle aree in cui sono state trovate. La distanza di fuga delle mandrie è stata una misura significativa per capire la timidezza degli animali ed è stata in media di 124m. Era raro che gli animali producessero reazioni di fuga in corsa dato che le linee di vista sono state mantenute per tutti gli avvicinamenti. La modellazione della regressione lineare ha rivelato che i motivi principali della distanza di fuga erano la pressione ricreativa, la posizione e la distanza dell'escursionista dal sentiero. C'era una relazione negativa tra la pressione ricreativa e la distanza di fuga e una relazione positiva tra la distanza dell'escursionista dal sentiero e la distanza di fuga. Mandrie in Pitztal sono stati trovati a fuggire a distanze maggiori di quelle in Karwendel. È stato notato che camosci si sono sentiti meno disturbati da escursionisti che si comportano prevedibilmente e rimangono sul sentiero. Raccomandazioni per la gestione di limitare il disturbo dei camosci vengono date.

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## 2 Introduction

Chamois (*Rupicapra rupicapra*) are a species of goat-antelope native to the European Alps, the Pyrenees, the Carpathians, the Tatra Mountains, the Balkans, parts of Turkey, the Caucasus, and the Apennines. The subspecies in this study, the alpine chamois (*Rupicapra rupicapra rupicapra*) is widely spread along the European Alps and additionally, was introduced to the South Island of New Zealand in the early 20<sup>th</sup> century (Forsyth, 2005).

In Europe, humanity has infringed on the habitat of chamois for the past 3000 years (Strassburger et al., 1978). Settlers cleared forest for agriculture and livestock, harvested timber, and started mineral extraction. Organised hunting of chamois in the Austrian state of Tyrol has been taking place for the last 400 years, while the predatory species of the lynx (*Lynx lynx*) and the wolf (*Canis lupus*) were exterminated in the region by the late 1800's. The current habitat of chamois is an alpine landscape shaped by humanity's influence. Urban settlements and transport infrastructure fill the valley bottoms, maintained forests cover the hillsides, while above the tree-line much of the land has been co-opted into summer pasture for domestic cows, goats, and sheep. Hunted populations of other game animals are maintained in these same landscapes, including red deer (*Cervus elaphus*), mouflon (*Ovis orientalis musimon*), and ibex (*Capra ibex*).

The increasing pressure of mass tourism has had a harmful effect on some populations of chamois, as herds and subspecies often have restricted ranges and are thus sensitive to environmental change (Peřsa and Ciach, 2015). In the European Alps profitable investment in tourism infrastructure puts pressure on the landscape's carrying capacity (Barker, 1982). The high concentration of tourists, their behaviour, as well as tourism infrastructure, can all result in negative impacts on the habitat, from which protected areas are not exempt (Gössling, 2002; Zaręba, 2008; Peřsa and Ciach, 2015). Alpine landscapes are seen by many urban inhabitants as places for recreation. Subsequently hikers, mountain bikers, and skiers, regularly transit through chamois habitat. These human activities create disturbances which are overlaid on top of natural disturbances (Pépin et al., 1996).

The sensitivity of wild animals to human disturbance is a result of a variety of aspects including experience, social status, habitat, and type of disturbance (Pépin et al., 1996). The reaction of hunted chamois populations has been found to be higher than those that are not hunted (Douglas, 1971). Chamois behaviour has been found at times to be much more influenced by human disturbance than by the rare risk of predation (Pépin et al., 1996). An increase in tourist numbers in chamois habitat has been shown to decrease herd size and increase the avoidance distance from mountain transport infrastructure (Peřsa and Ciach, 2015). It has been found that chamois near hiking trails move more frequently, are more vigilant, and feed and rest less often than others (Lamerenx et al., 1992). Pépin et al. (1996) states that trails result in unequal use of pasture. Therefore, species make compromises between resource efficiency and risk of disturbance (Pépin et al., 1996).

Hamr (1988) conducted research in Karwendel Nature Park and concluded that chamois become accustomed to human disturbance, when people remain predictable spatially and temporarily. Other studies within Western Europe have found the same result (Cederna and Lovari, 1985; Lamerenx et al., 1992; Patterson, 1988). Interestingly, disturbance by hikers, joggers, and mountain bikers have been found to be equal, all resulting in the same amount of impact on habitat use (Gander and Ingold, 1997). Existing literature shows that flushing distances are variable. In an area of Italy where chamois are rarely disturbed, the flushing distance can be as little as 25-30m (Cederna and Lovari, 1983). In



Figure 1: *Two chamois in Karwendel Nature Park. Photo credit: Colin Ronald.*

popular tourist areas in the Czech Republic, chamois can be approached to under 50m (Briedermann, 1976), while in Switzerland's similarly popular areas, flushing distances range from 20m to ten times that distance (Pachlatko, 1980). From the personal experience of the researcher, chamois in the states of Tyrol and South Tyrol can flush at distances from as little as 15m to distances far exceeding 400m.

Understanding the impact of human disturbance on wildlife across a variety of scales is essential for conservation management (Pépin et al., 1996). Now, 30 years after Hamr's similar research in the Karwendel, this study seeks to understand why the flushing distances of chamois can vary so drastically.

## 2.1 Aims of the Study

The aim of this study is to lend further understanding to the interactions between alpine chamois and human users of alpine landscapes. In particular, the study seeks to investigate the drivers of chamois disturbance, using measures of hiker tolerance as a proxy.

The following hypotheses are put forward:

1. Chamois herds which are regularly disturbed by people are less timid than those herds which are seldom disturbed.
2. Chamois herds which experience higher hunting pressure are more timid than those herds experiencing low hunting pressure.
3. Chamois herds are less disturbed by people walking on trails or near trails than those walking off trail.
4. Chamois herds in the Pitztal are more timid than those in the Karwendel (based on anecdotal evidence from the hunting community)

The following predictions are made, with the numbers referring to the respective hypotheses:

1. There will be a negative relationship between recreation pressure and flushing distance.
2. There will be a positive relationship between hunting pressure and flushing distance.
3. There will be a positive relationship between the researcher's distance from the trail and the flushing distance.
4. Flushing distances will be higher for herds in Pitztal than those herds in the Karwendel.

## 3 Methods

### 3.1 Study Area

All data was collected in Karwendel Nature Park and the Pitztal II Hunting Area in the Austrian state of Tyrol (Figure 3). The Karwendel has a history of tourism going back 150 years, and hosts around 1 million visitors annually (Nature Park Karwendel, 2018). The park covers an area of 727 km<sup>2</sup> (920 km<sup>2</sup> when the adjoining German portion is included) and is the largest nature park in Austria. It was founded in 1928 and covers elevations from 600m in the valley floors up to 2749m at the peak of Birkarspitze. Currently alpine meadows constitute around 10,000 ha of land area across 100 alms, with 7400 cattle spending their summer on these pastures (Nature Park Karwendel, 2018). Over the previous centuries the typical uses of this alpine landscape have been extensive pastoral agriculture, forestry, mining, alpine recreation, and hunting. Karwendel Nature Park includes areas protected by the Natura 2000 directive (Nature Park Karwendel, 2018).

There are five major entrances to the park, which are used by hikers, mountain bikers, skiers, and day tourists. There is a forest road taxi service from the village of Scharnitz, and some hunters use private vehicles on forest roads to access hunting stands. There is one permanent settlement within the park, Hinterriß, with road access solely from Germany in the north. One of the most common ways recreationalists approach the nature park is by using the Nordkettenbahn, consisting of a funicular railway and two cable cars. This tourism infrastructure transports people rapidly from central Innsbruck up to the margins of the park at 2300m within 25 minutes. The city itself has a population of 130,000 residents with 2.57 million overnight stays by tourists per year (Innsbruck Tourismus, 2018).

The Pitztal II study area is 40 km distant from the Karwendel. It has a local population of 7500 people, with visitors to the valley making 1.3 million overnight stays each year (Amt der Tiroler Landesregierung, 2018). These tourists are attracted throughout the year by recreational pursuits including hiking, mountain biking, ski touring, and hunting. The area, like Innsbruck adjoining the Karwendel, is most famous for winter tourism and has a number of ski resorts in the area. At the head of the valley is Kaunergrat Nature Park, covering 59,000 hectares of land from 750 to 3,768m in elevation. Although the study itself was not done within the nature park, the hunting area where the study was conducted does directly and seamlessly border the nature park. The alpine areas of the Pitztal valley face many recreational pressures similar to the Karwendel, despite being located an hours drive away from a large city.

Due to limitations of study method and tracking equipment, only groups of chamois located in open areas were studied. With the tree line in the region of study sitting between 1800 and 2000 metres, much of the data was collected at attitudes of 1900 to 2400 metres, in alpine grassland which would occasionally be intermingled with dwarf pine (*Pinus mugo*). In some instances data was collected at lower elevations, if the vegetation had been cleared due to anthropogenic activities.

### 3.2 Data Collection Method

Hiking trails and forest roads within the study area were hiked by the researcher over 13 days in the months of June, July, and August of 2018. Data was collected in daylight hours, with the earliest



Figure 2: *The author approaching a chamois in Karwendel Nature Park. Photo credit: Colin Ronald.*



Figure 3: Karwendel Nature Park (top right) and Pitztal II hunting area (bottom left) are the locations where the study was conducted. Both of these areas are in the Austrian state of Tyrol. The north side of Karwendel Nature Park is bordered by the German state of Bavaria.

observation at 06:00 and the latest at 21:15. Herds of alpine chamois above the tree-line were located using a combination of the naked eye and 10x42 binoculars. At a suitable location with good view lines and limited disturbance of the animals, the following data was collected:

- Location
- Number of animals in the herd
- Number of kids in the herd
- Time and date
- Weather conditions
- Trail type. These were categorised as; Route (an unformed track marked on the map, which has been created as a result of continued footfall by hikers and possibly game animals), Track (a constructed track marked on the map, which is maintained for hikers), 4WD Track (a constructed track with a gravel base wide enough for vehicles, marked on the map and intended for use by authorised road vehicles).

The researcher then proceeded along the trail until they were at the point where the trail was closest to the nearest animal in the herd. They would then walk directly towards the nearest animal in order to produce a fright response. Efforts were made to stay within sight of the animals so as not to surprise the target. In this way the method sought to give the animal good awareness of the researcher and let it make a choice about how close they permitted the researcher to approach. Data requiring distances and angles were measured using Swarovski EL Range 10x42 binoculars with integrated inclinometer and laser range finder (accuracy  $\pm 1\text{m}$ ). Data collected during this approach included the following:

- Animal position (up-slope, level, or down-slope from observer)
- Slope angle of the terrain the animal is located upon
- Type of terrain (scree slope, bluffs, grass, etc.)
- The presence of other people, domestic animals, or game animals. This was assessed by considering whether they were within the same cirque as the chamois herd, at a distance of less than 400m, or whether the sounds of these other animals could easily be heard.
- The behavioural state of the animal nearest the researcher
- Distance to refuge (distance between where the animal was when it responded to the observer, and the nearest obvious refuge. E.g. a steep rocky outcrop)
- Constant alert distance (the distance between the researcher and the target animal, where that animal maintains an alert stance, before producing a flushing response)
- Flushing distance (the distance from the researcher to the animal at the point when the escape response was triggered)
- Flushing angle (used to calculate the difference in elevation between the researcher and the animal)
- Escape distance (distance travelled by an animal moving away from the researcher)
- Maintained distance (the distance from the researcher that the animal will maintain once it has produced an escape response)
- Distance from trail (distance the observer has walked off the trail in order to produce the fright response)

### 3.3 The Recreation Pressure Model

The Forest Service of the Tyrolean Government developed a recreational use model as there was no existing data on the frequency of use of recreational infrastructure. The model used existing data from a variety of sources and takes into account the following:

- Population centres
- Summer and winter tourism numbers
- Walking and hiking trails
- Gradient of trails
- Sunshine exposure on trails
- Cycling trails
- Ski pistes
- Ski tour routes
- Cross-country ski routes
- Tyrolean luge runs
- Climbing areas
- Lakes
- Tourist accommodation and alpine huts
- Landscape project areas

- Sports venues
- Tourist attractions and places of interest

The geographical information system (GIS) programme ArcMap was used throughout the modelling process. Population and tourism data were developed into a map of population centres sufficiently large enough to impact on recreation. Recreational routes (hiking, cycling, skiing etc.) were assessed for proximity to population centres, sun exposure, and gradient (although only up to 1800m to account for the relatively low gradient of high alpine valleys, cirques, and glacial basins). Recreational facilities were then introduced to the model.

Population centres, routes, and facilities were given a point score and a buffer based on their relative contribution to recreational intensity. For example, ski piste were given a score of 4 and a buffer of 40m, while a place of interest was given a score of 1 and a buffer of 50m. All these scores and buffers were summed and merged, eventually resulting in a raster grid (25m<sup>2</sup>) map of recreational use values. These raster values were summarised based on the sum of the adjacent cells, giving area wide relationships reflecting the recreational infrastructure present. Individual raster cells varied in value from 0 to 1032, and classified into very low (<72), low (72 to 140), medium (140 to 230), and high (>230) recreational use (Figure 4). The model covers the whole state of Tyrol.

### 3.4 Mapping and Assignment of Recreational Attributes

On top of the recreational use map the location of experimental approaches of chamois herds were plotted into ArcMap, with each location given a 400 metre buffer. This 400m buffer was chosen to represent the sphere of disturbance around an animal – the chamois tended to first become aware of the researchers at a distance of 400m, given good sight lines. The buffer also allowed the points on the map to intersect with the various recreation values assigned by the recreation pressure model, as trail influence in the model extends out to just 40m. Without the buffer, almost all the points would have been in the ‘very low’ recreational pressure category (see Figure 4). On the map the intersection of the buffer and the recreational pressure were noted, and using the highest recreational category encountered by the buffer, the individual data point was given a recreational pressure category.

Additionally, an analysis of the proportion of each recreational value within each 400m buffer was conducted using ArcMap. The minimum value possible was 0 and the highest was 100. For example, a buffer with an area comprised of 25% very low, 25% low, and 50% medium would be given a recreation value of 42 ( $(0*25+1*25+2*50)/3$ ).

### 3.5 Linear Modelling

Linear regression analysis was used to control for the confounding effects of the explanatory variables associated with the flushing distance behavioural response of chamois herds. Initially a multiple linear regression using backward stepwise elimination was used. Secondly, an automatic LINEAR regression was developed as described in the paper "The Case for Being Automatic: Introducing the Automatic Linear Modelling (LINEAR) Procedure in SPSS Statistics" (Yang, 2013). Both of these models were constructed in SPSS Statistics.

In developing both linear models, the following variables were used:

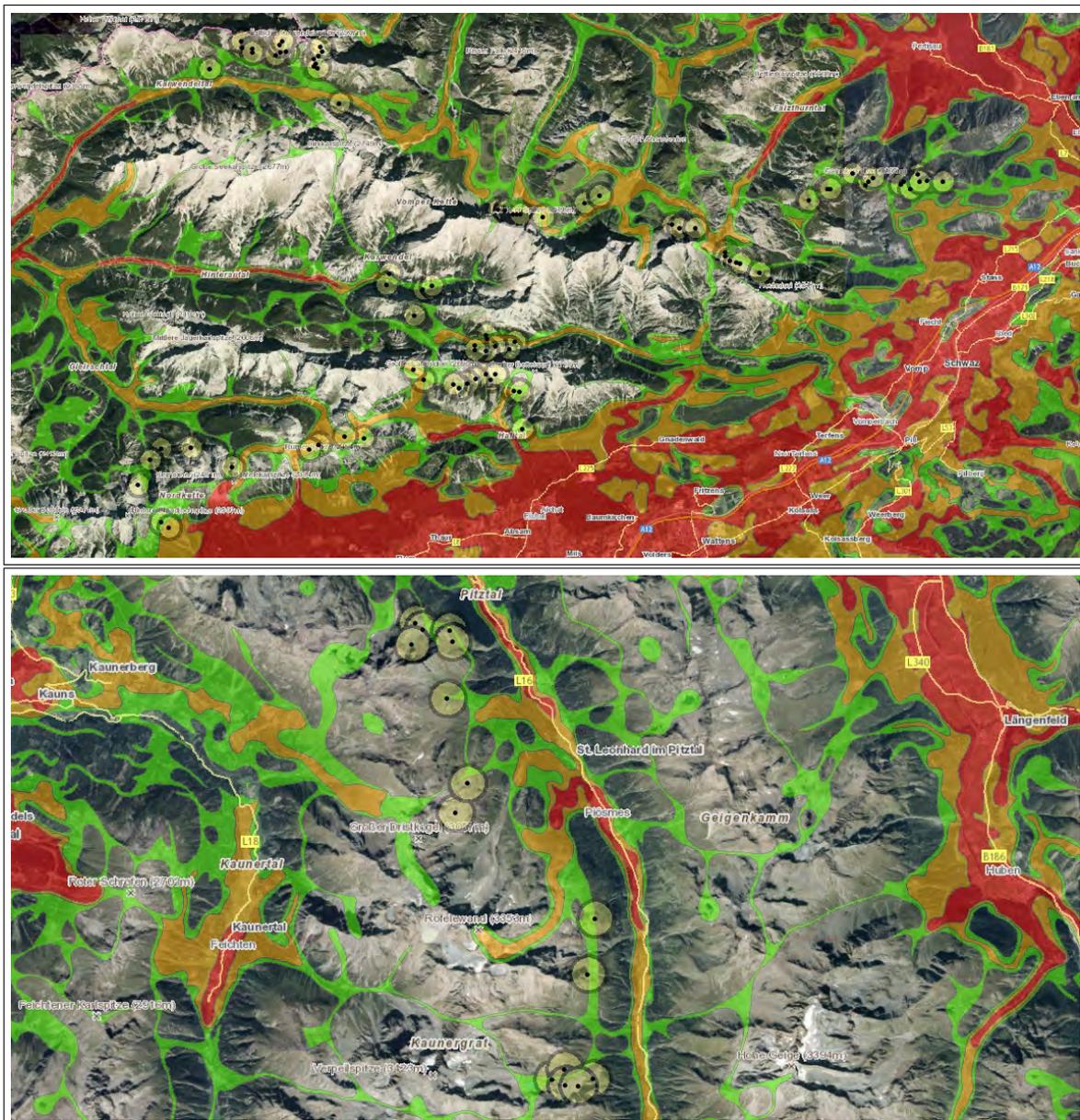


Figure 4: Map of the chamois herds experimented upon in the Karwendel Nature Park (above) and Pitztal II Hunting Area (below). Each herd (black point) has a 400 metre circular buffer. Recreation intensity according to the Forest Group of the Tyrolean Regional Government is indicated by the colours red (high), orange (medium), and green (low). Areas without a colour are experiencing very low recreational intensity.

- Time of day
- Weather conditions
- Slope angle
- Location
- Recreational pressure value - as used in the manual backward stepwise elimination multiple regression model.
- Recreational pressure category - as used in the LINEAR model.
- Hunting pressure - both as the percentage of animals of a population harvested per year, and as the number of animals harvested per hectare per year
- Terrain type
- Trail type
- The presence of domestic animals
- The presence of game animals
- Number of chamois in the herd
- Number of chamois kids in the herd - both as a number as well as a presence/absence variable
- Animal elevation in relation to observer
- Observer distance from trail
- Distance to an escape refuge

The following variables were excluded from use on the model calculations:

- Hunting areas - herds were often assessed when they were on the margins of the hunting areas (see figure 5), and hunting pressures are already included elsewhere in the model.
- Elevation difference - this was excluded because it is calculated based on trigonometrical principals which include flushing distance in the equation. These principals also result in implausible interactions between the variables when extrapolated, especially when the researcher is above the animal.
- The presence of recreationalists - this variable changes momentarily, was difficult to evaluate in the field, and is not useful for modelling when in the lab.
- State of animal - as above.
- Constant alert distance - this variable has a direct linear relationship to the dependent variable and is not useful for modelling when in the lab.
- Escape distance - as above
- Maintained distance - as above

Missing values are replaced with the series mean and outliers greater than three standard deviations from the mean were removed. Variables used were assessed for being continuous or categorical. Linearity between dependent and independent variables was checked with scatter-plots, and residuals were examined for normality. Multicollinearity was tested by assessing for bivariate correlations (>0.8) and the variance inflation factor (>10). A test for homoscedasticity was conducted using plots of predicted values and standardised residuals.

### **3.6 Hunting Data**

Hunting pressure data was provided by the Tyrolean Regional Government. Taking the mean of the years 2015 to 2018; the percentage of animals in a population shot per year, and the number of animals shot per hectare per year, was calculated for each hunting area. The seven hunting areas were then ranked for hunting pressure, for both percentage of population shot per year and the number of animals shot per hectare per year (Figure 5). The difference of means of flushing distances between the hunting areas was tested using the Independent Samples Kruskal-Wallis Test.

### **3.7 Testing for Differences**

The Independent Samples Kruskal-Wallis Test and box plots were used to test for differences of mean of flushing distance for categorical data. This included tests on recreational pressure, location (Karwendel vs Pitztal), sunlight (bright, shadow), temperature (low, medium, high), trail type (4WD, track, route), terrain type (scree, bluffs, rock etc.), the presence of domestic animals, the presence of other game animals, and the animal's elevation relative to the researcher. Relationships between continuous variables were assessed using a bivariate Pearson correlation and scatter-plots.



Figure 5: Maps of the hunting areas included in the study. The location of the chamois herds encountered are indicated with points. Top: Hunting areas of the Karwendel Nature Park. Bottom: The hunting area Pitztal II.

## 4 Results

### 4.1 Approaches on Herds

When approaching herds, the mean distance the researcher was off-trail was 144m (median 70, min 0, max 572), while the mean distance the animal was from the trail was 267m (median 196, min 30, max 867).

The average constant alert distance was 176m (median 176, min 33, max 484). The average flushing distance was 124m (median 120, min 15, max 367), and the mean escape distance was 50m (median 17, min 2, max 602). When approached with good sight lines (therefore no surprise close range threat was encountered by the animal), it was rare for animals to produce a running escape response. They tended to walk a few paces away as the researcher approached. This distance maintained from the researcher was 147m on average (median 138, mini 30, max 880).

It was discovered that the flushing distance was a good predictor of the other timidness values of constant alert distance and maintained distance (Figure 6). As a result of this, the statistical analysis focused on the flushing distance for the remainder of the study, with this factor acting as a proxy for the other timidness measurements.

### 4.2 Stepwise Regression Model

Initially a multiple linear regression using backward stepwise elimination was constructed, in order to control for the confounding effects of the explanatory variables associated with flushing distance behaviour. The model was calculated to predict *flushing distance* based on the *recreational pressure value*, the *location*, and the *distance of the observer from the trail*. A significant regression equation was found ( $F(3,96) = 14.798$ ,  $p < 0.000$ ), with an  $R^2$  of 0.316. Chamois herds predicted *flushing distance* is equal to  $112.312 - 1.167(\text{recreational pressure value}) + 44.011(\text{location}) + 0.144(\text{observer distance from trail})$ , where the *recreational pressure value* was calculated as a proportion of the 400m buffer around each herd (as described earlier), where *location* is coded as 0 = Karwendel, 1 = Pitztal, and where the *observer distance from trail* is measured in metres.

Flushing distance decreased 1.2 metres for each *recreational pressure value*, increased 44 metres for the *location* numeric, and increased 0.14 metres for each metre increase of the *observer distance from the trail*. *Recreational pressure value*, *location*, and *observer distance from trail* were all significant predictors of *flushing distance* (0.017, 0.008, and 0.000 respectively).

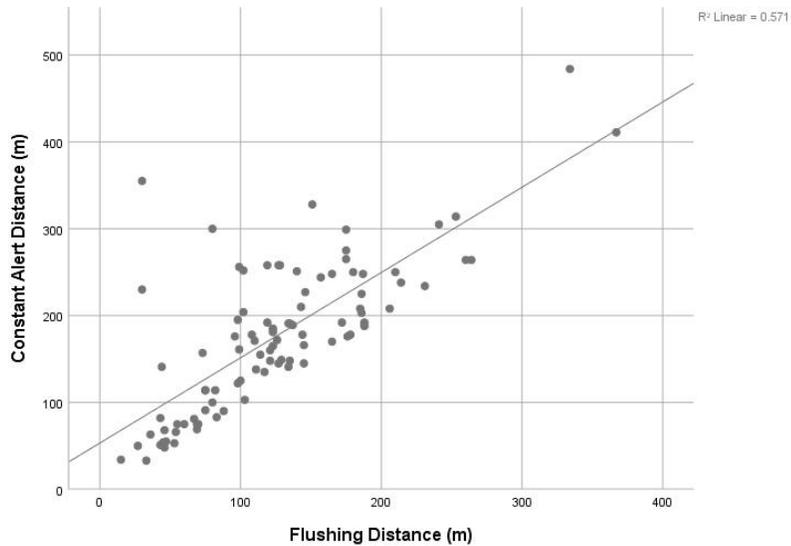
#### Worked example:

*recreational pressure value* = 13.41 (the mean value)

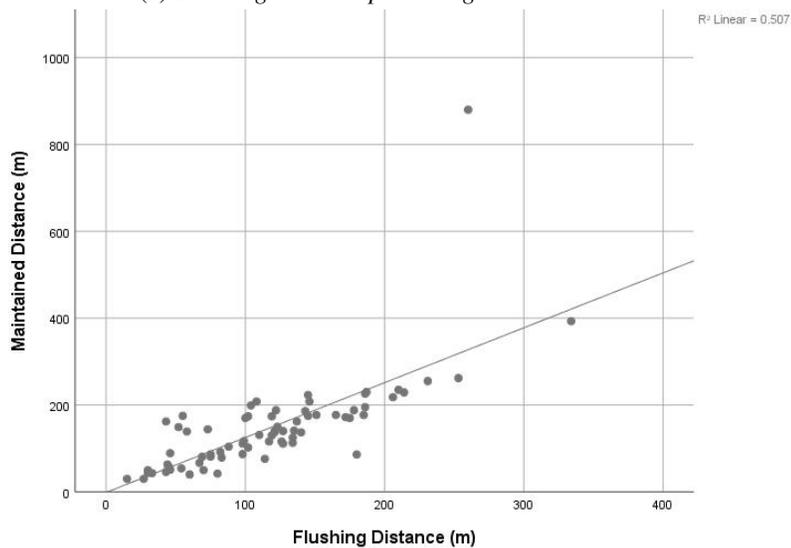
*location* = Karwendel

*observer distance from trail* = 143.53 (the mean value)

*flushing distance* =  $112.312 - 1.167(\text{recreational pressure value}) + 44.011(\text{location}) + 0.144(\text{observer distance from trail})$



(a) Flushing distance plotted against constant alert distance.



(b) Flushing distance plotted against maintained distance.

Figure 6: Flushing distance has a linear relationship with both constant alert distance and maintained distance. Therefore, for much of the statistical analysis, flushing distance is used as a proxy for the other measures of 'timidness'.

$$\begin{aligned} \text{flushing distance} &= 112.312 - 1.167(13.41) + 44.011(0) + 0.144(143.53) \\ \text{flushing distance} &= 117.33085 = 117 \text{ metres} \end{aligned}$$

It is important to note that this model uses the *recreational pressure value* variable rather than the *recreational pressure category* variable.

### 4.3 Automatic Linear Modelling (LINEAR)

In addition to the first model, an automatic linear model served to re-evaluate and confirm the results of the initial manual model. In this particular study, the automatic LINEAR process produced the same model whether a *forward stepwise* regression using the corrected Akaike information criterion (AICc) was used, or if a *best subsets* selection method was used for selecting variables (see Yang 2013).

The LINEAR regression was calculated to predict *flushing distance* based on the *recreational pressure category*, the *location*, and the *distance of the observer from the trail*. A significant regression equation was found ( $F(4,95) = 15.640$ ,  $p < 0.000$ ), with an  $R^2$  of 0.372. Predicted *flushing distance* is equal to  $219.442 + \text{RCC} + \text{LC} + 0.103 * (\text{observer distance from trail})$ ; where RCC and LC are defined in table 1 and both *flushing distance* and *observer distance from trail* are measured in metres.

Flushing distance decreased by 100m (high and medium categories) or by 72m (low category) compared to the very low *recreational use category*. The flushing distance was further decreased by 42 metres when the *location* was Karwendel, and increased by 0.1m for each metre increase of the *observer distance from the trail*.

#### Worked example:

*recreational pressure category* = low (the most frequent category)

*location* = Karwendel

*observer distance from trail* = 143.53 (the mean value)

$$\text{flushing distance} = 219.442 + \text{RCC} + \text{LC} + 0.103 * (\text{observer distance from trail})$$

$$\text{flushing distance} = 219.442 + (-72.897) + (-41.696) + 0.103 * (143.53)$$

$$\text{flushing distance} = 119.63259 = 120 \text{ metres.}$$

This result is just 3 metres different than the stepwise backward elimination model.

The relative importance of each variable is given as: *recreation category* (0.58), *location* (0.22), *observer distance from trail* (0.20). The statistical significance of each component of the model are: *intercept* ( $< 0.000$ ), *recreation category* ( $< 0.002$ ), *location* ( $< 0.008$ ), *observer distance from trail* ( $< 0.010$ ).

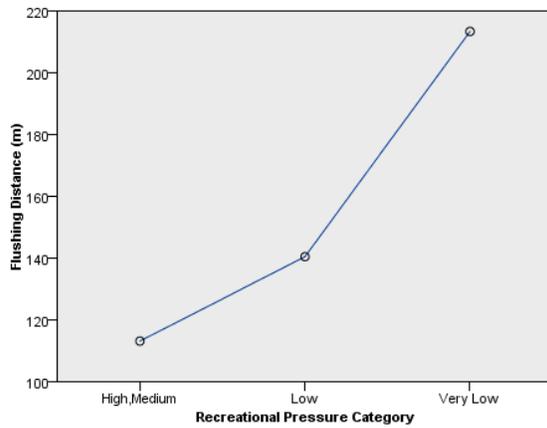
Linearity between dependent and independent variables were checked with scatter-plots and modelled as described in figure 7. Residuals were approximately normal, and predicted values were close to those observed (Figure 8).

### 4.4 Flushing Distance Variation

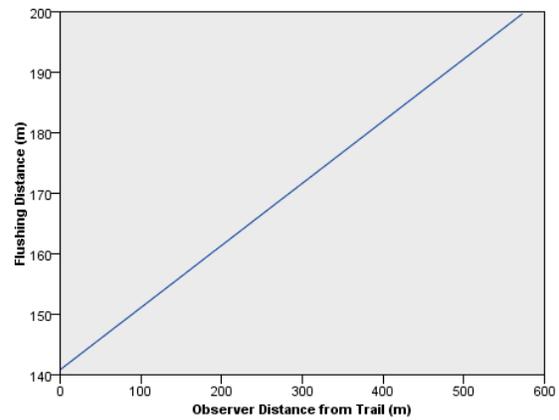
Karwendel Nature Park had a statistically significantly (0.008) flushing distance of 55m less than the herds in Pitztal (Figure 9).

Parameter	Description	Coefficient Value
Recreational Category Coefficient (RCC)	High or Medium	-100.208
	Low	-72.897
	Very Low	0
Location Coefficient (LC)	Karwendel	-41.696
	Pitztal	0

Table 1: *The coefficients necessary for the automatic linear modelling equation.*



(a) Grouped categories were used by the LINEAR model when modelling flushing distance from recreation pressure categories.



(b) The LINEAR model used observer distance from the trail to model flushing distance.

Figure 7: *Modelled relationships of two of the three variables used to model chamois herd flushing distance.*

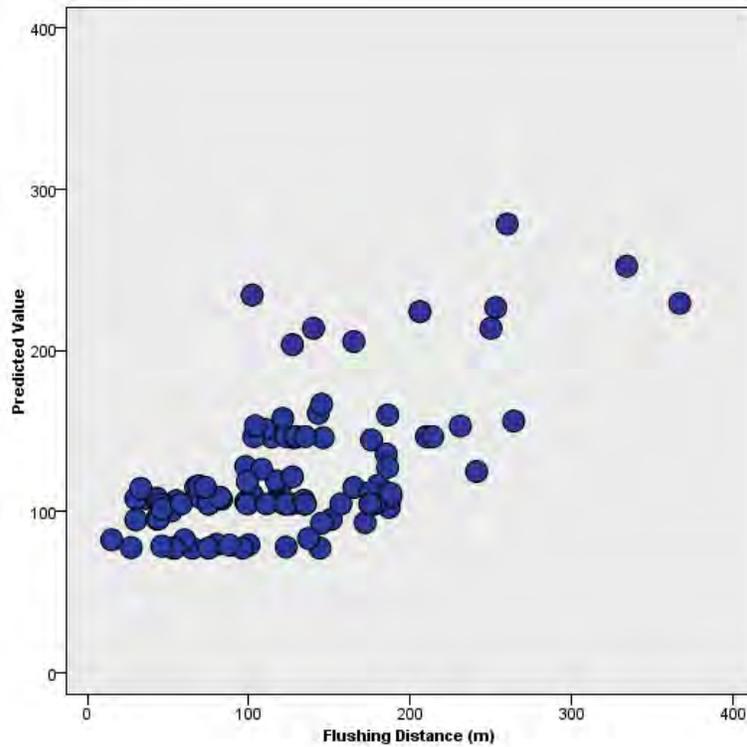


Figure 8: The predicted flushing distance as modelled by the LINEAR process, compared to the flushing distances observed in the field

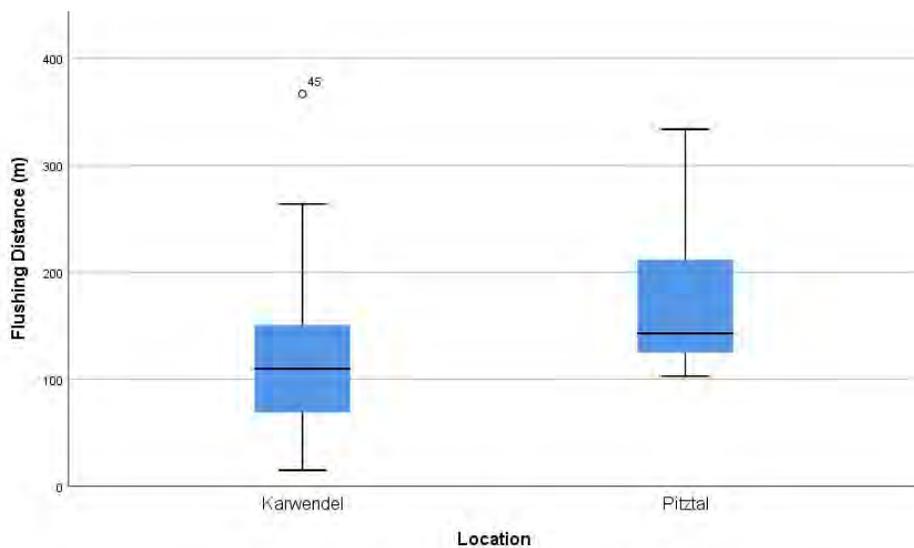


Figure 9: The difference of flushing distance between the Karwendel and Pitztal chamois populations. Independent Samples *t* Test mean difference 55m, significance (2-tailed) 0.008

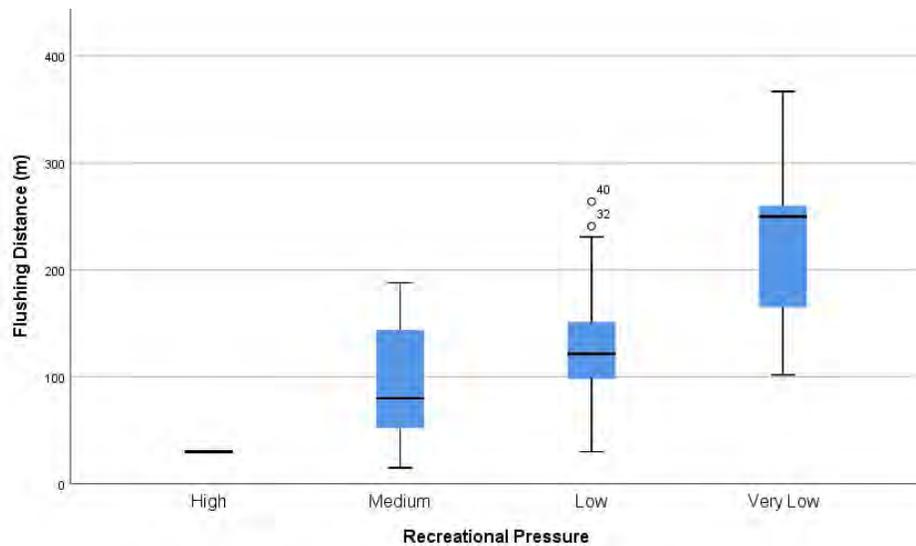


Figure 10: Difference of flushing distance between modelled recreational use categories. Independent samples Kruskal-Wallis Test significance 0.000. Pairwise comparisons: low, middle, and high are all significantly different to very low. However all pairwise combinations between low, medium, and high are not significant.

In areas categorised as very low recreational pressure, flushing distance was significant against all other categories. Areas of low recreational pressure recorded greater distances of 32m, 47m, and 81m respectively against low (sig. 0.013), medium (sig. 0.00), and high (0.049) categories. All other pairwise comparisons were insignificant (Figure 10). When using the 400m buffer zone to get a numerical value of recreation pressure (rather than categorical), it was found that herds which experience less pressure tend to flush at greater distances.

Trail type was a statistically insignificant indicator of flushing distance, as were the categorical variables of terrain type, sunlight, temperature, and approach angle. A positive relationship was found between observer distance from trail and the flushing distance (Figure 11).

Regarding the interactions of species, chamois were seen to graze alongside domestic goat (*Capra aegagrus hircus*) and cattle (*Bos taurus taurus*) herds, as well as wild populations of mouflon (*Ovis orientalis musimon*), red deer (*Cervus elaphus*), and marmot (*Marmota marmota*). Groups of mouflon tended to flush much earlier than chamois, making the chamois herds spook and flee at a running pace much earlier than they might have otherwise. However, there is no statistically significant evidence to back these observations. The alert calls of marmot also tended to alert chamois and make them adopt a constantly alert posture at a greater distance than they would regularly. Few hikers (*Homo sapiens ambulo*) or mountain bikers (*Homo sapiens velox*) were seen to disturb the chamois herds enough to produce any behavioural response, although one hunter (*Homo sapiens venor*) walking with a dog (*Canis lupus familiaris*) did result in chamois fleeing over a large distance exceeding 500m.

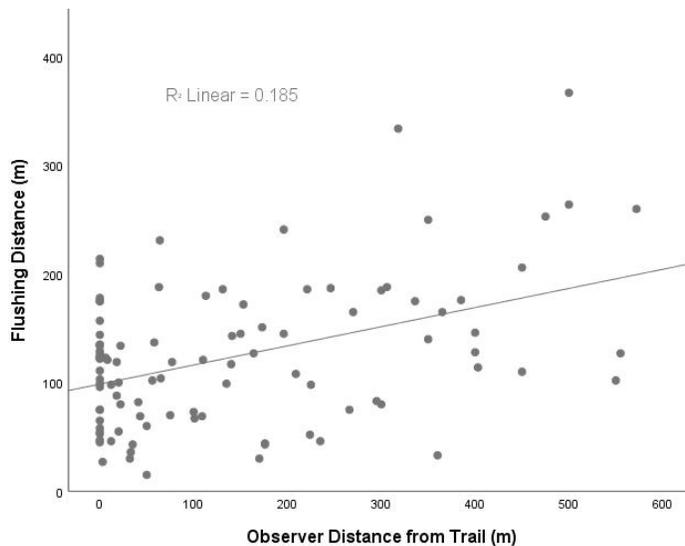


Figure 11: *Observer distance from trail has a positive relationship with flushing distance.  $R^2=0.185$*

#### 4.5 Overview of Herds, Topography, and Recreational and Hunting Environments

##### Herd Size and Composition

In total 100 herds of chamois were experimented upon, representing a total of 541 individual animals. 39% of the herds contained just one individual, 15% two individuals, with 7% and 8% of experimented herds containing 3 or 4 individuals respectively. The remaining 31% of herds held between 5 and 33 individuals (Figure 12). 25% of herds experimented upon had kids within the group, with a total of 105 kids counted. The maximum number of kids counted was 11, in a herd of 29 individuals total.

##### Location and Topography

85 of these herds were in Karwendel Nature Park, while the remaining 15 were in Pitztal. An attempt was made to expand the study to include Zillertal Nature Park, however over two days of searching no chamois were seen. Herds were mainly experimented upon in locations covered in grass or scree (Table 2), and were most often on moderately to steeply sloping ground (Figure 13).

15% of approaches were made from above the animal, 21% were made where the animal was at the same elevation as the researcher, and 64% of experimentations were made approaching the animal from below. The mean vertical difference between the researcher and the animal was 27m (median 24, min -88, max 200).

##### Recreational Environment

The Recreational Intensity Model of the Forest Group of the Tyrolean Regional Government, shows that 69% of herds were in locations graded as low or very low intensity, with 30% graded as medium

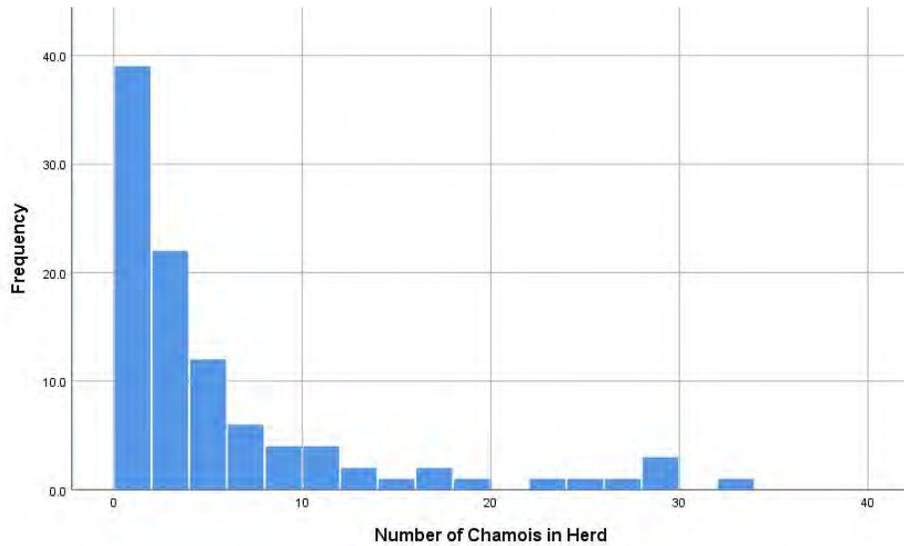


Figure 12: *The chamois herds experimented upon ranged in number from single individuals up to a maximum herd size of 33 (including nine kids).*

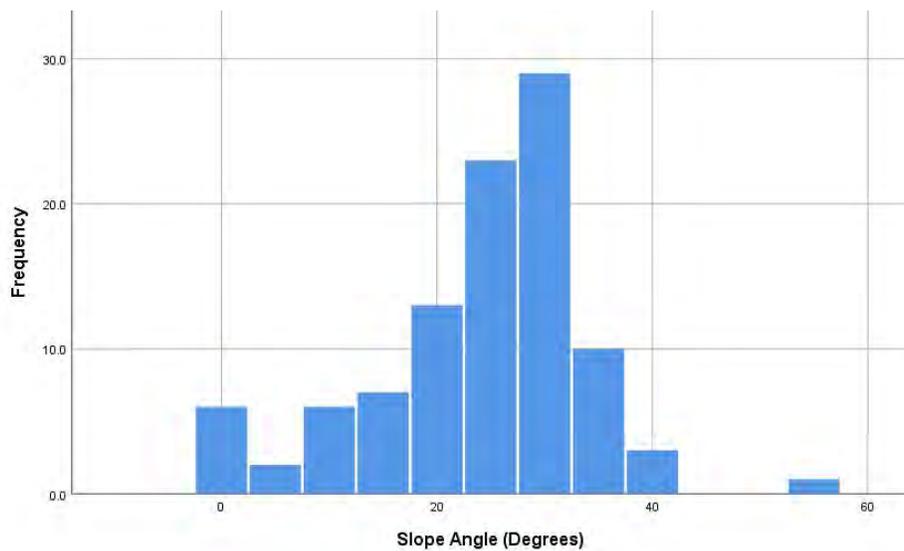


Figure 13: *The chamois herds experimented upon were distributed on slopes ranging from 0 to 55 degrees. Herds were most often on steep terrain between 20 and 40 degrees.*

<b>Terrain type</b>	<b>Number of herds</b>
Scree	36
Grass	31
Grass and rock	18
Grass and scree	6
Bluffs	4
Grass and bluffs	3
Rock	2

Table 2: *The number of herds experimented upon within the various landscape categories. The majority of herds were located in terrain which contained grass.*

intensity. Just one herd was in a high use area. Regarding the recreational pressure values calculated from the proportion of the buffer area occupied by each category, the highest value was 57, and there were 11 points with a recreation value under 1. The mean recreational pressure value was 13.41. A maximum value of 100 was theoretically possible.

20 herds were approached from forest roads, 46 were approached from tracks, and 34 were approached from marked routes. 27% of herds were experimented upon and produced a flushing response while the researcher was still upon the track, while 73% of herds required the researcher to move off trail in order to produce a flushing response.

### **Hunting Areas**

The data shows that there are significant differences in flushing distance between the hunting areas (sig. 0.000). However, this was only in three of the twenty-one potential pairwise comparisons, that being Unterinntal Nord v Scharnitz Seefeld Reith -33m (sig. 0.023), Unterinntal Nord v Pitztal II -45m (sig. 0.002), and Hinterriss v Pitztal II -34m (sig. 0.040).

Table 3 shows the ranking of these hunting areas by the percentage of the herd shot per year as well as the number of animals shot per hectare per year. The flushing distances associated with each area are displayed in figure 14.

<b>Ranked Hunting Pressure</b>		
	Percentage Harvested / Yr	Number Harvested / Ha / Yr
Hinterriss	2	5
Innsbruck-Nord	6	3
Inntal	7	4
Pertisau	1	1
Pitztal II	4	7
Scharnitz-Seefeld-Reith	5	6
Unterinntal-Nord	3	2

Table 3: *Hunting areas were ranked for hunting pressure using two different measures. 1. Percentage of the total chamois population harvested by hunters each year, and 2. The number of chamois harvested by hunting per hectare per year. Pertisau hunting area is noteworthy as it is ranked as having the highest hunting pressure under both forms of measurement. Inntal has the lowest hunting pressure when measured by percentage of population harvested per year, while Pitztal II has the lowest hunting pressure when measured by the number of animals harvested per hectare per year.*

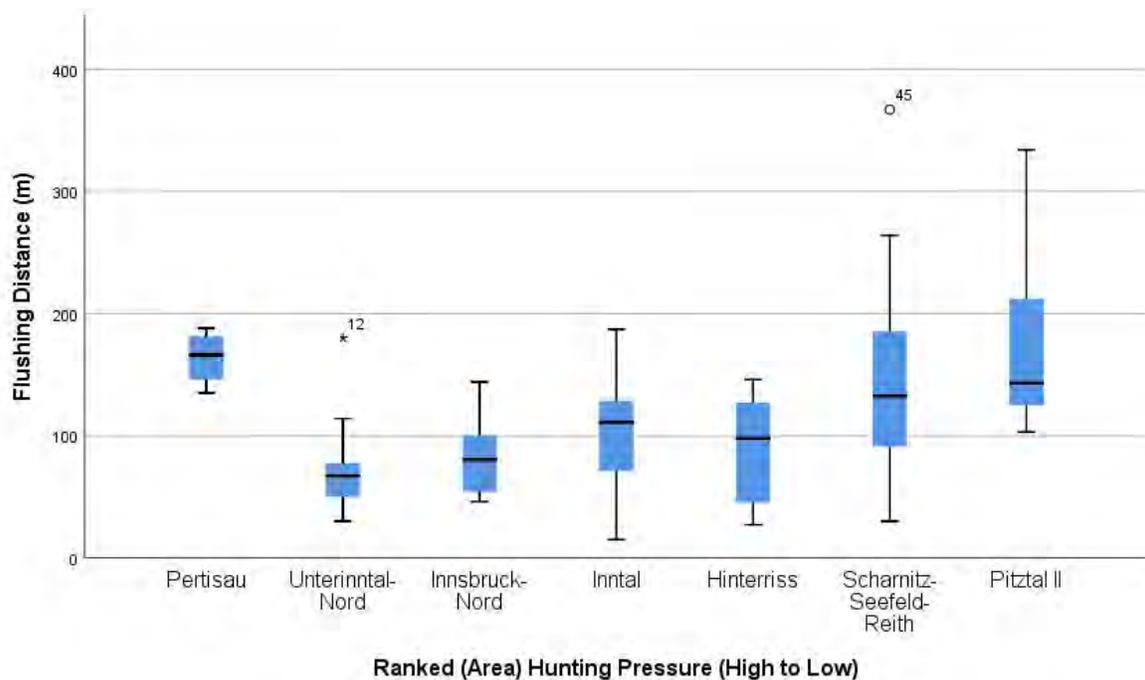


Figure 14: *Flushing distance for each hunting area, arranged left (high rank) to right (low rank) regarding the hunting pressure as measured by number of animals harvested per hectare per year.*

## 5 Discussion

### 5.1 Importance of Flushing Distance

This study describes the relationship between the various measures of chamois timidity as being inter-related and exchangeable. Flushing distance is the factor focussed on in the results of this report, however constant alert distance and maintained distance can also be used as they have a linear relationship with flushing distance. Other studies have found the same to be true (Bögel and Härer, 2002). The flushing distance measurement can be thought of as an evaluation of the tolerance that an animal has for a potential danger or disturbance (Altmann, 1974). While flushing distance is the result of many interacting variables, some of which are very difficult or impossible to measure, it has also been shown to be the best behavioural indicator of stress (Stemp, 1983).

Flushing difference between studies is difficult to evaluate due to different environments and methodology. However, in Berchtesgaden National Park the mean flushing distance recorded was within just two metres of the results described here (Bögel and Härer, 2002). Unfortunately, a past study in the Karwendel is not comparable as distances were estimated not measured, and therefore they are not suitable for comparison (Hamr, 1988). This study establishes that the variables most important for explaining the flushing distance, as confirmed by the multiple regression models, are the recreational pressure, the location, and the distance the observer is from the trail.

### 5.2 Recreational Pressure and Habituation to Human Disturbance

Recreational pressure on public land is one of the primary factors that contribute to the vulnerability of populations of wild animals (Papouchis et al., 2001; Losos et al., 1995). This has been shown to be the case with chamois (e.g. Pépin et al., 1996) as well as a variety of other wild and game animals including big horn sheep (*Ovis canadensis*), bison (*Bison bison*), mule deer (*Odocoileus hemionus*), and pronghorn antelope (*Antilocapra americana*). Chamois experiencing greater disturbance move more often, are more vigilant, feed less frequently, and rest less often, than those animals which are less disturbed (Pépin et al., 1996).

It is somewhat intuitive that animals in areas with higher recreational pressure would become accustomed to the human disturbances they experience. Conclusions from studies regarding chamois specific behavioural adaptation to human disturbance are mixed. A previous study in the Karwendel stated that increased frequency of disturbance increased chamois sensitivity, with the longest flushing distances recorded in June and July when the most hikers and livestock were present (Hamr, 1988). Hamr (1988) also concluded that chamois become accustomed to human disturbance as long as they are predictable both spatially and temporally. A study of chamois in Berchtesgaden National Park found herds in frequently disturbed areas respond less to disturbance than those in remote areas (Bögel and Härer, 2002), while a report from Abruzzo National Park, Italy, found flushing distances of 25-30m, where chamois are rarely disturbed (Cederna and Lovari, 1983). In the popular tourism area of the Elbe Sandstone Highlands in the Czech Republic, tourists can approach chamois to within 50m before they flee, although this was in dense forest (Briedermann, 1976). In the Swiss Alps, with very high levels of disturbance by tourists, flushing distances varied from 20m to 200m (Pachlatko, 1980). Considering other alpine animals, Neuhaus and Mainini (1998) found that marmots in areas with a

lot of recreational pressure reacted less to hiking activities than marmots in more remote and less disturbed areas. These frequently disturbed animals appear less shy, as they have learnt that typically hikers pose no threat (Neuhaus and Mainini, 1998).

The underlying reasons for the perceived lack of timidity in areas experiencing high recreational pressure could be concerning when considering the well-being of these animals. Animals which are disturbed infrequently have more time for foraging and can subsequently afford to be more cautious (Neuhaus and Mainini, 1998). These animals have built up energy stores already and can then invest in behaviours that aid their safety, such as increased vigilance, and fleeing from threats at greater distances. Inversely, animals which are frequently disturbed have had less time to feed and can ill afford to invest in behaviours ensuring safety. It would simply not be feasible to make alarm sounds or escape each time a hiker passes as the need to feed is too important, so these animals accept more risk (Neuhaus and Mainini, 1998). Potentially the chamois in this study that are more frequently disturbed and have shorter flushing distances are not more relaxed about hikers, but are rather more stressed and must accept greater risk now, in order to build up energy reserves and avoid starvation in the winter. This hypothesis would be in conflict with the assertion of Stemp (1983), who stated that flushing distance is the best behavioural indicator of stress.

In some ways this study acts to validate the recreational pressure model produced by the Tyrolean Forest Service. The model is based on the intensity of recreational activities (hiking, mountain biking, ski touring) as well as the level of infrastructure provided which facilitate these activities (roads, tracks, and routes). It is important to note that this habituation to disturbance is developed over a long period of time and not just based on the short term (Bögel and Härer, 2002), so the accuracy of the model holds true through the seasons.

### 5.3 Locational Considerations

The location of a chamois herd, and the associated vegetation, climate, and topography, plays an important role in a population's performance (Nievergelt, 1962), and will clearly have an impact on the flushing distance. As described earlier, Karwendel and Pitztal are certainly different environments. In this study the animals in Pitztal flushed at a distance of 55 metres further than the animals in Karwendel Nature Park. Although both areas have large recreational pressures from tourism, as well as comparable hunting pressures, the topography of the two areas are quite different.

Karwendel Nature Park sits in the Northern Limestone Alps. In the alpine zone grass heaths and pioneer vegetation of *Caricetum firmae*, *Elynetum myosuroides*, and *Thlaspietum rotundifoliae*, and the dwarf shrubs of *Rhododendretum hirsuti*, *Ericetum carneae*, and *Dryadetum octopetalae* grow on carbonate rocks (Laboratoire de Botanique, 1969). The karst landscape has scree and rock covering large areas, particularly in alpine cirques. The soils are calcareous and stony with acidic loamy soils in depressions and flat slopes (Dirnböck and Grabherr, 2000). *Pinus mugo* dominates the scrub belt up to approximately 1900m where it gives way to alpine grassland dominated by *Carex firma* or *Carex sempervirens* and *Sesleria albicans* (Dirnböck and Grabherr, 2000; Dullinger et al., 2000; Dirnböck et al., 2001).

Pitztal on the other hand, is part of the Ötztal mass in the Central Alps. Alpine grass heaths and pioneer vegetation of *Caricetum curvulae* and *Festucetum halleri* and dwarf scrub *Rhododendretum ferruginei*, *Vaccinietum myrtillin*, *V. uliginosi*, *Callunetum* spp., and *Loiseleurietum* spp. grow on



Figure 15: *ibex share the alpine landscape with herds of chamois. Photo credit: Leigh Mutton.*

silicate rocks (Laboratoire de Botanique, 1969), although vegetation islands on calcareous rock are present (Burgstaller and Schiffer, 1995). Large parts of the landscape are covered by bare rock and scree alongside glaciers moraines and pioneer vegetation (Burgstaller and Schiffer, 1995). The soils here are nutrient poor and more moist than the Limestone Alps, and have an acidity around pH 4 (Leuschner and Ellenberg, 2017). The most important grass species is *Carex curvulae* (Leuschner and Ellenberg, 2017), although *C. canescens*, *C. echinata*, *C. lachenalia*, *C. nigra*, *C. rostrate*, and *C. sempervirens* are present due to the variable topographies, with dryer areas as well as areas of permanently high groundwater (Burgstaller and Schiffer, 1995). The siliceous substrates have a significantly richer variety of vegetation than carbonaceous substrates (Wiersema, 1989), which are present in the Karwendel. The supply of good forage plants is low (Burgstaller and Schiffer, 1995) and the grassland here has a low fodder value (Leuschner and Ellenberg, 2017). Therefore, it could be expected that the chamois in the Pitztal are less healthy than those in the Karwendel, given that poor nutrition and starvation in the winter is a major cause of mortality for these animals.

Climate and weather can influence the health of a herd. In ibex, populations have been shown to be healthiest when precipitation is low, and there are populations which are in decline in wetter regions (Wolf, 1977; Graf, 1979; Elsner-Schack, 1982). Snow coverage and duration during the winter and spring are important to consider when comparing locations, as is the case in herds of ibex, where they have been shown to affect the accessibility of feed and the population distribution (Nievergelt, 1966; Hofmann and Nievergelt, 1972; Smith, 1977). With higher mortality of ibex being reported after winters of heavy snowfall (Couturier, 1962; Linzi, 1978), and despite the two locations being 40km apart, it is likely that variations in snow depth, coverage, and duration, plays an important role in considering feeding stress between the two populations of chamois.

Regarding topography, chamois are believed to prefer warm open landscapes. The same has been found for ibex, which favour habitat with warm, south facing, sheer terrain in open landscapes (Wiersema, 1989). The Karwendel offers far more of these landscapes, given the east-west orientation of the major ridge-lines and the shape of the land. The shape and aspect of land, as well as variations in altitude, can result in vastly different vegetative productivity. Even small changes in elevation can affect productivity dramatically. For example, a change in altitude of just 200m can result in twice the productivity for particular grasslands (Dietl, 1977).

If Neuhaus and Mainini (1998) are correct, that animals that are more stressed in their need to feed and build fat stores for the winter are more willing to accept disturbance risk, you would expect the animals in Pitztal to allow closer approaches and have a smaller flushing distance. However, in this study this was not the case, with animals fleeing on average at a distance of 55 metres greater than those in the Karwendel. With no significant differences in hunting harvests, and no understanding of exactly how many people use the two areas studied, the underlying cause for the discrepancy between the two populations remains unclear.

#### 5.4 Off-Trail Disturbance

As herds of chamois becoming acclimatised to recreational pressure in their environment, they also become accustomed to the patterns of behaviour they see in the humans that traverse their habitat. Thirty years ago, Joseph Hamr (1988) conducted a study in the Karwendel seeking to understand the behaviour of chamois when disturbed by recreationalists. The author of that study stated that hikers

could easily encroach within 150m of the animals. The researcher also observed that herds were not intimidated until hikers left the established trail and headed directly towards the animals. The study concluded that chamois herds became habituated to human disturbance as long as people remained predictable (i.e. stayed on trail walking at a steady speed). Another study in the Abruzzo Mountains of Italy had similar findings (Cederna and Lovari, 1983).

The animals know where the track is and the behaviour they expect a person to exhibit. When people break way from this expected behaviour the animals become more alert, and this is why the distance of the observer from the trail is the third variable used in the model to explain flushing distance. The further the recreationalist is from the trail (and therefore the expected behaviour), the more concern the chamois may have that this human is a threat.

Further studies on other ungulates and alpine mammals have found similar results, where animals become accustomed to hikers and mountain bikers when they stay on well utilised marked trail. These studies have included big horn sheep (Geist, 1975; Horejsi, 1976; DeForge, 1981; Hicks and Elder, 1979), marmots (Neuhaus and Mainini, 1998) and other wild species on public land subject to recreational pressure (Taylor and Knight, 2003).

Studies would indicate that moderate numbers of well-mannered hikers and mountain bikers would not have a particularly detrimental impact on the wild herds of ungulates (Cederna and Lovari, 1985; Patterson, 1988; Papouchis et al., 2001). In situations where hikers are off trail or unpredictable, it has been found that animals do not habituate (Papouchis et al., 2001; Bögel and Härer, 2002). Studies have found that downhill skiers, low flying aircraft, hang-glidors, and para-glidors, all resulted in increased responses of chamois (Hamr, 1988; Bögel and Härer, 2002). Unlike hiking and mountain biking where there is a defined trail, these other recreational activities have either loose or completely undefined passageways across the landscape, which removes the predictability and results in animals panicking and scattering. While traditionally hiking and mountaineering were the only summer activities, it is of concern today that there are more than 20 leisure activities in the mountains (Ott, 1988), of which fewer are restricted by season or trail use.

## 5.5 Hunting

Interestingly, in this study no relationship was found between hunting pressure and the timidness of the chamois herds. Hamr (1988) noted that hunters, when behaving like hikers, could easily approach to within shooting range (100 - 150m). He also stated that when these hunters approached while crawling or crouched, the alert levels of the chamois rose immediately.

The reaction of ungulates to human disturbance has been shown to be higher where hunting is permitted (Douglas, 1971; Sweeney et al., 1971; Jeppesen, 1987; Skogland and Grøvan, 1988). Cederna and Lovari (1983) found flushing distances of 30m for chamois in Abruzzo National Park where hunting is prohibited and chamois habitat is almost inaccessible to hikers. Briedermann (1976) reported that chamois in the Elbe Sandstone Range allow tourists to within 50 m before exhibiting alarm behaviour. Dense vegetation and the prohibition of hunting were suggested as likely causes.

The Tyrolean hunting association (Personnal Correspondance, 2018) claim it is important that chamois herds do not understand they are being hunted, and would therefore not develop escape behaviours. They recommend shooting from a short range, which increases the chance of an immediate kill shot

and also helps to enforce the notion that humans are not a threat at greater distances. As no influence of hunting was detected in this study it could be argued that the hunting community in these areas are doing a good job at ensuring these escape behaviours do not develop. However, as many of the herds sampled were near the boundaries of hunting areas (Figure 5), this idea would need to be investigated further.

## 6 Management Recommendations

The alpine chamois in Tirol are subject to human disturbance. It is important to understand these interactions and use this information to best manage the environment. Many studies around similar themes as those discussed in this paper make recommendations, and it is wise to discuss those management implications here. Although chamois as a whole are not threatened, isolated populations and subspecies are under threat, so appropriate conservation measures are required. Corlatti summarises the overall concept best, stating: “*Effective conservation measures, as with other taxa, should be established while the chamois is still abundant, rather than when it is reduced to just a few individuals on the top of a mountain*” (Corlatti et al., 2011).

Pę Ksa and Ciach (2015) state that activities in the mountains need to consider the needs of wild species, which is clearly true. However, they go on to say that visitor numbers need to be controlled. As there are many benefits to humanity experiencing nature, and community opposition to such a policy could cause harm to environmental causes, all other scientifically valid methods should be considered first. It is important that visitors to mountain landscapes are well informed regarding their impacts, and educated about how to reduce their impact on flora and fauna. In Bulgaria the local subspecies of chamois are conserved by popularising the species in the eyes of the local community and aiding children as well as adults to learn nature conservation (Valchev et al., 2006). A local population which is enthralled by nature and has learnt to respect the natural environment and its animals at a young age is insurance against destructive practises.

A management strategy must acknowledge economic factors, and the benefits of hunting and tourism which can lead to sustainable practises. Conservation does not occur in a vacuum. A healthy environment and thriving species are a luxury good, and a society which is economically stable enough does not need to extract resources at the expensive of nature. The hunting license and associated spending by hunters of Balkan chamois (*Rupicapra rupicapra balcanica*) motivates local government to manage the species appropriately as well as conserve its habitat (Valchev et al., 2006). Thus, the chamois becomes an umbrella species, in that many other species benefit from it’s protection.

Pepin (1996) and Hamr (1988) state the importance to minimising human disturbance by keeping to trails and remaining predictable. Hikers in the populated alpine regions of Europe should be advised than chamois need a buffer of about 150m (this study; Hamr, 1988). Human disturbance originating from the air is not confined to trail infrastructure, and is therefore unpredictable to chamois. Sports such as para-gliding and hang-gliding should be confined to selected take-off areas and pilots should maintain heights of above 300m (Hamr, 1988). The goal should be to provide a predictable environment for the animals. Mountain biking is confined to trails and is thus predictable. According to a number of studies it presents no greater disturbance than hiking and does not need to be separately restricted (Gander and Ingold, 1997; Taylor and Knight, 2003). Taylor and Knight do go on to say however, that due to their higher speed mountain bikers cover more ground in a day, so they have a greater opportunity to disturb wildlife per unit time.

Winter is a time of high energy losses for chamois and escape from a threat in snow is particularly taxing (Hamr, 1988). Ski touring needs special consideration, as in some areas chamois can be the most commonly encountered large mammal (Bielański et al., 2018). Although ski touring is only loosely limited to particular routes, disturbance from ascending skiers is similar to that of hikers (Bögel and Härer, 2002). However, the fast and more variable downhill routes result in strong alarm responses



Figure 16: *Mouflon* can be found in both the *Karwendel* and the *Pitztal*. They tend to be very shy and will often initiate escape responses in excess of 300m. Photo credit: Leigh Mutton.

(Hamr, 1988). In areas of concern, winter habitat could be identified and combined with recreational pressure modelling such as that conducted by the Forest Service of the Tyrolean Government. In this way, parts of landscapes that need relief from disturbance could be recognised and subjected to seasonal restrictions.

When constructing any new trails, routes should be carefully planned to follow existing edge-lines and avoid forages areas or wildlife corridors. Depending on the density of trails and the recreational pressure exerted now and in the future, new trails have the potential to restrict chamois habitat in the long term (Gander and Ingold, 1997).

At a time where 77% of Earth's land (excluding Antarctica) has been modified by direct human activities (Watson et al., 2018), it is important to reflect on the concept of wilderness and on the understanding of what a wild animal is. This is particularly pertinent in central and western Europe, where even alpine areas have been crafted into cultural landscapes. Yvon Chouinard of Patagonia Inc. states that "We are the last generation that can experience true wilderness" (Chouinard, 2016). While it is true that the concept is peculiar to each person (Spurr, 1966), we should be cautious of the ability of the words *Wild* and *Wilderness* to deteriorate in strength of meaning with each new generation. If a wild animal interacts with humanity every day, if it is restricted to an area drawn for it by human hands, and if it becomes so tame as to behave like a domestic animal in a field, then how can we say that that animal is truly wild?

## 7 Acknowledgements

As with everything in life, no man is an island and no one person accomplishes anything in isolation. Therefore, I must recognise the support and contributions of a large group of people who have helped put this paper together.

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## **Declaration of Commitment and Consent Form**

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*8 July 2019*