Social impact of environmental disasters: Evidence from Canary Islands volcanic eruption

Abstract

Social commitment to the environment, ecological attitudes and sense of place are essential indicators for the development of public policies aimed at environmental sustainability. Natural disasters are major events that affect people's well-being and perception of their environment. The objective of this research was to test the effects and consequences of the eruption of the volcano on the Spanish island of La Palma on 502 participants during a 10-month follow up. Of the total sample, 281 were direct victims of the volcanic eruptions and 221 participants formed the control group. Multiple analyses of variance were applied with repeated measures and by distinguishing the victim group and the control group participants. Three quadratic functions were also fitted relating the time variable to the following indicators: ecological attitudes, sense of place and perceived anxiety levels. In addition, the degree of commitment to nature was also measured. The results showed that this natural disaster predicted reductions in pro-ecological attitudes with an overall weight of 30.8% (43.9% for the victim group only) and in sense of place of 26.3% (36.8% for the victim group only). On the other hand, when analyzing stress levels, the natural disaster was able to explain 21.2% overall (92.8% for the victim group only) of the increases. The quadratic functions indicated that reductions and increases tended to stabilize two months after the natural disaster. We discuss the theorizing implicit in these effects and the implications they have for the development of public policies for environmental sustainability.

Keywords: natural disasters; sustainability; ecological attitudes; sense of place; place attachment; stress; ecological paradigm.

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1. Introduction

On September 19, 2021, the volcano located on the Spanish island of La Palma erupted near the town of El Paraíso, which belongs to the municipality of El Paso (read this information in De Luca, 2022). The volcanic eruption lasted 85 days and 8 hours (the last recorded day of volcanic activity was December 13, 2021) (Longpré, 2021). During the eruption, up to seven lava flows with a height of 6 meters were formed (LaSexta, 2021; Instituto Geográfico Nacional de España, 2021) with catastrophic material, environmental and psychological consequences. Approximately 6,000 residents of multiple localities near the volcano were evacuated (Longpré, 2021), 1,200 buildings were destroyed by lava flows, including private homes, three schools, a health clinic, a parish church and other urban infrastructure for public use (see Figure 1 for more information) (see RTVE, 2021). Of the 6,000 people evacuated, only 1,000 residents were able to return to their homes, which were not destroyed by the eruption (EFE Agency, 2021). At the environmental level, numerous clouds of toxic gases formed, forcing the total confinement of 33,000 people (see Rodríguez-Hernández et al., 2022). This natural disaster was a major event and represented a public health risk for the residents of the island of La Palma (Carracedo et al., 2022). Although there were no deaths formally reported, the consequences of this catastrophe on the mental health of the residents is still formally unknown.

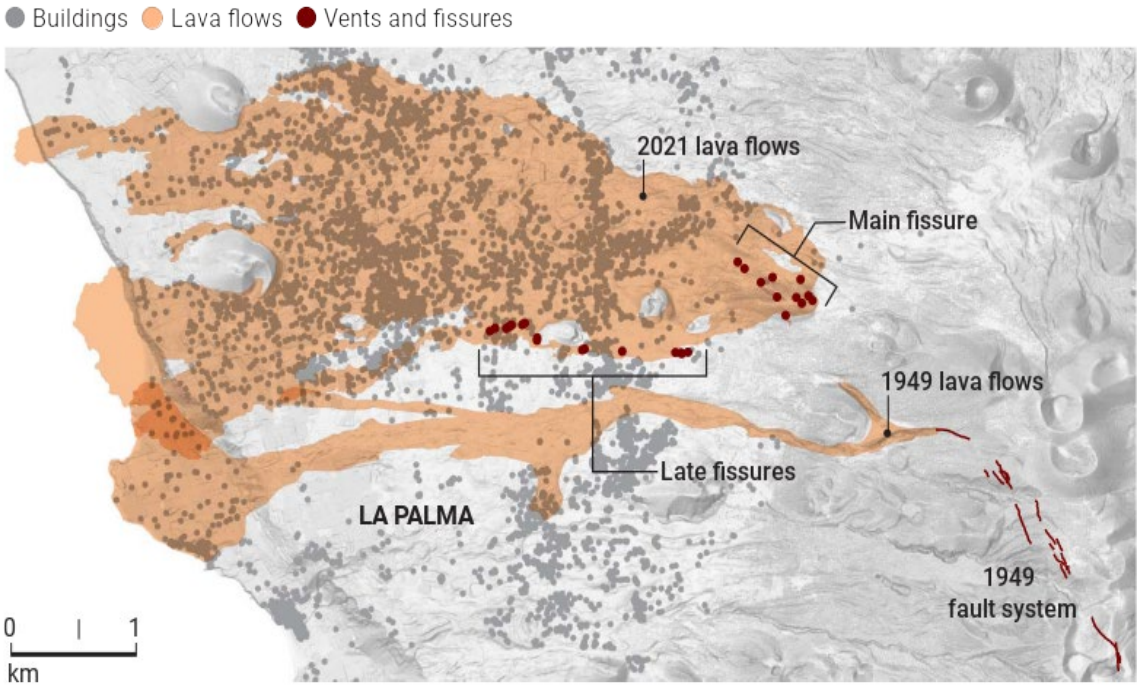

Figure 1. *Geographic map showing in orange the areas and localities affected by lava flows. Each grey point is a building destroyed by the advancing lava flows.* ***Map preparation and design:*** *Pablo J. González.* ***Licensed for use:*** *Published in the journal 'Science', March 24, 2022, under open access license (see González, 2022).*

In other studies that addressed the social impact of natural disasters and evacuation plans on affected victims, high levels of stress, post-traumatic stress and shock episodes were found (see Kaplan et al., 2015; Gissurardóttir et al., 2018; Lavenda et al., 2017; Jang et al., 2020); these symptoms were also observed in minors and children (e.g., Edwards et al., 2021). In general, the mental health of victims and volunteers who decided to help during these types of events was found to worsen (e.g., Espinoza et al., 2019). Additionally, symptoms related to depression and distress may also be highlighted (e.g., Marthoenis et al., 2018; Fukushima et al., 2019; Chen et al., 2020). In any case, psychological care and intervention programs that protect the mental health of victims are essential to reduce the psychosocial impact and risks attributed to a natural disaster (see Gray et al., 2021).

All the above information is provided with the objective of describing and characterizing in figures the impact of the eruption of the La Palma volcano. The environmental effects and psychological consequences of catastrophes of this type were the object of study in this research,

which aims to examine to what degree they alter the levels of sense of place, the degree of commitment to the environment and the ecological awareness of the direct and indirect victims.

1.1. The ecological paradigm and environmental sustainability

The ecological paradigm was born from the need to measure the worldviews of the general population in relation to the sustainability of the planet, the connection with nature and the reduction of the impact of human activities on the environment (Nisbet et al., 2007; Walton & Jones, 2017). Following on, this social paradigm aims to measure and characterize people's concept of ecology in relation to their environment (Hawcroft & Milfont, 2010). This measurement and characterization of ecology has become very popular because the problems attributed to the environment are increasingly global, general, and not limited to particular cases (see Chen & Zhao, 2021 Sadiq et al., 2022). It is scientifically proven that high levels of ecological attitudes of the population are required to effectively implement public and urban planning policies that favor environmental sustainability (e.g., Chekima et al., 2015; Liu et al., 2018; Ziegler, 2021). If the levels of ecological conception of the population are low, it is very difficult to ensure adequate collaboration between individuals and the successful implementation of environmental policies (Bezerra et al., 2021).

The measurement of the worldview of ecology has been investigated from many perspectives: attitudes towards environmentalist actions (Arnold et al., 2017; Bouman et al., 2018), the degree of connection and respect towards nature (e.g., Mayer & Frantz, 2004; Dutcher et al., 2007), and the question of ecological consciousness (see Wierzbiński et al., 2021) were all addressed. However, an operational way to measure the ecological paradigm is by analyzing the degree of engagement with the environment and the beliefs that determine the relationship between the person and the environment (e.g., Dunlap et al., 2000; Davis et al., 2009; Davis et al., 2011). In this context, the word "beliefs" refers to the cognitive system of meanings that the person uses to include to a greater or lesser extent the categories "nature" and "environmentalism" (Markus, 1977; Walton & Jones, 2018). This definition of beliefs is important because the meaning systems that the person learns or acquires will determine his or her behavior and actions, which in this context may be more or less ecological (e.g., Escolà-Gascón, 2020; Escolà-Gascón, Á., & Houran, 2021). Understanding these meaning systems is necessary for the proper development of social campaigns that seek to change the conceptions of the population to ultimately generate global changes in behaviors (Moser, 2009; Wyss et al., 2022).

However, given that meaning systems are constructed and explained by classical learning theories (see Morris, 2019), they may undergo changes or variations depending on the circumstances and stimuli that characterize each person's life situation (see Escolà-Gascón, Á., & Houran, 2021). Along this line, one of the most difficult circumstances to study is the impact of natural disasters on people's conceptions and ideologies and, specifically, on ecological conceptions (Segal et al., 2018; Yong & Lemyre, 2019). Indeed, natural disasters are known to generate a decrease in the degree of social trust in victims (e.g., Kang & Skidmore, 2018). In this case, we refer to natural disasters that have had negative consequences on the lives of people who resided in the environment in which the disaster occurred; these people can be considered victims of environmental disasters. In this research, the impact of the eruption of the La Palma volcano on the ecological commitment and beliefs of the victims was analyzed and followed up. This natural disaster was already described in the first paragraph of the introduction (see also Longpré, 2021).

1.2. Foundations and usefulness of sense of place in the ecological paradigm.

Sense of place is an environmental psychology construct that measures the type of attachment a person develops to a specific place (Jorgensen & Stedman, 2001; Adams et al., 2017). According to the prevailing scientific literature, sense of place is characterized on the basis of two dimensions: place attachment and place identity (see Boley et al., 2021 for a review). The first dimension refers to the affective dependence that a person has on a specific place; this affective dependence will depend directly on the individual's previous experiences developed in a specific place (Peng et al., 2020). The second dimension reports the degree to which a person subjectively identifies with the different characteristics that make up a specific environment (Daryanto & Song, 2021; Corbett et al., 2022). Scientific evidence suggests that this identification is related to belief systems (e.g., Devine-Wright et al., 2015; Moulay & Ujang, 2021). The more the meanings acquired by the individual coincide with the characteristics of the environment, the greater and better the perceived place identity (see Escolà-Gascón & Houran, 2021).

The sense of place has been used as a social indicator of collaboration between the population and the implementation of new urban policies and plans (e.g., Berg et al., 2021; Hawthorne et al., 2022). According to findings in the scientific literature, the higher the sense of place the greater the resistance to change among the population occupying a given municipality (Tan et al., 2018; Nugroho, & Zhang, 2022). This resistance to change could increase the discrepancies between the

urban plans that are desired to be implemented; consequently, the population would not collaborate with the successful implementation of public policies (Xu et al., 2022).

Likewise, several investigations observed that sense of place is related to connection with nature and environmentalism (Daryanto & Song, 2021; Dasgupta et al., 2022). Since this correlation is positive, sense of place may be a potential indicator for understanding the migration flows of victims who leave their homes due to a natural disaster (Chamlee-Wright & Storr, 2009; Henry, 2012). In general, people who have a high sense of place tend to stay in their residences despite the consequences of the natural disaster (Swapan & Sadeque, 2021). Other research observed that during the period in which the natural disaster occurs, victims tend to modify their perceptions about how to interpret the dangers of nature and re-evaluate previous conceptions about the degree of safety of natural environments (see Escolà-Gascón & Houran, 2021; Escolà-Gascón, 2022; Yang & Bae, 2022). Considering sense of place as a resource for coping and reacting to natural disasters (Call et al., 2017; Fatemi et al., 2017), people forced to leave their homes and who have high levels of sense of place are likely to have greater perceptual changes, including beliefs, commitment, and attitudes toward environmentalism and nature.

1.3. Operationalization of variables and hypotheses

The evaluation of the ecological paradigm was carried out by measuring the variables ecological attitudes and degree of commitment to nature. The sense of place was measured from the dimensions place identity and place attachment, which are included in the scale of Boley et al. (2021). The natural disaster used as a setting was the volcanic eruption of La Palma, primarily due to the convenience of the sample; we argue this convenience in more detail in the methods section.

As the impact of natural disasters on victims is usually negative, we hypothesize that ecological attitudes and sense of place decrease as the victim is more affected by the catastrophe. Furthermore, we hypothesize that this decrease tends to stabilize and repair itself once the natural disaster is over. More exploratory, we also hypothesized that engagement with nature would be affected by the natural disaster (we lack sufficient prior evidence to infer whether these affectations will be increasing or decreasing). As a complement, we measured anxiety levels, which served as an indicator of psychological well-being associated with the variables specified above.

2. Methods

2.1. Sample description

The sample of this study consisted of 502 participants from the Canary Islands. 281 participants (56%) were victims of the eruption of the La Palma volcano and 221 (44%) were not exposed to the hazards or risks of the eruption and did not reside on the island of La Palma. In total, 239 (48%) were women and 263 (52%) were adult men between the ages of 21 and 60 years (Mean age= 39.87; Standard deviation age= 11.620).

All participants signed an online informed consent form specifying that the data recorded in the surveys would be completely anonymous and would be analyzed for statistical purposes. Participation was voluntary and no financial compensation was provided.

In the informed consent, participants also had to declare: 1) not to have any previous formal psychiatric diagnosis; 2) not to suffer from any medical illness that would prevent proper collaboration with this research (e.g., dementia, severe terminal illness and/or severe handicaps); and 3) they declared to be of legal age and to collaborate in this study for a prolonged period of time (approximately 10-11 months). Participants had to answer several online questionnaires from June 2021 to March 2022 (the period during which the sample and responses were collected).

2.2. Materials

2.2.1. New Ecological Paradigm (NEP)

New Ecological Paradigm (NEP) is the name of the scale that examines ecological beliefs and skills based on 3 dimensions: 1) Satisfaction (5 items, alpha= 0.95) - this dimension analyzes the degree to which the person believes that nature is a positive, pleasant and safe environment for human life; 2) Investments (5 items, alpha= 0.92) - this factor measures the degree to which the individual believes that his or her actions favor nature, or, in other words, it measures the degree of involvement between nature and the individual; and 3) Alternatives (5 items, alpha= 0.85) - this dimension measures the degree to which the individual believes that he/she can develop leisure activities in non-natural environments. In this case, 'Alternatives' examines whether more urban environments can have the same satisfaction as natural environments for the individual. All responses were coded following the Likert scaling model (from 0 to 4). Each participant had to indicate the degree to which he or she agreed with the content of each item. The NEP has been statistically validated since its original publication (see Dunlap & Van Liere, 1978) and in

subsequent revisions (Dunlap et al., 2000). In all these studies, excellent psychometric properties were obtained for the NEP.

2.2.2. Willingness to sacrifice for the environment

This was a self-report scale developed by Davis et al. (2011) for the purpose of measuring the degree of engagement the individual has with nature. This degree of commitment is measured with five items that express content related to acts of sacrifice that the person should make in favor of nature. Using a graduated scale from 0 to 8, the participant must indicate the degree to which he/she would agree to make each of the sacrifices contained in the five items. The reliability of this scale was excellent (alpha coefficient greater than 0.8) and presented a very satisfactory validation as a psychometric indicator (Davis et al., 2015).

2.2.3. Abbreviated Place Attachment Scale (APAS)

The APAS is a self-report scale recently developed by Boley et al. (2021) with the aim of quantitatively measuring the degree of sense of place that a person perceives towards his or her environment. The APAS is a shortened version of a bank of 15 original items, of which only six were validated for psychometric reasons. Of the six total APAS items, three form the place identity dimension, which measures the degree to which a person's positive memories are identified with the physical characteristics of the environment. The remaining three items make up the dependence dimension, which measures the degree of affective dependence a person has on a specific place. Responses were coded using a Likert scaling model from 0 to 4 in which the participant had to determine the degree to which he/she agreed with the contents of each of the items. The statistical substantiation of the APAS was excellent at different levels. Boley et al. (2021) developed analyses of reliability, construct validity and also analyzed factorial invariance to test for significant cross-cultural differences when the APAS was used with samples from various countries. All the results support the goodness of the APAS and in this sample the reliability coefficients were also very good (ordinal alpha coefficients > 0.8).

2.2.4. State-Trait Anxiety Inventory (STAI)

The STAI is a questionnaire well known in clinical practice for measuring states of stress and trait anxiety in both healthy and pathological populations. It was originally developed by Spielberger et al. (1970) and has two versions consisting of 20 items each (state-type version or

"S" and trait-type version or "T"). The former measures dynamic and changing anxiety states according to circumstances and the latter evaluates anxiety as a stable personality trait. In this study only the state-type version was used since our purpose was to examine the longitudinal impact of the circumstances associated with natural disasters (specifically, the La Palma volcano disaster). In this version each item manifests a specific symptom of stress and the subject must determine the frequency in which he/she has perceived each of the symptoms in the last week. The coding of the responses was done with the Likert model from 0 to 3. The STAI-S was validated and adapted to multiple languages with satisfactory results in all of them (Andrade & Devlin, 2015). In addition, the reliability coefficients in this study were very satisfactory (urinal alpha >0.8).

2.3. Procedures

This research had a quasi-experimental and correlational design. Sampling was non-probabilistic and lasted a total of 10 months (from June 2021 to March 2022). In total, four data collections were applied distributed in time intervals of 2 months. Figure 2 illustrates the development of this research and describes the sample collection.

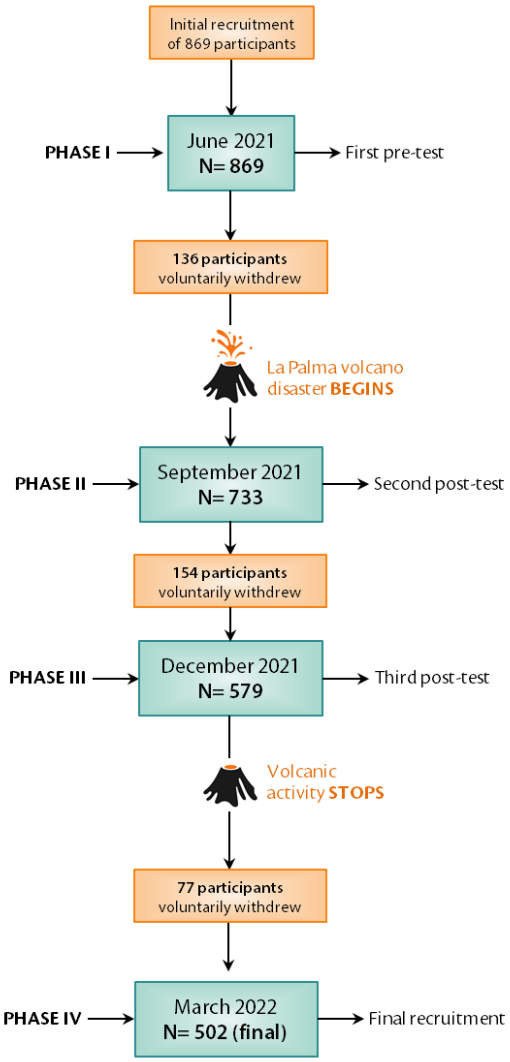

Figure 2. *Illustration and outline of the sampling and data collection during the 10 months of research. Diagram of own elaboration.*

Actually, the first data collection belonged to another research project on environmental psychology and urbanism. When the volcanic eruption began in September, the research team decided to focus its interests on including the natural catastrophe as an object of study variable. The reorganization of the project resulted in the present report shown here. The second data collection was carried out during the month of September (after the volcanic eruption began on September 19), the third data collection during the last 13 days of the volcanic activity (December), and the last data collection during the whole month of March 2022. The 2 month interval is a criterion that was established according to the beginning of the volcanic activity and the end date. Initially, during the month of June we wanted to perform a three-monthly

monitoring, but the arrival of this catastrophe forced us to reorganize the phases of data collection.

The approach was quasi-experimental because two types of groups of participants were defined: one group would be the victims affected by the volcano eruption (victim group) and the other group would function as a control group containing participants who were not affected by the eruption (control group). The discrimination or assignment of participants to each group was done by adding an extra question in the phase 3 data collection that asked the participant if he/she had been a direct victim of the La Palma volcano catastrophe. This included 1) complete loss of the home of residence due to lava flows and 2) having the home of residence affected (but not completely) by the eruption (e.g., partial collapse due to associated earthquakes, isolation of homes due to obstruction of roads and fires due to high temperatures). Participants who did not meet these criteria were classified into the control group. This extra query was included in the informed consent and was also repeated again in phase 4 data collection.

2.4. Statistical analysis

The data were processed with the SPSS statistical package, and the R programming language was also used to calculate effect sizes (see R Core Team, 2022, The JAMOVI Project, 2022). Two-factor analysis of variance tests (one repeated measures factor and one completely randomized factor) were applied. Statistical normality of the data distributions was assumed and the assumption of composite symmetry in the variance-covariance matrices between the groups was met for all dependent variables used (the Mauchly's sphericity test had acritical levels greater than 0.05). In the case of the completely randomized factor or with independent groups, the tests for homogeneity of variances were also met. The explained variance of each statistical contrast performed was measured from the partial eta-squared statistic, and Cohen's d corrected according to the criteria of Hedges' g was also used in the bivariate or pairwise comparisons.

In order to improve the fit and prediction of the functions of the dependent variables in the victim group according to the "time" variable (i.e., according to phases or time periods in which the data were collected), quadratic regression functions adjusted to the mean were used for the NEP, APAS and Anxiety (STAI) variables. The equation of the curve used was as follows:

$$\hat{y} = \beta_0 + \beta_1 X_p + \beta_2 X_p^2 \qquad [1]$$

The beta annotations are the parameters or regression coefficients. The subscript "p" is the initial of "phases" and corresponds to the predictor variable. In these analyses, regression to the mean was done because only the victim group averages for each time phase were taken into account. The purpose of fitting a quadratic model is to seek a better prediction of the observed effects and, by default, also an improvement in the function fit.

3. Results

The first step in summarizing the data from this sample is to provide descriptive statistics for all the variables analyzed and differentiated according to the control group and the victim group. Table 1 provides this initial and essential information for subsequent statistical inferences.

Table 1. *Descriptives statistics per group and measurement phase.*

Conditions	Dependent variables	Phase 1		Phase 2		Phase 3		Phase 4	
		M	S.D.	M	S.D.	M	S.D.	M	S.D.
Control (no victims) *n= 221*	NEP: Satisfaction	11.52	4.089	9.01	3.728	9.39	3.720	10.39	3.933
	NEP: Investments	11.15	4.184	9.64	4.053	9.48	4.06	10.77	3.709
	NEP: Alternatives	10.77	3.971	8.77	3.987	8.99	3.734	10.59	4.011
	NEP: total	33.43	9.799	27.43	8.954	27.86	8.730	31.74	8.787
	Nature commitment	21.72	8.617	23.54	8.842	24.64	7.891	25.21	8.606
	APAS: Place identity	6.07	2.701	5.60	3.245	5.457	2.655	7.15	2.799
	APAS: Dependence	6.06	2.587	5.77	3.190	5.32	2.646	7.18	2.744
	APAS: total	12.13	4.486	11.37	5.681	10.78	4.594	14.33	4.725
	STAI: anxiety state	23.22	4.818	24.16	4.733	23.58	4.638	22.42	5.001

	NEP: Satisfaction	11.14	3.717	9.34	3.378	7.24	3.652	9.63	3.108
	NEP: Investments	11.06	3.718	9.52	3.412	7.08	3.488	10.08	3.311
	NEP: Alternatives	11.08	3.784	9.33	3.428	6.96	3.190	9.59	3.102
	NEP: total	33.29	8.946	28.19	8.323	21.28	7.728	29.30	6.812
Victims *n= 281*	Nature commitment	21.11	7.547	23.61	8.438	23.21	7.540	26.51	7.192
	APAS: Place identity	6.79	2.729	5.36	2.923	3.35	2.747	6.09	2.165
	APAS: Dependence	6.67	2.928	5.28	2.835	3.44	2.803	6.11	2.185
	APAS: total	13.46	4.671	10.64	5.039	6.79	5.110	12.20	3.513
	STAI: anxiety state	23.03	4.903	30.40	5.437	34.46	6.809	29.52	5.385

Note: M= Means; S.D.= Standard Deviation.

The analyses of invariance (2-factor ANOVA) are shown in Table 2, as well as the variance explained and the effect sizes. As a complement and to facilitate the interpretation of the results, Figure 3 compiles the mean plots for each dependent variable. Using these graphs, it is possible to deduce in which phase the highest simple effects could be found.

Table 2. *Descriptives statistics per group and measurement phase.*

Variables	effects	df	F	Partial η^2 (Corrected)	Follow up *post hoc* tests (Only significant results are reported and Bonferroni correction was used)
NEP: Satisfaction	Follow up	3	105.762*	0.175	Phase 1-Phase 3 (t= 15.918; d= 0.710) Phase 1-Phase 4 (t= 6.988; d= 0.312) Phase 2-Phase 3 (t= 14.745; d= 0.658) Phase 2-Phase 4 (t= 5.814; d= 0.260) Phase 3-Phase 4 (t= -8.931; d= -0.399)
	Conditions	1	11.830*	0.023	
	Interaction	3	11.657*	0.023	
NEP:	Follow up	3	80.352*	0.138	Phase 1-Phase 2 (t= 7.950; d= 0.355)

Investments	Conditions	1	12.128*	0.024	Phase 1-Phase 3 (t= 14.725; d= 0.657) Phase 1-Phase 4 (t= 3.577; d= 0.120)
	Interaction	3	15.961*	0.031	Phase 2-Phase 3 (t= 6.775; d= 0.302) Phase 2-Phase 4 (t= -4.373; d=-0.195) Phase 3-Phase 4 (t= -11.148; d= -0.498)
NEP: Alternatives	Follow up	3	89.264*	0.151	Phase 1-Phase 2 (t= 9.792; d= 0.437)
	Conditions	1	5.520	-	Phase 1-Phase 3 (t= 15.410; d= 0.688) Phase 1-Phase 4 (t= 4.359; d= 0.195)
	Interaction	3	19.831*	0.038	Phase 2-Phase 3 (t= 5.618; d= 0.521) Phase 2-Phase 4 (t= -5.434; d= -0.243) Phase 3-Phase 4 (t= -11.052; d= -0.493)
NEP: total	Follow up	3	222.119*	0.308	Phase 1-Phase 2 (t= 15.577; d= 0.695)
	Conditions	1	11.240*	0.022	Phase 1-Phase 3 (t= 24.657; d= 1.100) Phase 1-Phase 4 (t= 7.976; d= 0.356)
	Interaction	3	42.207*	0.078	Phase 2-Phase 3 (t= 9.080; d= 0.405) Phase 2-Phase 4 (t= -7.601; d= -0.339) Phase 3-Phase 4 (t= -16.681; d= -0.745)
Nature commitment	Follow up	3	34.547*	0.065	Phase 1-Phase 2 (t= -4.926; d= -0.222)
	Conditions	1	0.119	-	Phase 1-Phase 3 (t= -5.734; d= -0.256) Phase 1-Phase 4 (t= -10.142; d= -0.453)
	Interaction	3	3.468	-	Phase 2-Phase 4 (t= -5.216; d= -0.233) Phase 3-Phase 4 (t= -4.408; d= -0.197)
APAS: Place identity	Follow up	3	108.908*	0.179	Phase 1-Phase 2 (t= 6.927; d= 0.309)
	Conditions	1	13.889*	0.027	Phase 1-Phase 3 (t= 14.704; d= 0.656) Phase 2-Phase 3 (t= 7.778; d= 0.347)
	Interaction	3	37.905	0.070	Phase 2-Phase 4 (t= -8.290; d= -0.370) Phase 3-Phase 4 (t= 16.068; d= -0.717)
APAS: Dependence	Follow up	3	105.613*	0.174	Phase 1-Phase 2 (t= 5.981; d= 0.267)
	Conditions	1	15.805*	0.031	Phase 1-Phase 3 (t= 14.155; d= 0.632) Phase 2-Phase 3 (t= 8.174; d= 0.65)
	Interaction	3	27.909*	0.053	Phase 2-Phase 4 (t= -8.020; d= -0.358) Phase 3-Phase 4 (t= -16.194; -0.723)
APAS: total	Follow up	3	178.283*	0.263	Phase 1-Phase 2 (t= 8.319; d= 0.371)
	Conditions	1	16.901*	0.033	Phase 1-Phase 3 (t= 18.609; d= 0.831) Phase 2-Phase 3 (t= 10.289; d= 0.459)
	Interaction	3	54.192*	0.098	Phase 2-Phase 4 (t= -10.517; d= -0.469) Phase 3-Phase 4 (t= -20.806; -0.929)

STAI: anxiety state	Follow up	3	134.638*	0.212	Phase 1-Phase 2 (t= -13.715; d= -0.612) Phase 1-Phase 3 (t= -19.456; d= -0.868) Phase 1-Phase 4 (t= -9.389; d= -0.419) Phase 2-Phase 3 (t= -5.741; d= -0.256) Phase 2-Phase 4 (t= 4.326; d= 0.193) Phase 3-Phase 4 (t= 10.067; d= 0.449)
	Conditions	1	401.120*	0.445	
	Interaction	3	114.846*	0.187	

Note: *p<0.001

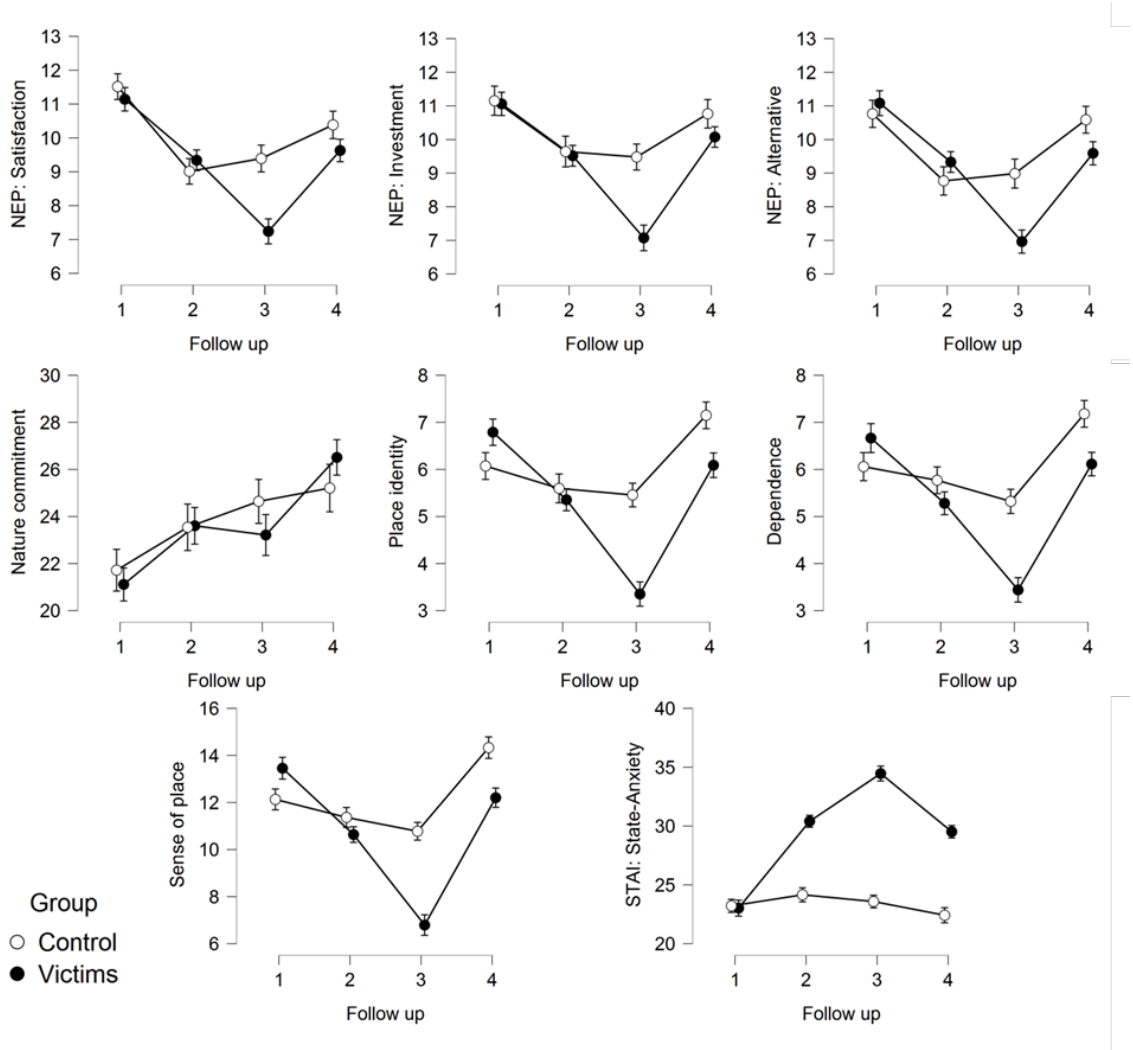

Figure 3. *Mean plots illustrating the trends of the means for each dependent variable and fixing on the x-axis (horizontal) the time variable or phases of data collection. Phase 3 shows the most significant or most relevant single effects.*

The results in Table 2 indicate that the main effects associated with the time variable (phases or "Follow up") generate variations in all the dependent variables included. These variations

explain 30.8% of the variance (specifically in the case of NEP total scores). The main effects of the control group vs. victim group variable (“Conditions”) also had significant effects (the largest achieved effect was found in the anxiety variable, for which 44.5% of the total variance of the scores was explained). The variable Conditions had no significant effects on the “nature commitment” and "alternatives" dimensions of the NEP questionnaire. The interaction main effects showed significant results for most of the dependent variables with the exception of the nature commitment variable. The highest explained variance for the interactions can be found in the anxiety variable, which accounts for 18.7% of the explained variance. Therefore, with these results (including the post-hoc tests) and focusing on the group of victims, we can conclude that the La Palma volcano catastrophe tends to generate decreases in the levels of ecological conception and beliefs (see NEP scale and dimensions) and sense of place (see APAS scale and dimensions). In contrast, the effects of the catastrophe on stress levels, specifically in the group of victims, generated initial increases that were correlated with the dates that determined the intensity of the volcanic activity. The variable nature commitment showed increases in scores as the natural catastrophe progressed. This is relevant because it informs how natural catastrophes could reinforce people's real commitment to the natural care of the environment.

Considering Figure 3, patterns and trends are observed that are in line with the previous results. The trend in most of the variables is initially decreasing (probably due to the La Palma volcano eruption) and in the last phase, having overcome the end of the volcanic activity, the average levels tend to increase. This trend can be applied to all variables with the exception of the anxiety and nature commitment variables, which, as we have already seen, offer different patterns.

Figure 3 shows information on the simple effects that may be of interest in this study. Looking at the trends in the graphs, we can see that the differences between the control group and the victim group are greater when the measurements reach phase 3 for all dependent variables, with the exception of nature commitment. This supports the need to test statistically whether such visual differences in the graphs can also occur at the statistical level. To this end, Table 3 summarizes the simple effects tests focusing on phase three of the measurements, which is where the distances between the means of one group and the other are greatest.

Table 3. *Analysis of the simple effects of measurement phase 3 (control vs. victims).*

Variables	Mean difference	Standard error	t-test (Bonferroni correction was used)	Cohen's d (Corrected version using Hedges' g)
NEP: Satisfaction	2.152	0.328	6.552*	0.584
NEP: Investments	2.405	0.335	7.185*	0.640
NEP: Alternatives	2.022	0.327	6.188*	0.590
NEP: total	6.579	0.764	8.611*	0.804
Nature commitment	1.429	0.724	1.973	-
APAS: Place identity	2.105	0.247	8.520*	0.778
APAS: Dependence	1.880	0.247	7.611*	0.687
APAS: total	3.985	0.427	9.337*	0.816
STAI: anxiety state	-10.875	0.477	-22.783*	1.828

Note: *p<0.001

As expected, the simple effects tested were significant and the effect sizes were moderate for all variables. This reinforces the results concluded in the previous paragraphs and supports the hypothesis of the effects that natural disasters can have on ecological beliefs, commitment to the environment, sense of place and stress levels.

The trends in the victim group mean plots of the APAS and NEP (total scores) and anxiety variables can be quite useful indicators that summarize the above information in a more accurate and adjusted way. Visually, the trend of these graphs seems to coincide or have a parabola shape. As the time variable (measured in 4 phases) can be considered a continuous quantitative variable, this detail suggested the possibility of fitting three quadratic functions (adapted to these variables) that would make it possible to predict the impact of this type of catastrophe with a smaller margin of error (and with a greater explained variance) on the victims. Figure 4 brings together the quadratic functions.

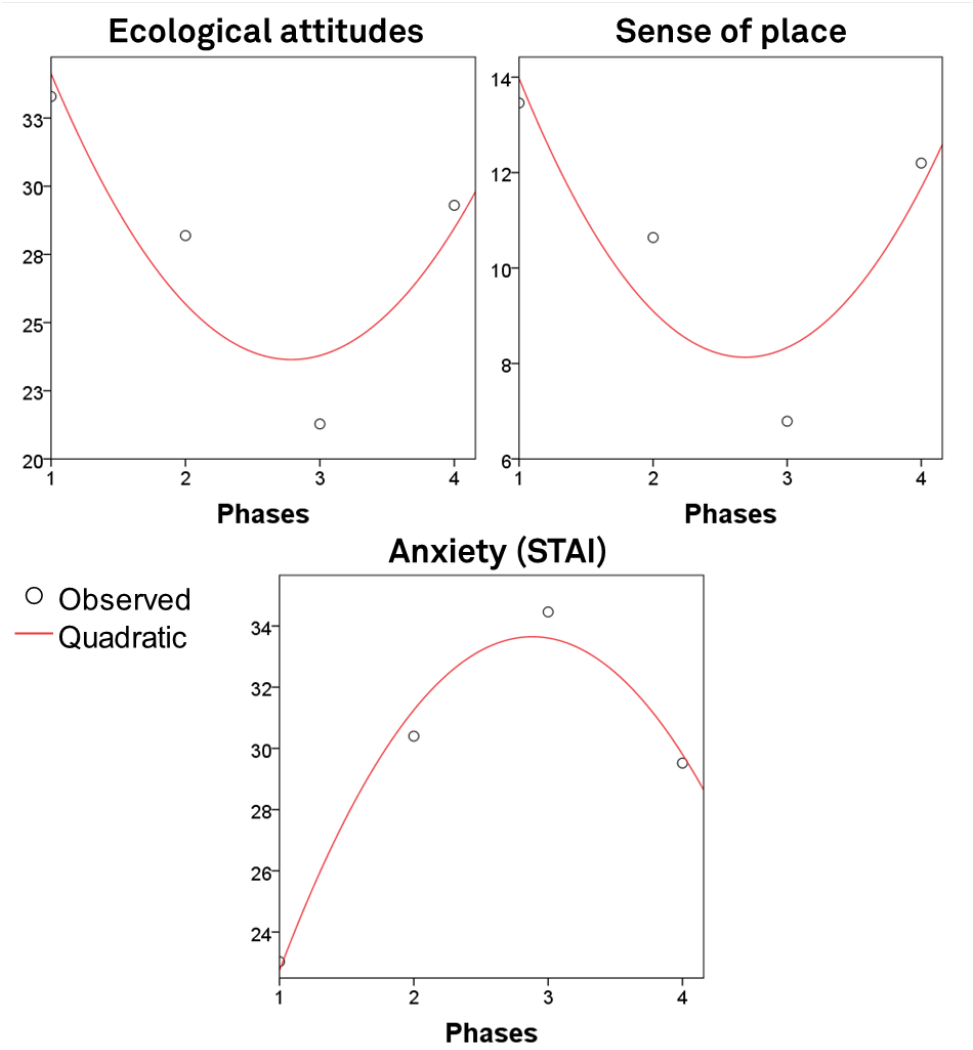

Figure 4. *Quadratic functions illustrating the curvilinear relationship between NEP, APAS and anxiety scores with the predictor variable time or phases.*

In the case of ecological attitudes (NEP scores), a quadratic association index of 0.902 was obtained with an explained variance of 43.9% (unstandardized regression coefficients: β_0= 49.135, β= -18.288, β_2= 3.280). For the sense of place variable (APAS scores), the quadratic correlation was 0.888 and the time variable explained 36.8% of the variance (unstandardized regression coefficients: β_0= 22.968, β= -11.051, β^2= 2.058). Finally, for the anxiety variable, a correlation index of 0.988 was found with an explained variance of 92.8% (unstandardized regression coefficients: β_0= 8.082, β= 17.741, β^2= -3.078).

As the sample size of the time variable was limited to 4 phases, the critical levels associated with the regression coefficients were not significant. This means that all of them were greater than 0.05 ($p>0.05$). However, it is mathematically appreciable that the parameter values of the equations clearly differ from "0" (e.g., $17.741 \neq 0$). We believe this is due to a problem with the number of phases (n=4). Considering the weights associated with the explained variance, if the sample size increased the beta coefficients would indeed be significant (with $p<0.05$). We make this important observation at this point of the report to warn that these quadratic analyses should be taken only as a guideline and as a possible reference for future research. In no case do they present statistically stable results. On these lines, we note that this last analysis was only complementary and is provided in case it could be of pedagogical use to other researchers.

4. Discussion

This research aimed to analyze the effects of natural disasters on the levels of ecological attitudes, commitment to nature, sense of place and anxiety. The eruption of the La Palma volcano was used as a natural disaster that affected more than 6,000 individuals residing in municipalities near the volcano. The importance of analyzing changes in these variables lies in two areas of public interest. First, it is convenient to know whether natural disasters affect ecological attitudes and commitment to the environment as a source of evidence for making decisions regarding the development of environmental campaigns and policies that strengthen the society-ecology link (see Chekima et al., 2015; Liu et al., 2018; Ziegler, 2021).

Second, it is essential to analyze sense of place because it represents a coping mechanism that a person uses to deal with crisis situations (such as natural disasters) and resulting difficulties related to the environment. Functional coping mechanisms would imply relatively high and stable levels of sense of place throughout the unfolding of the natural disaster (Swapan & Sadeque, 2021; Yang & Bae, 2022). Knowing how society reacts to and copes with natural disasters is also

useful information for political authorities, who should attend to the victims and offer them both direct solutions and the necessary psychosocial support to ensure well-being and the defense of life.

The results of this research report three significant trends in three different groups of variables. First, ecological attitudes/beliefs and sense of place tend to decrease systematically at the onset of the natural disaster (see Figure 3); this decline continues to decrease after its remission. Our results support the theory that victims of a natural disaster are in conflict with the environment, perceive it as unsafe and, therefore, have no motives, stimuli, or reasons to hold beliefs/attitudes in favor of environmentalism and associated efforts to protect the environment. This may be related to an indirect distrust of the ecological culture or paradigm. This distrust could be explained by the very threats related to natural disasters, which at the same time favor reductions in 17.5% of the levels of satisfaction with the environment.

If we take into consideration that sense of place intervenes as a coping mechanism (see Call et al., 2017; Fatemi et al., 2017), this decrease also reveals a process of detachment with the environment. Moreover, if we take into account the contributions of Swapan & Sadeque (2021), the fact that victims are separated from their homes may also have effects on the person-environment relationship and impair perceived attachment to place. Swapan & Sadeque's (2021) approach was the other way around: elevated levels of sense of place are what promote the decision in victims to remain in the homes of residence. Our results would support that the decision to stay in homes of residence vs. leave would also have effects on the levels of sense of place. In the sample of this study, the group of victims completely abandoned their homes and were not able to return to their homes until January 2022. Taking all this on board, we have more reasons to affirm that abandonment of homes impairs the levels of sense of place. However, this speculation is a hypothesis that should be contrasted in future research, because in this study it was not possible to discriminate whether this decrease in sense of place was due to the catastrophe itself or to the specific fact of abandoning homes. What was obtained in this research was evidence of association, but not of causation, which invites a cautious interpretation of the findings. To conclude this first point, it should be added that after the decrease in the trend of the scores of these variables, there is an increase or growth that coincides with the remission of the volcanic activity recorded. This is important, as it would imply that the alterations and reductions observed in this research would be temporary. It is true that this increase in scores was not proportional nor did it coincide with the initial June 2021 scores. This also warns that a longer

longitudinal follow-up in time (i.e., with more phases or moments of measurement) will be necessary to understand and know when the levels of these variables will stabilize after a natural disaster.

Second, it is important to note the pattern or trend of the nature commitment variable. Unlike the other graphs and curves, the trend of the means in this variable was increasing at all points in time. This more or less stable growth may be related to the desires to collaborate and find a solution to the problems produced by the natural disaster (Walton & Jones, 2018). Put in other words and in hypothetical terms, these increases could be explained because the victims would associate the catastrophe as a problem attributed to nature and, consequently, if they engage with nature, they would be committed to finding a solution to the catastrophe that happened. This would also be along the same lines explained by the cognitive theory of meaning systems (see Morris, 2019; Escolà-Gascón & Houran, 2021): the meaning that people could have about nature would be implicitly linked to "solving something" (in this case, it would be an environmental problem). This logic allows us to understand why there was this growth in the trend of averages. The more the catastrophe progressed and the situation worsened, the more intense the desire or willingness to commit to nature became. Undoubtedly, this trend will have to be contrasted and examined in subsequent research providing analysis on the consistency of the results.

Third, the trend of the means relative to stress levels should also be interpreted. These results coincide with other previous research that analyzed the stress level curves of natural disaster victims (López-Vázquez, E., & Marván, 2003; Fitzpatrick, 2021). As the natural disaster progresses and causes greater damage, it represents a greater danger and, consequently, generates more intense anxiety reactions. Theories explaining the processes of regulation and self-regulation can easily justify the results obtained (e.g., Jones & Bright, 2001). Stress is a physiological response based on activation of the sympathetic nervous system (see Brown et al., 2017). These activations are rationally to be expected and normal when real dangers exist in the environment that threaten the safety of individuals (Saraç-Lesavre & Laurent, 2018; Esterwood & Saeed, 2020). In these contexts, stress is a natural mechanism of the organism to warn us of potential threats; when we detect potential threats, we can make the anticipatory decision of how to fight, prevent the danger, or simply escape from the threat (Boyce & Ellis, 2005; Brosschot et al., 2019). Understanding this functional sense of stress in situations with habitual hazards (such as natural disasters), we can ask the following: how to regulate the stress levels of the population

(specifically of the victims) in order to procure an adaptive reduction of the population's alarm levels?

Although the results of this research do not allow us to answer this question precisely, the records obtained of stress levels were initially increasing and, after the volcanic activity ceased and the Spanish government began to repair the material damage, stress levels decreased abruptly and systematically. Volcanic inactivity, damage repair and social support were events that coincided with the decrease in stress levels, which is in line with the normalized functioning of stress discussed above and of the socio-political interventions that were applied by the government: 1) guaranteeing the safety of the affected citizens and minimizing the dangers/threats attributed to the respective natural disaster; and 2) guaranteed security - political actions were directed towards the reduction of social alarm signals (by repairing the material damage caused, economic compensations, etc.) and towards the social support of the affected victims (see EL PAÍS, 2021). This also coincides with evidence provided by other research (e.g., McGuire et al., 2018).

4.1. Limitations

The study of the environmental and psychosocial impact of natural disasters is not straightforward because natural accidents cannot be reproduced experimentally in a laboratory under completely controlled conditions. This observation implies that published research has not provided results from which empirical and experimental causality can be inferred, and this study is no exception. The design employed was quasi-experimental because there was no random assignment of participants to the research conditions (victim group vs. control group). This means that the observed effects are not technically causal and must be interpreted from a correlational perspective. However, this does not mean that they are not useful results or effects for scientific knowledge within this field. The evidence from this research reports that worldviews of ecology and sense of place are factors that are negatively affected by natural disasters. This has a number of psychosocial and political implications that we have already discussed in the previous paragraphs.

Another drawback of this study was that only a single natural disaster was chosen as a major event for analysis, which has implications for the generalizability of the data. This limitation raises is the following question: to what degree can the effects observed in this natural disaster be extrapolated to other natural disasters? This is a question that is partially resolved by the

generalization and statistical inference made with the data from this study (furthermore, the results were significant and moderate and high effect sizes were obtained). However, until these results are replicated in other studies based on different natural disasters, we cannot have any consistent assurance of such generalization. In addition, it should also be explored whether the characteristics of each natural disaster may moderate the effects observed in this research. It would be possible that more sudden and less controllable natural disasters (e.g., an earthquake) may have relevant changes in the curves and trends of the variables analyzed. It should be remembered that this volcanic eruption had no fatalities and could be managed in advance, but this is not the case for all disasters. This would also add variability that would have to be analyzed in future research.

Finally, another point to be taken with caution is the quadratic functions that were fitted with the NEP, APAS and anxiety variables. To apply the fitting of these functions, it was assumed that the time variable should be quantitative-continuous. The implication of this was to assume that we should no longer limit ourselves to the 4 averages based on the four temporal phases of measurement. Thus, the quadratic function would represent the predicted means taking the time variable as continuous. This should be interpreted with great caution because there were only 4 direct forecasts (observations). This number is not enough to be able to fit a function in a statistically stable way and there could be problems with the power of the critical levels. Regarding this analysis, we would like to emphasize that it was only a complementary analysis intended to provide pedagogical information on how to approach future research taking into account certain effects. We recommend that these analyses using quadratic curves be replicated in future studies from a time series approach with a larger number of repeated measures (at least >20 time phases).

4.2. Conclusions

The study of the impact of the La Palma volcano disaster allows the highlighting of four essential conclusions and evidences: 1) natural disasters damage the attitudes, beliefs and pro-ecological behaviors of the victims affected by the accident. If this decrease in pro-ecological behaviors is prolonged over time, it could be a resistance (and therefore a risk) for the development of sustainable urban environments. 2) Levels of commitment to nature and the environment increased after the catastrophe, which could be related to a system of beliefs and meanings that associates commitment actions with actions aimed at solving the natural accidents

produced by the catastrophe. We speculate that this increase does not necessarily reflect a real commitment to nature. 3) Sense of place levels were also altered after the catastrophe and decreased significantly. This is important because until now, the scientific literature considered sense of place as an antecedent variable that conditioned victims' decisions (whether to stay in or leave their homes); our results provide evidence that sense of place also acts as a consequent or dependent variable, given that it receives systematic effects and changes attributed to the course of the natural disaster. This would indicate that the decisions of the victims could change correlatively if the sense of place also changes, which could be an interesting psychosocial indicator for political and emergency authorities. And, finally, 4) Anxiety and stress levels have an antagonistic tendency to the curvilinear function of the NEP and APAS variables. This means that stress levels increase as the natural disaster progresses and decrease abruptly after it ends. We add that this abrupt decrease can also be explained by the social support received by the victims and by the repair of material damage, which helps to restore the infrastructure and public life of each affected municipality.

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