

9-1-2023

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[10.1016/j.jenvp.2023.102071](https://doi.org/10.1016/j.jenvp.2023.102071)

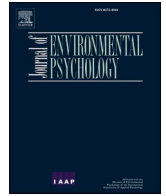
Leviston, Z., Stanley, S. K., Rodney, R. M., Wakler, I., Reynolds, J., Christensen, B. K., . . . Vardoulakis, S. (2023). Solastalgia mediates between bushfire impact and mental health outcomes: A study of Australia's 2019–2020 bushfire season. *Journal of Environmental Psychology*, 90, article 102071. <https://doi.org/10.1016/j.jenvp.2023.102071>

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## Solastalgia mediates between bushfire impact and mental health outcomes: A study of Australia's 2019–2020 bushfire season

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### ARTICLE INFO

Handling Editor: W. Schultz

#### Keywords:

Solastalgia  
Ecological grief  
Bushfire  
Wildfire  
Disaster recovery  
Mental health

### ABSTRACT

In 2019–2020, Australia experienced an unprecedented bushfire season that caused widespread environmental destruction across the continent, and especially to its south-east corner. Over two studies, we examine mental health outcomes of individuals impacted by bushfire, drawing on the concept of solastalgia – the sense of distress arising from unwanted environmental change – as a potential explanation for the mental health consequences of bushfire. In Study 1, we surveyed 2084 residents from the Australian Capital Territory and surrounding regions directly after the bushfire season. Participants were asked about exposure to the 2019–2020 bushfires, and to a previous regional fire of significance, experience of solastalgia, and five mental health indicators. In Study 2, we broaden our focus to all of Australia, and administer our measures with a nationally representative sample six months after the conclusion of the bushfire season ( $N = 1477$ ). In both studies, we find the severity of reported bushfire impact is significantly associated with mental health, such that greater impact predicts poorer outcomes. Moreover, we find the experience of solastalgia mediates the relationship between bushfire impact and mental health and wellbeing. Experiencing solastalgia is a partial, but important, mechanism for understanding the impact of bushfire exposure on mental health and wellbeing. Importantly, people not directly impacted by a bushfire event also experience solastalgia and subsequent poorer mental health outcomes following bushfires. We suggest that future measurements of the impact of abrupt environmental change events, including bushfires, consider the role of solastalgia and localised environmental contexts in shaping the mental health impacts to the population.

### 1. Introduction

In 2019–2020, Australia experienced a bushfire season with catastrophic impacts on communities and ecologies across large parts of the continent. The fires were long lasting and unparalleled in their severity, with possible significant impacts to psychological and physical health of those exposed.

Experiencing environmental disasters can impair people's everyday functioning and mental health (Beaglehole et al., 2018). With respect to

bushfires, experiences of post-traumatic stress disorder, depression, and severe psychological distress are common among impacted communities, even after several years have passed (Bryant et al., 2014). Fear for one's life, property loss, and the death of a loved one each predict poorer mental health outcomes (Bryant et al., 2014, 2020). The severity of impact from bushfires is important, with research showing that communities more highly impacted by bushfires display adverse mental health outcomes at higher rates than medium- and low-impacted communities (Bryant et al., 2014).

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<https://doi.org/10.1016/j.jenvp.2023.102071>

Received 1 February 2023; Received in revised form 16 June 2023; Accepted 9 July 2023

Available online 11 July 2023

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Bushfires can have a significant impact not just on individuals, but communities, the environment, and culture (Filkov et al., 2020; Gibbs et al., 2013; Williamson et al., 2020). Therefore, those who are not directly exposed to bushfire (i.e., not directly threatened by the fire front but exposed to media coverage, or learn of others' direct experiences with the fire) can also experience mental trauma due to a bushfire event (Byrne et al., 2006). These vicarious mental health effects suggest adverse impacts do not solely arise from a first-hand physical experience of bushfire and attendant threats to one's life and livelihood. Instead, less tangible forms of loss may also be implicated in negative consequences for health and wellbeing. Moreover, research on the impacts of bushfire on mental health has typically focussed on human elements of loss, such as the loss of human life, fear for one's own life, and loss of private property (e.g., Bryant et al., 2018). Few studies have examined the impact of environmental and ecological loss (and associated loss of 'place') caused by bushfires on health-related outcomes.

Given the growing body of research acknowledging the consequences of environmental degradation for wellbeing (e.g., Clayton & Karazsia, 2020; Higginbotham et al., 2006; Hogg et al., 2021), we explore how experiences of psychological loss associated with environmental change during the 2019–2020 Australian bushfires contribute to psychological distress. We do so by drawing on the psychological construct of solastalgia.

### 1.1. Solastalgia

'Solastalgia' is the sense of distress induced by ecological change perceived as negative (Albrecht, 2005, 2019). Relating to the ecological desolation of the place where one lives, solastalgia contributes to a deteriorated sense of belonging or 'place identity'. Solastalgia has variously been described as the "homesickness one gets when one is still at 'home'" (Albrecht, 2005, p. 45), and as the psychological, spiritual, and emotional distress caused by unwanted transformations to cherished landscapes (Galway et al., 2019). Solastalgia itself is not a mental illness (Albrecht, 2019), but the experience is distressing and recognised as "capable of causing a real and diagnosable illness" (Albrecht, 2005, p. 53).

In addition to adverse mental health outcomes, those who experience unwanted environmental change describe a sense of loss of control and mastery over their surroundings. Solastalgia "... undermines a personal and community sense of identity and control" (Albrecht, 2005, p. 46), borne from a sense of frustration at being helpless to stop or reverse ecological or environmental decline.

Solastalgia research has its roots in place-based qualitative research (Albrecht, 2005; Connor et al., 2004). Drawing on experiences in the south-west of Western Australia, and the Hunter Valley region of New South Wales, Albrecht and colleagues documented residents' lived experience of localised environmental change to develop and refine the construct. Much of this founding research concerns incremental and chronic changes to landscapes in the form of drought and open-cut mining impacts (Albrecht, 2005).

Research on the experience of solastalgia in response to *abrupt* environmental change – like bushfire – has only developed more recently. This work has been facilitated by the development of an Environmental Distress Scale (Higginbotham et al., 2006) which incorporates a 9-item solastalgia subscale, allowing investigation of solastalgia in survey-based research. Previous research has shown that bushfire-related solastalgia is associated with increases in clinically significant psychological distress (Eisenman et al., 2015). Eisenman et al.'s (2015) research was conducted one year after a serious wildfire in Arizona, United States. The authors found that, among 1387 households in communities adjacent to the fire, higher solastalgia was associated with clinically significant psychological distress, as indicated by responses on the Kessler Psychological Distress Scale. Similar work is yet to be replicated in Australia, so it is unclear whether the associations they identified are universal, or whether they will differ according to the

specific environmental and cultural contexts of a bushfire event.

Due to its diverse climatic zones and landscapes, Australia is highly vulnerable to a wide variety of climate-change-exacerbated environmental impacts. More severe and frequent heatwaves, bushfire seasons, flooding events, and drought are anticipated in different Australian regions, with multiple of these impacts potentially coinciding (Australian Academy of Science, 2021). Research on solastalgia typically investigates a key event or environmental stressor on feelings of loss of solace from place, such as after bushfire (e.g., Eisenman et al., 2015), volcanic eruption (e.g., Warsini et al., 2014), or coastal erosion (e.g., Phillips & Murphy, 2021). In the context of repeated environmental losses, this traditional approach overlooks the possible role of competing and compounding stressors and events that may affect the same communities. Some areas are more ecologically prone to bushfires than others, and this applies to many parts of Australia (Sharples et al., 2016). These areas are often highly vulnerable to other impacts, such as flood and storm exposure, and in places of higher socio-economic disadvantage (Sewell et al., 2016). Therefore, people's psychological responses to a particular bushfire or other climate disaster event may not occur in isolation, but can be shaped by a history of similar events, anxiety about future events, and coping appraisals in the face of repeated events.

Though much of the research on solastalgia comes from Australia (Galway et al., 2019), none has specifically examined solastalgia and wellbeing associations in the context of Australian bushfires. The size and frequency of bushfires are increasing in Australia (Lindenmayer & Taylor, 2020), as demonstrated by the Australian bushfires of 2019–2020. The bushfire danger period started early in the season,<sup>1</sup> with large parts of the fire-impacted areas already affected by prolonged drought. New South Wales, whose default bushfire danger period ranges from the start of October through to the end of March, had already declared the commencement of the 2019 bushfire danger period for much of the State by 17th of August (NSW Rural Fire Service, 2019a). The 2019–2020 bushfires were an unprecedented event and resulted in 34 people directly losing their lives, with many more injured, 417 excess deaths and 4456 hospitalisations attributed to the smoke, over 2400 residential properties lost, over 24 million hectares of land destroyed, and between 1 and 3 billion animals perishing, including iconic and endangered native species (Binskin, Bennett, & Macintosh, 2020; Borchers Arriagada et al., 2020; Richards et al., 2020; World Wildlife Fund, 2020). The smoke from the fires was transported by the wind over hundreds of kilometres, exposing around 10 million Australians to unprecedented levels of air pollution (Vardoulakis et al., 2020a, 2020b). The fires directly impacted parts of every Australian State and Territory, with the most intense and destructive fronts concentrated in the south-east of the continent. The fires were given significant global attention and received near continuous media coverage domestically. These 'Black Summer bushfires', as they came to be popularly described, are considered one of the world's most severe in recorded history (Rodney et al., 2021).

Over two studies, we investigate the mental health outcomes of being impacted by the 2019–2020 bushfire, first in a concentrated area in the south-east of Australia soon after the bushfires, and second with a large national sample six months after the bushfires. We aim to test whether solastalgia mediates between bushfire impact and mental health, both immediately following a bushfire within an impacted community, and

<sup>1</sup> The Australian 'bushfire season' typically applies to the whole year, running from June through to May. Peak times of bushfire activity and fire risk differ across Australia; in Northern parts of Australia activity is greater during the 'dry season' (spanning April to November), while in southern Australia (where loss of life due to bushfire most commonly occurs), danger periods typically peak in the summer and early autumn months (December through March; BOM, 2023). Each State and Territory jurisdiction can define the starting date of peak fire activity, which may vary from year to year (BOM, 2023, p. 1 June; Australian Institute for Disaster Resilience, 2023 1 June).

after the passage of time for a population with a highly varied experience of the bushfires. A two-stage approach with localised and national samples will allow for testing whether the mediational role of solastalgia can be both replicated and generalised.

## 1.2. Current studies

The Australian Capital Territory (ACT), home to Australia's capital Canberra, experienced several fires during the 2019–2020 season that threatened suburbs in the city's east and south, but was most severely impacted by extremely poor air quality from bushfire smoke driven from large fire fronts in nearby New South Wales. More than 95% of surveyed residents reported at least one physical health symptom due to bushfire smoke, and over half reported symptoms of anxiety, depression and poorer sleep (Rodney et al., 2021). Those with previous exposure to bushfire reported poorer physical and mental health outcomes (Rodney et al., 2021). A state of emergency for the ACT was declared on January 31<sup>st</sup>, 2020 through to February 2<sup>nd</sup>, 2020, the first such declaration since a significant bushfire event affected much of the Territory in January 2003.

The 2003 ACT bushfires resulted in four deaths, hundreds of injuries, and the total destruction of 470 homes (with many more damaged). Research on the impact of the 2003 bushfires indicated residents experienced considerable health and psychosocial problems for years after the fire (Camilleri et al., 2010). To explore the possibility of compounding stressors impacting solastalgia and wellbeing, we explore whether previous experiences with bushfire is also associated with residents' experiences following the 2019–2020 bushfire season.

In addition to previous bushfire exposure, we differentiate between milder forms of exposure and more severe exposure to the bushfire fronts. A mild exposure, for example being near to an area immediately threatened by bushfire, may have substantively different ramifications for psychological wellbeing than more severe exposure. Having to protect one's property from destruction, or being a first responder, risks not just one's physical safety, but entails greater first-hand exposure to the rapid environmental change and loss that drives solastalgia. In these studies, we differentiate between milder forms of exposure and more severe exposure utilising the framework developed by Rodney et al. (2021). Information about the coding process is included in the Method section below and in Supplementary Material.

## 2. Study 1

Study 1 explores associations between bushfire impact, solastalgia, mental health, and wellbeing outcomes in a large sample of people living in Canberra and surrounding regions during the 2019–2020 bushfires. We expected that increased severity of bushfire impact would be associated with poorer mental health and wellbeing outcomes, and that this association would be mediated by solastalgia. That is, we propose that solastalgia may partially explain why bushfire impact contributes to poorer mental health and wellbeing (consistent with Eisenman et al., 2015).

### 2.1. Methods

Residents of the ACT and immediately surrounding areas of New South Wales (NSW) aged 18 and above were eligible to take part in the survey. Participants were recruited over a six-week period between March and April 2020, via three methods: a random mail-out to 10,000 addresses selected from the ACTmapi database; an externally run population panel; a convenience sample recruited via social media, radio advertisements, and word of mouth.

We received 2095 completed responses, comprising 639 mail-out respondents, 644 panel respondents, and 812 convenience sample respondents. Eleven respondents were out of the area of interest or did not provide a valid postcode, and 190 respondents were identified as

multivariate outliers on the solastalgia or DASS21 measure (Mahalanobis  $p < .001$ ) and were thus excluded from analyses. The remaining participants ( $N = 1894$ ) were 57.7% female (41.2% male, 0.2% 'other', 0.2% preferring not to say, and 0.8% not responding), with a mean age of 50.56 years ( $SD = 16.73$ ; median = 52 years). Approximately 13% of the sample had completed a high school certificate or less, 17% a trade, apprenticeship, certificate or diploma, and 71% had completed a University degree. This suggests that our final sample included a greater proportion of women, and was on average older and more highly educated than the general ACT population based on census data (Australian Bureau of Statistics, 2021).

The measures reported here were included as part of a larger survey about Canberra residents' experiences of bushfire, bushfire smoke, poor air quality, health behaviours, and physical and mental responses during the 'period of interest' of the 2019–2020 bushfire season – 15 December 2019 to 15 February 2020 (Rodney et al., 2021). This date range was selected as it coincided with the period during which the most significant levels of bushfire smoke-related air pollution affected the ACT. Ethics approval was granted by the Human Research Ethics Committee of the Australian National University (protocol number: 2020/029) prior to data collection. The measures in Study 1 are described below.

#### 2.1.1. Bushfire impact score

Bushfire impact was measured by asking respondents to nominate what ways they were affected by the bushfire during the period of interest. Participants indicated whether they had experienced the following impacts: 'I voluntarily relocated', 'I was forced to evacuate', 'I had damage to or loss of property', 'I had a family or close friend affected', 'I had to cancel or alter travel or holiday plans', 'I was a firefighter or first responder', and 'Other'.

Following Rodney et al. (2021), and after coding open-ended responses detailing 'Other' impacts, a Bushfire Impact index was created consisting of three levels of exposure – none (none or indirect exposure to bushfire); mild (classified as responses limited to being in an area with fire nearby, evacuation due to bushfire, area of significance lost other than home, family member was affected, and/or home was affected while away); and severe (if experience included loss of or damage to property, direct contact with fire e.g., firefighter, or protecting property). See Supplementary Material for more information.

#### 2.1.2. Previous bushfire experience

Respondents were asked whether they had experience with bushfire prior to the period of interest, by indicating whether they had experienced the following: 'I had been in an area with fire nearby', 'I was evacuated due to bushfire', 'I experienced loss or damage to property', 'I had direct contact with bushfire (e.g., firefighter or protecting property', 'other').

Following Rodney et al. (2021), a Previous Bushfire Experience index was created consisting of three levels of previous exposure – none (not affected, or effects were limited to health and/or smoke effects); mild (responses limited to voluntary evacuation, family or close friend affected, cancellation or alteration of holiday plans/events, and/or business or work affected); and severe (if experience included forced evacuation, damage to or loss of property, firefighter, first responder, volunteer, protected property, alert to evacuate, and/or worry about property or risk).

#### 2.1.3. Solastalgia

We included the nine items of the revised solastalgia subscale of the Environmental Distress Scale (Higginbotham et al., 2006), e.g., "Unique aspects of nature that made this place special are being lost forever". Participants indicated their agreement with the statements in relation to change in their local environment in the Canberra region on a 5-point scale from '1 – strongly agree' to '5 – strongly disagree', with an additional option of 'does not apply'. Items were reverse-coded so that higher scores represented greater experiences of solastalgia, and

responses of 'does not apply' were removed prior to analyses. A psychometric analysis of the scale's properties using the Study 1 and 2 datasets showed redundant content of four of the scale's items, and recommended a short-form scale consisting of only five items (see Christensen et al., 2023, and Supplementary Material for an overview of the scale shortening process). Thus, we used the five items comprising this Brief Solastalgia scale in the current study ( $\alpha = 0.89$ ;  $M = 3.19$ ,  $SD = 0.96$ ; see Supplementary Material for retained items).

#### 2.1.4. Mental health and wellbeing

To examine mental health and wellbeing outcomes, we included the measures described below. The measures were selected to capture both negative and positive outcomes, and to cover aspects of both mental health (depression, anxiety, stress, and general psychological distress) and psychological wellbeing. Moreover, the instruments are widely used, with good reliability and validity, and are easy to administer in surveys, thus making them suitable for replication work.

**DASS21.** The Depression, Anxiety, and Stress Scale (DASS21; Lovibond & Lovibond, 1995) was used to measure experiences of depression ( $\alpha = 0.89$ ;  $M = 1.44$ ,  $SD = 0.49$ ), anxiety ( $\alpha = 0.82$ ;  $M = 1.37$ ,  $SD = 0.44$ ), and stress ( $\alpha = 0.90$ ;  $M = 1.63$ ,  $SD = 0.58$ ), with seven items per construct. Participants rated the extent each statement (e.g., 'I found it hard to wind down') applied to them during the period of interest (i.e., from 15 December 2019 to 15 February 2020), from '1 – did not apply to me at all' to '4 – applied to me very much, or most of the time'.

**Distress.** The Distress Questionnaire-5 (Batterham et al., 2016) was used to measure psychological distress experienced by participants during the period of interest. We included this measure as the DASS21 was developed specifically to differentiate between depression, anxiety, and stress, whereas the Distress Questionnaire provides a more general indicator of distress. Five items, e.g., "I had trouble staying focused on tasks" were measured on a scale from '1 – never' to '5 – always', with higher scores denoting higher distress ( $\alpha = 0.91$ ;  $M = 2.14$ ,  $SD = 0.88$ ).

**Psychological Wellbeing.** Psychological wellbeing was measured using the 5-item World Health Organisation Well-being Index (WHO-5; Topp et al., 2015), e.g., 'I woke up feeling fresh and rested'. Responses were measured on a 6-point scale from '1 – all of the time' to '6 – at no time'. Responses were reverse-coded such that higher scores denoted higher wellbeing ( $\alpha = 0.90$ ;  $M = 3.40$ ;  $SD = 1.07$ ).

## 2.2. Results

Over half of respondents (60.9%) reported at least one bushfire impact. The most reported impact was having to cancel or alter travel or holiday plans<sup>2</sup> (35.1%; coded as a mild impact), followed by having a family or close friend affected (28.3%; coded as a mild impact). Reported frequencies of each bushfire impact is included in Supplementary Material. Using our Bushfire Impact index, 801 participants (42.3%)<sup>3</sup> were recorded as experiencing no impact, 923 (48.7%) as experiencing mild impact, and 149 (7.9%) as experiencing severe impact. Data on impact was missing for 21 (1.1%) participants.

Table 1 presents the correlations between the key study variables. Of note, the severity of bushfire impact from the 2019–2020 fires was significantly related to poorer scores across each of the mental health and wellbeing outcomes, as well as to solastalgia, though the severity of impact from a previous bushfire was not significantly associated with any

<sup>2</sup> The prevalence of this response is likely due to the bushfires coinciding with the summer holiday period. The 'period of interest' did not coincide with covid-related restrictions on movement, which were to come into effect in March of 2020.

<sup>3</sup> The discrepancy of this score from those not nominating any impact (39.1%) is due to some participants nominating 'Other'. During hand coding some of these open-ended responses were not deemed to constitute mild or severe bushfire impact.

mental health and wellbeing outcomes.

Using hierarchical regressions, we assessed the unique contribution of bushfire impact, solastalgia, and previous bushfire experience in explaining mental health outcomes during the period of interest.<sup>4</sup> Previous research suggests scores on the DASS are associated with demographic variables (Crawford & Henry, 2003), therefore associations between outcome variables and demographics were run (see Supplementary Materials). As age and gender (but not education) were consistently significantly related to our outcome variables, and may also relate to bushfire exposure, they were controlled for in an initial step of the regression. At Step 2, we entered bushfire impact and previous bushfire exposure, and finally in Step 3, solastalgia.

Table 2 suggests that between 12% and 28% of the variance in mental health and wellbeing outcomes was explained by our full models. Controlling for participants' age and gender, bushfire impact had a negative effect on all outcomes. Previous bushfire experience explained no unique variance for any of the outcome variables. The inclusion of solastalgia explained additional variance for all outcome variables, consistently accounting for the most variance of all predictor variables. The regression results also show a drop in the strength of prediction of bushfire impact when solastalgia is added to the model, suggesting a possible mediation effect.

#### 2.2.1. The mediating effect of solastalgia

To test the mediating role of solastalgia in the association between bushfire impact and mental health and wellbeing outcomes, a path model was constructed in R using Lavaan (Rosseel, 2012) using the robust maximum likelihood estimator (MLR). The model (Fig. 1) was a fully saturated path model, with the bushfire impact index set to predict each of the five mental health and wellbeing outcomes through the mediator of solastalgia. The sample size for this model was 1527 due to listwise deletion.

Bushfire impact was a significant predictor of solastalgia ( $\beta = 0.08$ ,  $p = .002$ ; 95% CI [0.03, 0.13]). In Table 3, we present the standardised direct, indirect (through solastalgia), and total effects of bushfire impact on each of the mental health and wellbeing outcomes, as well as the effect of solastalgia on each outcome. These demonstrate that part of the association between the severity of bushfire impact and mental health and wellbeing is accounted for by experiencing solastalgia. That is, those who faced more severe effects of the 2019–2020 bushfires experienced significantly poorer mental health and wellbeing, and this was to some extent explained by their heightened experience of solastalgia.

When the model is run while controlling for age and gender, all direct, indirect, and total effects remain statistically significant, including the effect of bushfire impact on solastalgia ( $\beta = 0.06$ ,  $p = .029$ ; 95% CI [0.01, 0.11]; See Table S6 in Supplementary Material for full results). Interestingly, in this model, age is not a significant predictor of solastalgia ( $\beta = -0.04$ ,  $p = .124$ ; 95% CI [-0.09, 0.01]). Although our full models are saturated and therefore fit statistics are unavailable, dropping the path from age to solastalgia reveals that our model provides excellent fit to the data ( $\chi^2(1) = 2.33$ ,  $p = .127$ , CFI = 1.00, TLI = 0.99, RMSEA = 0.03, 90% CI [0.00, 0.08], SRMR = 0.01, N = 1516).

## 2.3. Discussion

Study 1, conducted with residents of the ACT and surrounding regions immediately after the bushfires, showed that people who were

<sup>4</sup> As our Bushfire Impact index and previous exposure measures were ordinal (3 levels), we computed the regressions with a binary measure of impact and previous exposure (whereby mild and severe impact were combined, thus creating a '0 = no impact'/'1 = impact' binary score). As results were consistent across models (see Supplementary Material for results using the binary index), regressions in the main text use the more fine-grained though ordinal impact and exposure variables.

**Table 1**  
Bivariate correlations of key variables in Study 1.

	1.	2.	3.	4.	5.	6.	7.
1. Bushfire impact							
2. Solastalgia	.09**						
3. DASS21 - Depression	.17**	.27**					
4. DASS21 - Anxiety	.18**	.21**	.72**				
5. DASS21 - Stress	.27**	.28**	.77**	.73**			
6. DQ5 - Distress	.24**	.28**	.72**	.62**	.76**		
7. WHO5 - Psychol. Wellbeing	-.20**	-.28**	-.57**	-.44**	-.59**	-.66**	
8. Previous bushfire impact	.04	.03	-.02	.01	-.01	.01	-.02

Note. Associations with bushfire impact and previous bushfire impact are based on Spearman's correlations, all others are Pearson's correlations. \*  $p < .01$ ; \*\*  $p < .001$ .  $N$  ranges from 1664 (correlation between DASS21 anxiety and Solastalgia) and 1835 (correlation between Bushfire impact and DQ5 - Distress).

more severely impacted by the 2019–2020 bushfires self-reported feeling more depressed, anxious, stressed, distressed, and experiencing lower psychological wellbeing during the period of the bushfires. Our findings indicate that a diminished sense of solace from one's landscape contributes to self-reported distress. Across all outcome variables, the link between bushfire impact and distress/wellbeing was partially mediated by solastalgia. Although the mediating effect of solastalgia was small (Table 3), it remained statistically significant when controlling for age and gender (Table S6), suggesting the effect is robust.

It is not clear from this study the extent to which the impacts of bushfire on mental health and wellbeing persist across time, nor whether some effects only emerge with the passage of time. We did show that those who had prior experience with bushfire did not recall significantly greater mental health or wellbeing impacts at the time of the more recent 2019–2020 exposure. Therefore, the experience of a previous bushfire impact does not necessarily exacerbate the distress experienced at subsequent exposure. However, we cannot say how long mental health or wellbeing effects of bushfire may remain, as participants in this study were reporting their distress and wellbeing *during the period of the fires*. Previous research (e.g., Bryant et al., 2018) suggests a small but significant proportion (20%) of people continue to experience psychological symptoms five years after an event, though it is not clear how this is compounded by secondary events such as job loss or other psychosocial factors. It is also unclear from this study whether the mediating role of solastalgia is a temporary response to the impacts of a severe event, or whether solastalgia persists temporally. Eisenman et al. (2015) surveyed participants approximately one year after a wildfire in Arizona and noted ongoing solastalgia and distress in the community, suggesting long-term impairments are possible.

In addition to this temporal element, Study 1 was limited in geographical focus, leaving open the possibility that the associations we observed were due to the unique environmental impacts to one particular region. During the bushfires, much of the ACT was blanketed by heavy smoke, and while not treated here as a direct bushfire impact, may have been a contributing factor to levels of solastalgia (see Rodney et al., 2021 for the bushfire smoke's adverse contribution to health outcomes, and Eisenman & Galway, 2022 for a review of the effects of bushfire smoke on mental health and wellbeing).

As most research on solastalgia is geographically localised, little is known about whether the precursors and antecedents to solastalgia extend beyond local geographical boundaries. The Australian bushfires of 2019–2020 impacted large areas of Australia, but in different ways and to different degrees. These wider impacts included significant fires and loss of human life and threatened species in South Australia, large fires in the south west of Western Australia, and fires in multiple parts of Tasmania. Moreover, media coverage of the fires was widely broadcast across Australia, potentially exposing all Australian residents vicariously to distress and adverse mental health effects stemming from feelings of environmental loss (Loois et al., 2020). Much of the imagery that was broadcast included portrayals of environmental destruction to flora and fauna that is identifiable as uniquely Australian (e.g., koalas), in addition to being a characteristic of more heavily fire-impacted areas.

In Study 2, we broaden our research focus to all of Australia. Moreover, we test whether the significant associations observed between bushfire impact with solastalgia and mental health outcomes are identifiable six months after the conclusion of the bushfire season, across areas with a diverse array of exposure to the bushfires.

### 3. Study 2

In Study 2 we surveyed a nationally representative sample of Australian residents collected six months after the 2019–20 Australian summer. Here we explore the associations between severity of experiences in the 2019–2020 bushfires, and *current* experience of solastalgia and mental health.

#### 3.1. Methods

Participants were recruited via the panel aggregator Qualtrics, and completed the survey online between August 20 and September 20, 2020. The questions were part of a larger study of attitudes to climate change. Ethics approval was granted by the Human Research Ethics Committee of the Australian National University (protocol number: 2020/429) prior to data collection. A total of 5110 participants completed the survey. Multivariate outlier analysis (Mahalanobis  $< 0.001$ ) identified 604 outliers on the solastalgia and DASS21 measure, who were removed. The remaining participants ( $N = 4512$ ) were 49.6% female (50.1% male, 0.1% "other" and 0.2% "prefer not to say"), with an average age of 48.34 years ( $SD = 17.50$ ; median = 48 years).

To select the sample for our study, participants responded to an initial question asking "Please think about your local environment. Do you think that over the last few years the quality of your local environment is getting better, staying the same, or getting worse?" Responses were recorded on a 5-point scale with the labels '1 – getting much worse'/'2 – getting a bit worse'/'3 – staying the same'/'4 – getting a bit better'/'5 – getting much better'. Those who selected either 1 ( $n = 253$ ) or 2 ( $n = 1224$ ) were then directed to complete the solastalgia scale. This subsample ( $N = 1477$ ) were 51.7% female (47.9% male, 0.2% "other" and 0.3% "prefer not to say"), with an average age of 46.10 years ( $SD = 17.46$ ; median = 44 years).

##### 3.1.1. Bushfire impact

Bushfire impact was measured using the same item and coding as in Study 1 with reference to the bushfires of 2019–2020, and with reference to the same period of interest – 15 December 2019 to 15 February 2020 (see Supplementary Material for more information on the coding process). As previous bushfire experience was not found to significantly relate to other variables in Study 1, it was not used in further analyses.

##### 3.1.2. Solastalgia

Participants responded to the 9-item subscale of the Environmental Distress Scale by rating their agreement with the statements with relation to changes in their local environment from '1 – strongly disagree' to '7 – strongly agree'. Unlike Study 1, an option for 'does not apply' was

**Table 2**  
Hierarchical regressions with key variables predicting mental health outcomes.

	DASS21 - Depression				DASS21 - Anxiety				DASS21 - Stress				DQ5 - Distress				WHO5 - Psych. Wellbeing			
	b	SE	$\beta$	t	b	SE	$\beta$	t	b	SE	$\beta$	t	b	SE	$\beta$	t	b	SE	$\beta$	t
<i>Constant</i>	1.63	.04		40.27**	1.61	.04		44.60**	2.01	.05		43.04**	2.88	.07		42.71**	2.99	.09		34.71**
Age	-0.01	.00	-.19	-7.96**	-0.01	.00	-.23	-9.88**	-0.01	.00	-.29	-12.92**	-0.02	.00	-.36	-16.95**	0.01	.00	.21	9.57**
Gender	0.13	.02	.13	5.62**	0.10	.02	.11	4.84**	0.21	.03	.18	8.11**	0.38	.04	.21	10.07**	-0.48	.05	-.22	-9.95**
	$R^2 = .06^{**}$				$R^2 = .08^{**}$				$R^2 = .14^{**}$				$R^2 = .21^{**}$				$R^2 = .11^{**}$			
<i>Constant</i>	1.52	.05		33.07**	1.53	.04		37.00**	1.85	.05		35.20**	2.66	.08		34.97**	3.30	.10		33.85**
Age	0.00	.00	-.16	-6.96**	-0.01	.00	-.21	-8.94**	-0.01	.00	-.26	-11.59**	-0.02	.00	-.33	-15.76**	0.01	.00	.18	8.22**
Gender	0.11	.02	.11	4.79**	0.09	.02	.10	4.19**	0.18	.03	.15	6.86**	0.34	.04	.19	9.07**	-0.44	.05	-.20	-9.07**
Bushfire Impact	0.06	.01	.15	6.66**	0.04	.01	.12	5.21**	0.10	.01	.21	9.67**	0.12	.01	.17	8.17**	-0.15	.02	-.18	-8.22**
Previous impact	0.00	.02	.00	0.13	0.01	.02	.01	0.50	-0.02	.02	-.02	-0.83	0.00	.03	.00	0.13	-0.02	.04	-.01	-0.45
	$R^2\Delta = .02$ ; $F\Delta = 22.20^{**}$				$R^2\Delta = .01$ ; $F\Delta = 13.79^{**}$				$R^2\Delta = .04$ ; $F\Delta = 46.96^{**}$				$R^2\Delta = .03$ ; $F\Delta = 33.45^{**}$				$R^2\Delta = .03$ ; $F\Delta = 33.96^{**}$			
<i>Constant</i>	1.17	.06		19.53**	1.29	.05		23.60**	1.46	.07		21.38**	2.04	.10		20.99**	4.09	.12		32.86**
Age	0.00	.00	-.16	-6.83**	-0.01	.00	-.20	-8.53**	-0.01	.00	-.25	-11.28**	-0.02	.00	-.33	-15.40**	0.01	.00	.16	7.23**
Gender	0.09	.02	.09	4.04**	0.08	.02	.09	3.67**	0.16	.03	.13	5.87**	0.30	.04	.17	7.91**	-0.41	.05	-.19	-8.33**
Bushfire Impact	0.05	.01	.12	5.24**	0.03	.01	.10	4.01**	0.08	.01	.18	8.00**	0.09	.01	.14	6.47**	-0.12	.02	-.15	-6.70**
Previous impact	0.00	.02	.01	0.22	0.01	.02	.01	0.34	-0.01	.02	-.01	-0.43	0.00	.03	.00	0.11	-0.02	.04	-.01	-0.63
Solastalgia	0.12	.01	.24	10.32**	0.08	.01	.18	7.73**	0.14	.01	.22	10.20**	0.22	.02	.23	11.13**	-0.25	.02	-.23	-10.12**
	$R^2\Delta = .06$ ; $F\Delta = 106.51^{**}$				$R^2\Delta = .03$ ; $F\Delta = 59.73^{**}$				$R^2\Delta = .05$ ; $F\Delta = 103.97^{**}$				$R^2\Delta = .05$ ; $F\Delta = 102.37^{**}$				$R^2\Delta = .05$ ; $F\Delta = 102.37^{**}$			
	$R^2 = .14^{**}$				$R^2 = .12^{**}$				$R^2 = .23^{**}$				$R^2 = .28^{**}$				$R^2 = .19^{**}$			

Note. Ordinal measure of bushfire impact used. \* $p < .01$ ; \*\* $p < .001$  [dummy-coded gender 1 set to female]. DASS21 = Depression, Anxiety, and Stress Scale; DQ5 = Psychological distress scale; WHO5 = Psychological wellbeing scale.

not included, as participants completing this scale were selected on the basis of indicating decline of their local environment. We opted for this approach to identify the impact of different levels of psychological distress caused by perceived environmental decline on mental health, without introducing 'noise' from those who consider their environment to be staying the same or improving. As for Study 1, we used the 5-item Brief Solastalgia Scale developed by Christensen et al. (2023) ( $\alpha = 0.89$ ;  $M = 4.72$ ,  $SD = 1.15$ ).

3.1.3. Mental health measures

As for Study 1, participants completed the three DASS21 subscales: depression ( $\alpha = 0.94$ ;  $M = 1.53$ ,  $SD = 0.67$ ), anxiety ( $\alpha = 0.90$ ;  $M = 1.35$ ,  $SD = 0.53$ ), and stress ( $\alpha = 0.92$ ;  $M = 1.57$ ,  $SD = 0.63$ ).

3.2. Results

Just under one-fifth of respondents (full sample 18.1%, subsample who perceived environmental decline 18.7%) reported at least one bushfire impact. The most common reported impact was having a family or close friend affected (full sample 9.9%, subsample 12.1%), followed by having to cancel or alter travel or holiday plans (full sample 6.5%, subsample 9.6%). Reported frequencies of each impact is included in Supplementary Material. Using our Bushfire Impact index, most participants were recorded as experiencing no impact (full sample 82.6%, subsample 77.6%), with 13.3% (full sample) and 17.3% (subsample) recorded as experiencing mild impact, and the remainder (4.1% for the full sample, and 5.1% for the subsample) recorded as experiencing severe impact.

Table 4 displays the correlations between the study variables. As for Study 1, direct bushfire impact was significantly correlated with solastalgia and each of the DASS subscales, and solastalgia was also significantly positively correlated with each of the DASS subscales.

Hierarchical regressions were conducted to assess the unique contribution of bushfire impact, and solastalgia in explaining mental health outcomes during the period of interest, while accounting for age and gender (Table 5). The addition of bushfire impact significantly increased the variance explained (over and above demographic variables) for anxiety and stress, but not depression. In each case, bushfire impact predicted greater distress. Adding solastalgia in a third and final step explained significantly greater variance, and solastalgia consistently predicted poorer mental health.<sup>5</sup>

We replicated the model created in Study 1 such that bushfire impact was set to predict mental health, this time indexed by the DASS, mediated by solastalgia. We again used the MLR estimator in Lavaan and used listwise deletion, which meant our sample size for the model was 1454.

Bushfire impact significantly predicted greater solastalgia ( $\beta = 0.10$ ,  $p = .001$ , 95% CI [0.04, 0.15]), indicating that the more severe the impact of the 2019–2020 bushfire season participants recalled, the more they currently felt the psychological loss to their local environment. As shown in Table 6, experience of the bushfires predicted greater anxiety and stress, and these effects were significantly mediated by solastalgia, which exerted a weak effect on all three mental health outcomes. Interestingly, bushfire impact was not significantly related to depression in Study 2.

Controlling for age and gender, the significant direct effects of bushfire impact on anxiety and stress remain. All indirect and total effects in the original model are still statistically significant, including the effect of bushfire impact on solastalgia ( $\beta = 0.09$ ,  $p = .001$ ; 95% CI [0.04, 0.14]; See Table S7 in the Supplementary Material for full results). In this model, neither age nor gender significantly related to solastalgia,

<sup>5</sup> As for Study 1, the regressions were repeated using a binary measure of bushfire impact (Table S5, Supplementary Material). Again, results were consistent across models, so the more fine-grained ordinal measure of bushfire impact was retained for analyses.



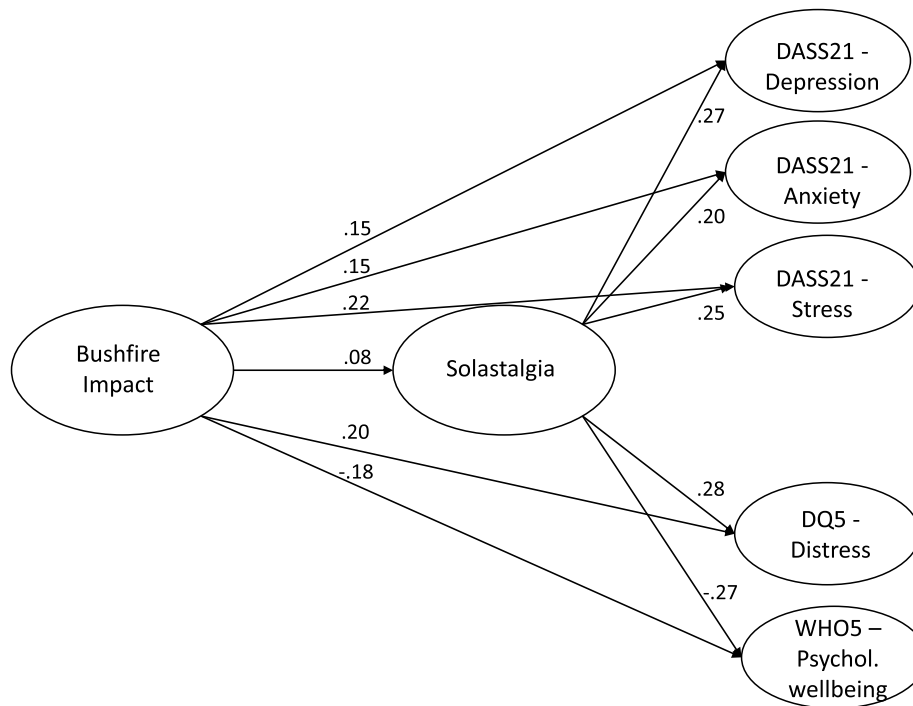


Fig. 1. Path model for the mediating role of Solastalgia between Bushfire impact and mental health outcomes in Study 1.

**Table 3**  
Direct, indirect, and total effects of Bushfire Impact on mental health outcomes, as mediated by Solastalgia, in Study 1.

	R <sup>2</sup>	Bushfire Impact			Solastalgia
		Direct Effect	Indirect Effect	Total Effect	
DASS21 – Depression	.10	.15 [.10, .20]	.02 [.01, .04]	.17 [.12, .22]	.27 [.22, .31]
DASS21 – Anxiety	.07	.15 [.10, .20]	.02 [.01, .03]	.17 [.11, .22]	.20 [.16, .25]
DASS21 – Stress	.12	.22 [.17, .26]	.02 [.01, .03]	.24 [.19, .29]	.25 [.21, .30]
DQ5 – Distress	.13	.20 [.15, .24]	.02 [.01, .04]	.22 [.17, .27]	.28 [.24, .33]
WHO5 – Psychol. Wellbeing	.11	-.18 [-.23, -.13]	-.02 [-.04, -.01]	-.20 [-.25, -.15]	-.27 [-.32, -.22]

Note. Standardised estimates are presented, with 95% confidence intervals in square brackets. All estimates are significant to the  $p < .01$  level.

**Table 4**  
Bivariate correlations of key variables in Study 2 (full sample correlations appear below the diagonal, with subsample correlations above the diagonal).

	1.	2.	3.	4.	5.
1. Bushfire impact	–				
2. Solastalgia	.12**	–			
3. DASS21 - Depression	.10**	.17**	–		
4. DASS21 - Anxiety	.12**	.16**	.75**	–	
5. DASS21 - Stress	.13**	.16**	.81**	.82**	–

Note. Associations with bushfire impact are based on Spearman’s correlations, all others are Pearson’s correlations. \*\*  $p < .001$ . Note that correlations with Solastalgia will have lower *N*s for full sample due to pairwise deletion - *N* ranges from 1450 (correlation between Solastalgia and DAAS21 – Stress) and 4499 (correlation between Bushfire impact and DASS21 – Stress).

and removing these paths again demonstrated excellent model fit ( $\chi^2(2) = 2.60, p = .272, CFI = 1.00, TLI = 0.998, RMSEA = 0.01, 90\% CI [0.00, 0.06], SRMR = 0.01, N = 1447$ ).

3.3. Discussion

In Study 2, we successfully replicated our initial findings with a large nationally representative sample. The variance explained in the mediation replication was reduced, non-significantly predicting depression, and a weaker – though significant – predictor of anxiety and stress. This suggests that the impact of bushfires on mental health outcomes either wanes over time (the Australian sample was surveyed approximately six months post-bushfire), is stronger among those in regions more heavily impacted by the bushfire (for Study 1, 42.3% participants reported no impact, compared with 82.6% reporting no impact in Study 2), or both. Alternatively, there may be something unique about those who perceive their environment as worsening with respect to mental health outcomes. Nevertheless, the psychological effects are still evident in our national sample six months after the fires.

4. General discussion

Using a geographically focused sample and nationally representative survey, we show that increased severity of one’s experience during the 2019–2020 bushfire season predicts greater psychological distress and poorer mental health and wellbeing. We also contribute to the literature on solastalgia, showing that solastalgia mediates the relationship between bushfire impact and poor mental health and wellbeing outcomes. These associations persisted six months after a major bushfire event. Our findings suggest that psychological distress in response to environmental loss is one plausible pathway through which experiencing bushfire results in higher risk of distress. Although the effects were small, they were significant and consistent: we found the same pattern of results when participation was constrained to bushfire-affected areas (Study 1), and when examined nationally (Study 2), as well as among those self-reporting their levels of stress, depression, and anxiety at the time of the fires (Study 1) and those reporting their *current* levels of stress,

**Table 5**  
Hierarchical regressions with key variables predicting mental health outcomes in Study 2.

	DASS21 - Depression				DASS21 - Anxiety				DASS21 - Stress			
	b	SE b	β	t	b	SE b	β	t	b	SE b	β	t
<i>Constant</i>	1.92	.03		59.05**	1.74	.03		68.93**	2.12	.03		72.36**
Age	−0.01	.00	−.23	−15.45**	−0.01	.00	−.28	−18.82**	−0.01	.00	−.34	−23.62**
Gender	0.07	.02	.05	3.61*	0.03	.02	.03	2.25	0.08	.02	.06	4.32
	R <sup>2</sup> = .06**				R <sup>2</sup> = .08**				R <sup>2</sup> = .13**			
<i>Constant</i>	1.89	.03		57.82**	1.71	.03		67.43**	2.12	.03		70.88**
Age	−0.01	.00	−.23	−15.28**	−0.01	.00	−.27	−18.60**	−0.01	.00	−.33	−23.44**
Gender	0.07	.02	.05	3.43*	0.03	.02	.03	1.97	0.07	.02	.06	4.08
Bushfire Impact	0.09	.02	.07	4.74	0.11	.01	.11	7.68**	0.12	.02	.09	6.71*
	R <sup>2</sup> Δ = .00; FΔ = 22.49**				R <sup>2</sup> Δ = .01; FΔ = 58.93**				R <sup>2</sup> Δ = .00; FΔ = 45.04**			
<i>Constant</i>	1.54	.10		15.39**	1.49	.08		19.05**	1.83	.09		20.74**
Age	−0.01	.00	−.21	−8.26**	−0.01	.00	−.27	−10.44**	−0.01	.00	−.32	−12.82**
Gender	0.09	.04	.06	2.45*	0.01	.03	.01	0.44	0.07	.03	.05	2.02
Bushfire Impact	0.03	.03	.02	0.78	0.07	.03	.07	2.71*	0.08	.03	.06	2.51
Solastalgia	0.10	.02	.16	6.24**	0.07	.01	.13	5.34**	0.08	.01	.14	5.72**
	R <sup>2</sup> Δ = .02; FΔ = 38.96**				R <sup>2</sup> Δ = .02; FΔ = 28.54**				R <sup>2</sup> Δ = .02; FΔ = 32.74**			
	R <sup>2</sup> = .08**				R <sup>2</sup> = .10**				R <sup>2</sup> = .14**			

Note. Ordinal measure of bushfire impact used. \**p* < .01; \*\**p* < .001 [dummy-coded gender 1 set to female]. DASS21 = Depression, Anxiety, and Stress Scale.

**Table 6**  
Direct, indirect, and total effects of Bushfire on mental health outcomes, as mediated by Solastalgia in Study 2.

	R <sup>2</sup>	Bushfire Impact			Solastalgia
		Direct Effect	Indirect Effect	Total Effect	Total Effect
DASS21 – Depression	.03	.03 [−.02, .08]	.02** [.01, .03]	.05 [−.01, .10]	.17*** [.12, .23]
DASS21 – Anxiety	.03	.08** [.02, .13]	.01** [.004, .02]	.09** [.04, .14]	.15*** [.10, .22]
DASS21 – Stress	.03	.07** [.02, .12]	.02** [.01, .03]	.09** [.03, .14]	.16*** [.11, .22]

Note. Standardised estimates are presented, with 95% confidence intervals in square brackets. \*\*\**p* < .001 level, \*\**p* < .01, \**p* < .05.

depression, and anxiety (Study 2). This paints a compelling picture of the lasting mental health and wellbeing impacts of bushfires, and identifies that solastalgia in response to a large, single event potentially transcends local boundaries.

Importantly, these effects were constrained to participants’ experiences of the 2019–2020 fires. In Study 1, we recorded and coded the severity of impacts from bushfire prior to the 2019–2020 fire season. Counter to expectations, previous bushfire impact was *not* significantly related to mental health or wellbeing outcomes. This suggests that the impact of the 2019–2020 bushfires on mental health and wellbeing at the time was not compounded by previous bushfire experience. This null finding may also point to the uniquely severe magnitude, intensity, and duration of the 2019–2020 fires. Alternatively, it may suggest that the mental health and wellbeing consequences of bushfire experience do reduce over time, though the precise timing of the previous bushfire experience was not captured for everyone (68.1% indicated they were referring to the 2003 bushfire experience, though for the remainder it

was unclear when their recent experience was). Indeed, our data do suggest a weaker bushfire impact – mental health association six months on from the fires, compared to more recent recall of mental health at the time of the fires. It is possible that intermediate events, such as the Covid-19 pandemic, could have stronger effects on mental health and wellbeing, and may even interact with bushfire experience (such that recovery is compounded by more proximal adverse conditions).<sup>6</sup> Further research is needed to test the longevity of mental health and wellbeing effects of natural disaster within affected communities, and who is most at risk of prolonged effects, as research shows that the most common trajectory post-disaster is one of recovery (Bonanno et al., 2010).

Consistent with expectations, and previous research on the mental health and wellbeing impacts of bushfires (e.g., Bryant et al., 2020), we found the more severely respondents were impacted by bushfire, the more likely they experienced poorer outcomes. Moreover, regression results reveal the unique effect of solastalgia on outcomes, suggesting solastalgia may affect mental health and wellbeing regardless of one’s experience in the bushfires. This is consistent with suggestions that the experience and expression of solastalgia is fundamental to environmental distress more generally (Higginbotham et al., 2006). This unique effect was also observed for Study 2, where solastalgia was not measured specifically in relation to the bushfires, but in terms of the quality of one’s local environment. It may be that those experiencing solastalgia for reasons in addition to the bushfires (e.g., drought, water shortages, pollution) have poorer mental health outcomes than those exposed to fewer events. However, this finding also supports the idea that solastalgia is experienced independent of objective experience; it is about the *perception* of environmental degradation (Connor et al., 2004; Rehling & Sigston, 2020), and thus, the loss of place entailed by solastalgia is broad-reaching.

It is plausible that one does not have to directly experience a bushfire in order to feel environmental loss and grief. This ‘vicarious distress’

<sup>6</sup> Participants in Study 1 were asked about their mental health and wellbeing for a period prior to the Covid-19 pandemic, however it is plausible current covid-related events during the study collection period (such as border closures) influenced the accuracy of retrospective reporting. The majority of Study 2 participants would have experienced covid-related lockdowns, thus may have been more influenced by covid-related factors from a mental health and wellbeing perspective. We do note, however, the relative consistency of the relationships between the study variables across the two studies.

may have resulted from witnessing (principally via media for our national participants, or through smoke for our ACT residents) the dramatic and abrupt transformation of a vast landscape that has environmental attributes immediately recognisable as 'Australian'. As solastalgia is thought to be closely tied to place-identity, we suggest the concept is applicable to shared experiences beyond localised geographical boundaries (in this case, a continent). This is consistent with research suggesting attachment to place occurs not just at a local level, but at national and even global levels (Devine-Wright et al., 2015). It also reflects the different ways in which 'place' has come to be understood in the solastalgia literature; as not merely a geographical construct, but increasingly as a socio-cultural, ecological, or environmental construct (Galway et al., 2019). The idea that vicarious exposure can lead to solastalgia is also consistent with research and theory on climate anxiety. While many people experience the abrupt impacts of climate change mostly indirectly, such as via news reports, this exposure is sufficient to lead to climate anxiety (Clayton, 2020). Additionally, solastalgia is sometimes described as a form of grief, with the second part of the word derived from *algos*, meaning "suffering, grief, or pain" (Connor et al., 2004, p. 5), and thus is likely closely related to the concept of ecological grief, particularly when special parts of the environment are irrevocably lost (for a review of ecological grief, see Cunsolo & Ellis, 2018).

#### 4.1. Implications for human health responses and future research

Taken together, our results suggest the way we usually measure the impacts of bushfire and other disasters should extend beyond identifying physical, concrete impacts such as rebuilding lost infrastructure. We recommend better accounting for the psychological distress caused by experiencing and witnessing environmental loss.

Although we have focused on the role of solastalgia in understanding the mental health and wellbeing impacts of bushfire, we do not suggest that experiencing solastalgia is a form of mental illness or pathological response to environmental disaster. While Albrecht (2011) conceptualised solastalgia as a form of 'psychoterratic illness', emotional responses to environmental disaster are normal, and may even play an important role in motivating the public to take action on climate change (Bickel & Preston, 2022; Stanley et al., 2021).

Instead, we echo calls to be wary of problematising environmental distress (e.g., Clayton, 2020).

While our results suggest that solastalgia helps mediate the effects of experiencing a bushfire on mental health and wellbeing, they also allow that experiencing solastalgia does not inevitably diminish mental wellbeing. Many who experience solastalgia also experience positive wellbeing. An important avenue for future research would be to understand better what may buffer the negative mental health outcomes of experiencing distress at environmental loss. For example, distress may be compounded by the expectation that the damaging event may happen again and further decimate their landscape, and alleviate when the community has confidence they are adequately prepared to avert the next environmental crisis.

It is important to note that our study – like the rest of the emerging literature on solastalgia – only searched for negative consequences of solastalgia. It is possible, perhaps likely, that solastalgia also has positive consequences. For example, it may bring communities together in grief at the loss of a common sense of place, it may stimulate political action to better mitigate and adapt to climate change and other forms of environmental degradation (see Albrecht, 2019, pp. 54-61 for an example of how the concept has been applied successfully in a legal context), it may help disaster preparedness efforts by individuals and communities, and it may help motivate behaviours to restore environments. These outcomes may all boost mental health and wellbeing in the short- and long-term and help temper the negative effects of experiencing solastalgia. These suggestions are all speculative though, and require further empirical investigation.

#### 4.2. Limitations and future research

As our two studies were cross-sectional, they cannot definitively support the causal pathway we propose. The direction of effects is supported by theory and replicates earlier work on wildfire effects in Arizona (Eisenman et al., 2015). However, these effects may also exist because those with poorer mental health are more inclined to rate other things, including the state of their local environment, poorly (that is, it is plausible that wellbeing also affects solastalgia). Longitudinal research is needed to clarify the extent solastalgia affects wellbeing over time and vice versa.

A further limitation is that, in addition to biases associated with self-reported data, the timing of the surveys may have introduced some recall bias. In Study 1 we asked participants to recall how they felt at the time of the bushfires, and in Study 2, how they were impacted by bushfires six months previous. We recommend future studies track the same individuals over time (ideally, before, directly after, and at a future time point after significant environmental change) to provide greater clarity on how exposure to environmental change, solastalgia, and mental health interact. Moreover, such studies should consider the role of sociodemographic factors such as cultural background, socioeconomic status, social capital, and social cohesion in such interactions.

Some of the small effects found between severity of bushfire impacts and other key study variables may be due to the difficulty in capturing gradations of impact. Our current measure, though consistent with standard ways of measuring bushfire impact (e.g., Bryant et al., 2014), necessarily involves some assumptions in assigning impact scores, and may not capture the fact that similar impacts could be experienced very differently by people. Future research might use more nuanced measures to accommodate these differences, for example by asking people to rate the subjective intensity of their experiences.

Finally, solastalgia may occur for reasons other than, or in addition to, a significant event such as bushfires (although bushfires would have been undoubtedly salient to Study 1 participants, where bushfire and bushfire smoke was the central focus of the survey). Having directly experienced the impacts of bushfire increases the likelihood that one will experience psychological loss stemming from adverse environmental change, but it is likely that perceptions of environmental loss from multiple stressors compound. Delineating the influence of different local, regional, and global environmental stressors in feelings of solastalgia, and their flow-on impacts for mental health and wellbeing, is an important next phase for solastalgia research.

#### 4.3. Conclusion

In conclusion, we suggest that the experience of psychological loss due to environmental change is one important mechanism in understanding how and why exposure to bushfire translates to poorer mental health and wellbeing outcomes. As the severity and frequency of climate exacerbated events, including bushfires, increases (Dowdy, 2020), a fuller understanding of the ways through which these events affect people's mental health and wellbeing is critical. We urge further research to guide health practitioners' and policy-makers' preparedness and responses to environmental loss. Guidance might encompass whether and how solastalgia can be embedded in planning and development processes, and ameliorated through effective environmental protection and restoration, and disaster risk prevention and reduction strategies.

#### Funding

The research reported in this paper was directly supported by funds provided by the ANU College of Health and Medicine (Study 1) and by the ANU Research School of Psychology (Study 2). Other support was provided by National Health and Medical Research Council (NHMRC) Fellowship 1173146 to AC, and by the HEAL (Healthy Environments

And Lives) National Research Network, which receives funding from the NHMRC Special Initiative in Human Health and Environmental Change (Grant No. 2008937) (SV, IW).

### Funding sources

This research was funded by the Australian National University, College of Health and Medicine, and the Australian National University, Research School of Psychology .

### Author contributions

ZL, SS, RR, IW, JR, BC, AC, AL, JL, AND SV contributed to the conception and design of the studies. SS and RR obtained ethics approval. RR, ZL, SS, and IW conducted data collection and database management. ZL, SS, RR, and CM were responsible for data analysis. ZL, SS, and IW drafted the manuscript, and all authors contributed to manuscript revision, read, and approved the submitted version.

### Data availability statement

Datasets are not publicly available as consent was not drawn from Study 1 participants for this usage of their data. However, all analysed datasets can be requested by emailing the corresponding author.

### Declaration of competing interest

The authors have no relevant financial or non-financial interests to disclose.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jenvp.2023.102071>.

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