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# Perceptions of Occupational Heat, Sun Exposure, and Health Risk Prevention: A Qualitative Study of Forestry Workers in South Africa

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**Abstract:** Occupational exposure to heat and solar ultraviolet radiation (UVR) threatens the health and wellbeing of outdoor workers. These threats are likely to increase as a result of climate change. This study examined the perceptions of occupational heat and sun exposure and health risk prevention among forestry workers removing alien invasive vegetation in the Western Cape, South Africa. The linkages between workers' perceptions of heat, solar UVR, and herbicide exposure and impacts under the current climate were investigated to better understand potential adaptation needs under a changing climate. Using focus group discussions and participatory risk mapping, heat stresses identified by workers were either environmental (e.g., lack of shade) or work-related (e.g., wearing required personal protective equipment). Several heat and solar UVR health impacts were reportedly experienced by workers; local indigenous knowledge and coping mechanisms, such as wearing ochre for sun protection, were used to prevent these impacts. Despite workers' current efforts to protect their health, existing gaps and opportunities to improve working conditions were identified. Institutional structures for improved reporting of adverse events are imperative, together with awareness and education campaigns about the risks associated with working in hot and sunny environments.

**Keywords:** climate change; perceptions; outdoor workers; South Africa; herbicides; pesticides; temperature; solar ultraviolet radiation; forestry workers

## 1. Introduction

Outdoor workers are particularly vulnerable to health risks from increasing global temperatures. Forestry workers in South Africa have compounded heat exposure risks from also having to wear protective equipment and carrying heavy chemical sprayer backpacks and equipment for mechanical removal (e.g., chainsaws) while working in the heat. Although working protocols and legislation

can reduce workers' heat exposures, worker perceptions, behaviors, and contextual issues play an equally or sometimes more important role. Characterizing worker perceptions can aid in risk reduction, management, and prevention planning. This study examined the perceptions of occupational heat and sun exposure, and health risk prevention among forestry workers removing alien invasive vegetation in the Western Cape Province of South Africa. We investigated the linkages between workers' perceptions of heat, sun, and herbicide exposure and impacts under the current climate, as a basis to understand potential adaptation needs under a changing climate. A distinction was made between the atmospheric parameters of heat and sun exposure (i.e., solar ultraviolet radiation (UVR)) to investigate differences in perceptions of each, as control measures for mitigating health impacts by exposure vary.

### 1.1. Climate Change Impacts on Occupational Health

Subtropical regions of Africa have warmed at a rate greater than the global average [1–3]. This warming is projected to continue under climate change [2,3]. Southern Africa is thus projected to be a climate change “hotspot” in terms of extreme high temperatures [4], with plausible increases projected from 4 °C to 6 °C above present day climate by 2100 under a business-as-usual emissions scenario [3]. It is paramount, therefore, that exposure risks for outdoor workers be managed by employers and employees.

#### 1.1.1. Heat Exposure and Impacts

In South Africa, outdoor workers in sectors like agriculture, forestry, construction, mining, and outdoor services are already vulnerable to heat stress [5,6]. Increases in heat exposure will, therefore, further impact occupational health and work capacity [5,7]. Exposure to high temperatures in the workplace can have direct health and wellbeing impacts, such as fatigue, reduced mental performance, heat rash, fainting, vomiting, heat stroke, chemical poisoning, strong discomfort, and can, as well, be fatal [5,8,9]. In addition, chronic heat exposure in the workplace has been linked to long-term health effects, including chronic kidney disease, mental health problems, and cardiovascular diseases [5,10]. Studies have also found that exposure to workplace heat can lead to increased injuries and accidents [7,11,12]. In a future climate scenario, where global temperature increases by 2100 are limited to a global average of 1.5 °C, total working hours are projected to decrease by 2.2% by 2030, due to higher temperatures and consequent loss or slowing of working time; in Western Africa, this could be as much as 5% [1].

Heat stress in the workplace can be determined by environmental heat (i.e., air temperature, humidity, solar radiation, and wind speed), metabolic heat that is generated by physical activity, and the thermal effect of clothing [13]. The agricultural and forestry sectors are at high risk for occupational heat-related exposures and health impacts [10,14–16]. Workers in these sectors are highly exposed to environmental heat with limited shade, are often engaging in vigorous physical activity (i.e., metabolic heat), and are usually wearing clothing and protective equipment that hinders heat dissipation (i.e., thermal effect of clothing). A study in North Carolina, USA, found that the heat-related fatality rate for agricultural workers was fourteen times that of the general population [15]. Worker mortality from heat exposure is a concern since in a changing climate, higher temperatures are occurring more often and for longer periods of time.

#### 1.1.2. Sun Exposure and Impacts

In relation to many occupational risks for outdoor workers, solar radiation could be classified as the oldest occupational risk with multiple environmental factors playing a role in exposure risks. Exposure to and acute health effects from excess solar UVR may affect not only human skin and eyes [17,18], but also the immune system [17,19]. Solar UVR may also adversely affect the effectiveness of vaccinations [19]. The effects of solar UVR on the skin are not limited to premature aging but include various types of skin cancer [17–19], of which, melanoma is the most serious [20] as it may be fatal. Keratinocyte cancers, such as basal and squamous cell carcinomas, are also consequences

of chronic sun exposure and in some countries have been recognized as an occupational disease [21]. Long-term exposure risks to solar radiation for workers' eyes include pterygium, cataracts, and macular degeneration [16].

For South African forestry workers, solar radiation risks are high given that the UVR exposures can occur throughout the year [22]. The country's topography includes coastal plains at sea level and a central plateau, known as the Highveld, at an average altitude of 1200 m. A stationary high-pressure cell over the Highveld and interior of the country results in relatively cloudless skies, which together with the altitude contributes to high solar UVR levels. During summer, most of the interior of the country experiences levels above 10 on the Global Solar UV Index (UVI) [23], with the highest observed over the Northern Cape Province. In winter, the northern parts of the country have the highest levels of about 5 UVI, while they are lower in the southern regions.

Protecting outdoor workers' skin and eyes from solar UVR is key and requires both interventions from the employer (training and protective equipment), as well as the employee (wearing skin and eye protection regularly and consistently, knowing the signs of heat and sun related illnesses).

### 1.1.3. Herbicide Exposure and Impacts

In conjunction with heat and sun exposures, agricultural and forestry outdoor workers are also exposed to a broad range of pesticides with varying acute and chronic toxicity. Forestry workers predominately use herbicides (e.g., glyphosate) as part of their control and vegetation removal measures. Firstly, there are health risks with exposures to the inherent toxicity of the herbicides (often long-term low dose exposures) when mixing and applying. Then, there is the risk of increased exposures linked to climate change and heat from higher temperatures. Pesticides have been shown to have increased volatilization in high temperatures and in certain cases break down into more toxic compounds. This volatilization could result in increased evaporation into the air that workers breathe, as well as increasing applications to compensate for this loss. Thirdly, differing activities with herbicides while in the heat and sun, such as mixing, cleaning of equipment, and using a backpack application sprayer and handheld sprayers for cut stumping, increase heat stress (i.e., metabolic heat). A study in the US found that cut stumping activities by forestry workers resulted in recommended exposure limits for heat stress being exceeded [24]. When characterizing workers' heat and sun exposure risks, it is also important to contextualize the intertwining effect of pesticide exposures on health and risk perceptions.

## 1.2. Perceptions of Occupational Heat and Sun Exposure

Occupational health policies that address climate change adaptation, as well as heat and sun exposure risks, are unlikely to achieve their objectives if they do not also address behavioral issues within their target populations, given that risk perceptions impact on protection behaviors [24–26]. Perceptions of outdoor workers vulnerable to extreme weather variations who are required to implement protective measures must, therefore, be characterized and understood by employers and those developing risk reduction strategies [27]. There appear, however, to be no published studies within South Africa that address issues related to outdoor workers' perceptions of climate change, occupational heat, sun, and herbicide exposure. More research is, therefore, required to inform local and regional policy and, ultimately, national (and global) policies and strategies to address the risks posed by occupational heat and sun exposure. A study of forestry workers with South Africa's Working for Water (WfW) programme has provided a good case study and is further discussed in this article.

## 1.3. Current Practices for Heat and Sun Protection

The most significant protection against the adverse health effects of heat and sun exposure is effective implementation of controls within the work environment [28]. In the field of occupational health, "controls" refer to measures devised to eradicate or diminish hazards or hazardous exposures (e.g., sun block, water, sunglasses, hats, cool zones, prohibition of work in high temperatures). The feasibility and success of heat and sun controls are especially complex when the occupation is

exclusively practiced outdoors [29]. The potential health effects of heat or sun are compounded when workers are not able to fully protect themselves because of complex working conditions and contexts, lack of access to controls, and limited knowledge on how to reduce exposure risks [30]. Given the challenge of protecting working populations from heat and sun exposure, as well as the increases in temperature due to climate change, inadequate strategies for protection of at-risk worker populations could worsen health impacts and hinder economic and social development [6]. This is of significance for resource-constrained settings within emerging economies, such as South Africa.

It is estimated that the world's vulnerable population is made up of several billion people within all low- and middle-income countries, which includes outdoor workers in physically demanding jobs in agriculture, construction, quarries, outdoor cleaning, waste collecting, and road building and repair [29]. In 2015, South Africa's workforce was estimated to be over 18 million people. Whilst it is not known what proportion of people engage in work almost exclusively outdoors, it is estimated that, in 2015, agriculture contributed to 5.6% of total employment [31]. Just this subset of the population is a significant number of the working population who are potentially exposed to excessive sun and heat. Despite this, there is no official provision for the protection of climate-vulnerable working populations.

The South African Occupational Health and Safety Act (No. 85 of 1993) provides for workers' rights to a safe and healthy occupational environment. There is, however, no specific legislation or safety limits regarding temperature and solar UVR exposure for outdoor workers (such as those engaged in agriculture, forestry, or construction) in South Africa [6]. In addition, little attention is paid to occupational health in the country's climate change policies and plans [32,33]. It is, therefore, necessary to further understand the current and anticipated challenges faced by such outdoor workers to inform any strategies with the objective of mitigating risks due to climate change on outdoor workers.

In 2018, the National Institute for Occupational Safety and Health (NIOSH), which operates under the Centres for Disease Control and Prevention (CDC) in the United States, recommended that outdoor work should be avoided at certain times of the day when "sun exposure is the greatest" [34]. In addition, workers should have access to shade when they take breaks and wear proper clothing, such as wide-brimmed hats, sunglasses with side panels, as well as sunscreen. A further suggestion was that outdoor workers should be trained in all aspects of sun exposure, including the health risks, symptoms of overexposure, and measures to prevent exposure [34].

An international standard applicable to heat stress, is ISO 7243, which is used in countries such as the United Kingdom, Australia, China, and Japan. This standard is based on the wet bulb globe temperature index (WBGT) and it was developed in the United States to control casualties from heat exposure at military training centres [35]. ISO 7243 was derived from the Effective Temperature Index, which combined temperature, humidity, radiation, and wind into a single value [35]. The original WBGT consisted of two readings, the wet bulb temperature and the globe temperature, but was weighted for clothing color or absorptivity (in this case military clothing) [35]. It is important to consider not only the type and level of activities performed by people but also the clothing they wear during heat exposure, as all these parameters have an influence on metabolic rate [35]. While type and level of activities are considered in ISO 7243, Parsons [35] recommended in his review article that the WBGT index should include clothing absorptivity, especially during high solar radiation.

#### *1.4. Working for Water Programme*

The Working for Water (WfW) programme is a long-running nationwide state-funded public works initiative, which provides outdoor-based jobs to workers from low-income communities in South Africa. The programme was launched by the South African Department of Environmental Affairs (DEA) in 1995 [36] to protect and restore the biodiversity and ecological functionality of important water sources in all nine of South Africa's provinces, through the control and removal of alien invasive vegetation [37]. WfW provides employment and skills development by sourcing workers from communities with high unemployment rates in their areas of operation. Contractors are subcontracted by WfW to provide teams of workers and are responsible for overseeing the implementation of procedures to remove alien

vegetation, and for occupational health and safety of their employees (i.e., clearing teams). The length of contracts and the time of the year when clearing takes place is dependent on the species being removed, at what stage of growth the vegetation is at, and whether this is a repeat clearing to remove secondary growth.

Workers in the WfW programme are typically exposed to several hazards (e.g., herbicides and equipment such as chainsaws) while removing alien vegetation in harsh outdoor working environments (e.g., steep mountain slopes, high altitude, thick reed vegetation). In order to reduce the levels of exposure to occupational hazards from herbicides, clearing equipment and snake bites, WfW relies largely on promoting the use of personal protective equipment (PPE), but also administrative and behavioral controls. These controls are based on standard operating procedures to ensure reduction in risks associated with the work, and strategies (such as training) to ensure compliance with standard operating procedures [38]. According to the draft Project Operating Standards [38], if temperatures are above 30 °C for one or more hours, contractors should provide shade, ensure that hats are worn, and that there is sufficient water. WfW protocols and standard operating procedure do require that appropriate PPE is always worn [38,39]. PPE worn varies by the type of work. PPE for general workers cutting vegetation includes, “hardhat, eye protection, high visibility overalls / vest, gloves, safety boots with steel toecap, shin guards, foot guards” [39]. PPE for herbicide application includes, “hard hat, eye protection, wrist length PVC gloves, high visibility clothing, rain suit as per label, waterproof safety boots with steel toecap, respirator/face mask as per label and PVC apron as per label” [39]. An example of the types of PPE that the workers wear when spraying herbicides is shown in Figure 1.



**Figure 1.** Example of Working for Water workers putting on backpack and Personal Protective Equipment (PPE) for herbicide spraying (Photo by Hanna-Andrea Rother).

The main purpose of the PPE for herbicide application is to reduce exposure to chemical hazards (i.e., chemical impermeable aprons, long-sleeved shirts, and trousers), rather than from the outdoor elements per se. Wearing such PPE in high temperatures can increase the risk of workers to heat-related illnesses [14,40]. The PPE may protect the workers from some exposure to solar UVR but risks still exist. Depending on bodily position and activity, horizontal surfaces can receive twice as much exposure as vertical surfaces when an upright body is perpendicular to the Sun [41]. The facial region has been found to receive between 19% and 56% of the ambient solar UVR, while vertical surfaces such as the

arms (when hanging down beside the body) receive about 40% of the ambient. Thus, even though wearing PPE and clothing may protect the arms and legs, exposed anatomic sites such as the face, ears, and hands could be exposed to around 50% of the ambient UVR and thus be a potential health threat for WfW workers [42]. The WfW programme, which is one of the world's biggest for controlling invasive vegetation, is regarded as successful in providing skills and training to unemployed populations from low-income communities [42]. There have been concerns, however, about worker safety in relation to exposure to occupational hazards [43]. For example, exposure to herbicides is theoretically mitigated using PPE. In a 2012 study on the use of PPE by WfW workers, however, it was found that low PPE compliance persists, despite workers' awareness of the risks of herbicide exposure. PPE use was found to be influenced by workers' socio-cultural context (i.e., gender dynamics and social status), workers' risk perception of herbicide use, and their environmental and logistical working conditions. The findings suggested that interventions other than PPE promotion, such as engineering or administrative controls, should be explored [43]. This is of relevance due to the distinct possibility that even with 'perfect' adherence to PPE, its use in relation to unavoidable dangerous heat and sun exposure may increase the risk of adverse events compared to not using PPE at all. As Andrade-Rivas and Rother [43] determined that reduction of exposure to an obvious occupational hazard (herbicides) was suboptimal, further exploration is required of the risks of heat and sun exposures in WfW workers, which are interlinked and possibly more complicated to address.

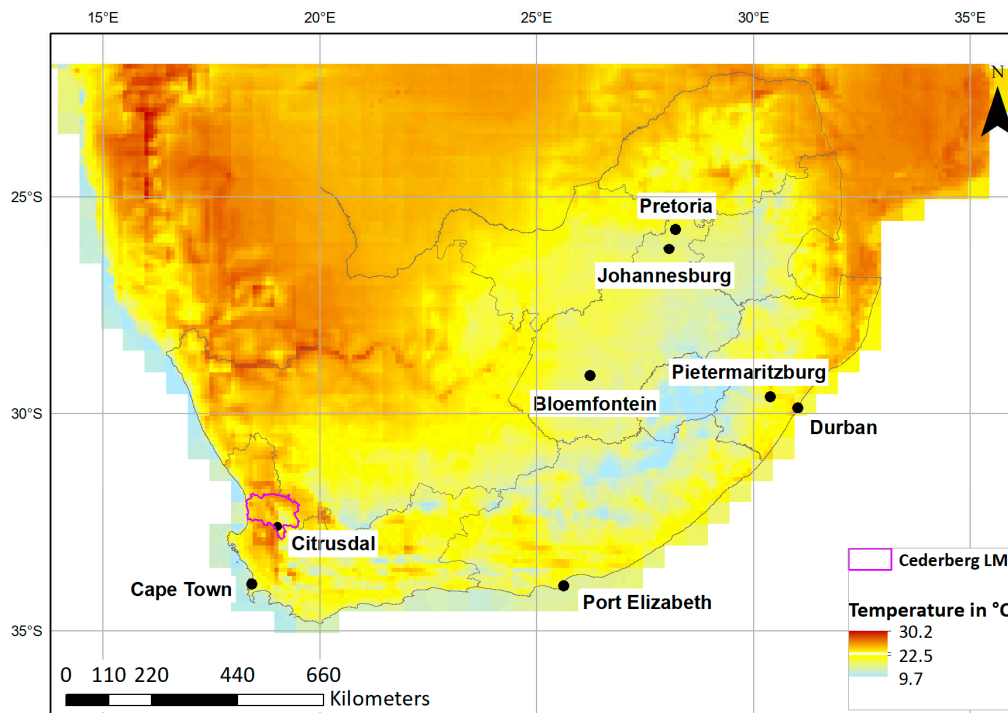
The aim of this study was to understand the risk perceptions of WfW workers and document their work practices related to the occupational hazards of heat and sun exposure (i.e., solar UVR), as well as to identify implementable exposure prevention strategies. Given the potential effects of climate change on health in southern Africa [44,45], improved understanding of perceptions and practices of outdoor workers toward heat and climate change, as well as sun exposure, need to inform the government's national policies, as well as provide information for relevant organizations internationally.

## 2. Method

This study was part of a larger research project assessing the human health risks of WfW workers removing alien vegetation in the Western Cape Province, South Africa; particularly in relation to chemical use exposures [43]. For this study, the WfW programme management identified an area (i.e., Citrusdal) where workers were working in extreme heat during alien invasive vegetation removal in January 2015 to participate in the study presented here. WfW workers are not a homogeneous group [43]. Many are transient and the turnover of workers at times can be high. Therefore, it is not possible to indicate the length of time the study participants worked in the programme and whether they worked or work year around or for just a short period.

### 2.1. Study Site

The study took place in Citrusdal, Western Cape (32.594020° S, 19.016140° E), which is in the south-western part of South Africa, from 20 to 21 January 2015. Figure 2 displays the location of Citrusdal, as well as simulated average maximum temperatures for 1961–1990 from the South African Council for Scientific and Industrial Research [46]. These temperatures are shown here to highlight that Citrusdal, with a simulated average maximum temperature of 24.0 °C, is in an area of South Africa with high average maximum temperatures. The indicative seasonal average of UVI at Cape Town during summer (i.e., maximum) is 12–14 and in winter (i.e., minimum) is 2–3 [47].



**Figure 2.** Map of South Africa showing simulated historical (1961–1990) average maximum temperature (°C). Location of Citrusdal in the south-western part of the country is highlighted in the Cederberg Local Municipality (LM) within the Western Cape Province.

## 2.2. Data Collection

### 2.2.1. Focus Groups

A participatory research approach (i.e., focus groups) was used to highlight the perceptions of WfW workers and contractors in relation to chemical and sun exposure and health risks and the potential impacts of climate change.

Four focus groups were conducted. There was one group of contractors who are responsible for hiring and managing their teams of workers, and who have a contract with DEA. The other groups were the workers who performed the vegetation clearing. These groups were engaged separately as the two groups were expected to have different perceptions, and workers may not have wanted to discuss sensitive workplace health issues in front of their employer. Worker groups were split according to their language preference (i.e., Afrikaans or isiXhosa) for ease of facilitating discussion.

Focus group participants were selected through purposive sampling. One group comprised of contractors, and the remaining groups of workers were split up according to the language that they speak. Groups were also further divided by gender where possible. In total there were 30 participants, with the groups divided as follows:

- Group 1: Afrikaans speaking contractors (n = 2 females, n = 6 males)
- Group 2: isiXhosa speaking workers (n = 5 females, n = 2 males)
- Group 3: Afrikaans speaking female workers (n = 9)
- Group 4: Afrikaans speaking male workers (n = 6)

The focus group facilitator (H-AR) spoke in English, with translators translating between Afrikaans and English (groups 1,3–4) or isiXhosa and English (group 2).

The workers' focus group discussions (including the mapping were framed to understand the workers' perceptions of exposure and health impacts from heat, sun, and/or herbicides. The focus group discussions for contractors were focused on understanding the perceptions of their own exposure

and impacts, and the exposure and impacts of their workers to heat, sun, and/or herbicides. In both groups, questions on the prevention of exposure and impacts were asked, although they were also aligned to the different perspectives of the two groups. The participants' skin phototypes were not measured as part of the focus group. However, in general, Black South Africans' skin phototypes range from III to VI [48].

The discussion facilitator mediated a structured discussion to cover the main themes outlined in Table 1, column 1.

**Table 1.** Topics covered per theme in the focus group discussions.

Theme	Topics Covered
Working conditions and exposure pathways	<ul style="list-style-type: none"> <li>Hazard mapping of work site. Areas where they work, rest, keep water, etc. and areas of exposure to heat, sun and herbicides, and where health impacts are the highest.</li> </ul>
Perceptions of Heat	<ul style="list-style-type: none"> <li>When (time of day) they get hot when working</li> <li>How working when it is too hot impacts on their work, and what they are not able to do?</li> <li>If it is getting easier or harder to work in the heat</li> <li>What are complaints when working in the heat?</li> <li>How do they feel when it is "too hot"? Have they been sick from working in the heat?</li> <li>Are there health risks from being "too hot" at work?</li> </ul>
Heat Stress Reduction Practices	<ul style="list-style-type: none"> <li>When they are feeling "too hot" what do they do to cool off?</li> </ul>
Perceptions of sun exposure	<ul style="list-style-type: none"> <li>Advantages and disadvantages of working in full sun</li> <li>If it is getting easier or harder to work in the sun</li> <li>What effects have they experienced from working in the sun?</li> <li>The risk of health impacts from sun exposure to dark skin compared to fair skin</li> </ul>
Sun protection practices	<ul style="list-style-type: none"> <li>What type of protection they use and if it is available from work, or if they bring it from home?</li> </ul>
Perceptions of herbicide exposure in relation to heat and sun	<ul style="list-style-type: none"> <li>The impacts of sun and heat on working when handling and spraying herbicides</li> <li>If exposure to herbicides or health impacts from herbicides are different in heat or full sun?</li> <li>Frequency of applying herbicides in full sun</li> </ul>
Knowledge of climate change	<ul style="list-style-type: none"> <li>If they had heard of climate change and what it means to them</li> </ul>

### 2.2.2. Heat and Sun Exposure and Risk Assessment through Mapping

Each focus group session began with a mapping exercise to assess heat, sun, and herbicide exposures at work, producing eight maps in total (two examples in Figure 3). As a participatory research method, mapping facilitates a process of drawing out the expertise and knowledge of the participants, and it has also been used for planning, education, and participant empowerment [49,50]. Regarded as a useful health and safety investigative and assessment tool, mapping can provide vital evidence to support suggestions for improvement through characterizing participant-identified risks.



Mapping starts with the premise that the participants have detailed knowledge and expertise that may not be forthcoming through standard focus group discussions. It allows participants and researchers to see the interconnectedness of potential health problems and exposures within workplaces. Through the use of drawing, color-coding, and simple symbols, mapping can overcome the barrier of language differences and potential limited literacy. In addition, its use encourages discussion and analysis, and as such is also helpful as an icebreaker [51].



**Figure 3.** Examples of heat and sun exposure artwork drawn by study participants (these images were retained as drawn and have not been redrawn in any software package to preserve the details hand drawn by the participants.) (A) Highlights the difference between heat exposure (blue) and sun exposure (red) from successive follow-up visits. This shows increased exposure when vegetation is shorter in later follow-ups (on right hand side, labeled as “2nd follow-up, 6 months (after previous visit)”). (B) Highlights the varied work environment including mountains, rivers, trees, reeds (labeled in Afrikaans as “riette”) and open fields. Afrikaans translation of words in 3B are hoof pad = main road, plaas pad = farm road, steilte = uphill, polle = grass, steil opdraend = steep uphill.

Focus group participants were randomly assigned into one of two mapping groups. They were asked to collaboratively draw a representation of a typical working environment and site where they clear invasive alien vegetation in Citrusdal, using a standard key for mapping out the main

exposures and landmarks, as illustrated in Box 1. Mapping included the main features of the landscape, WfW-related structures, as well as herbicide, sun, and heat exposures that participants experienced.

The main purpose of the mapping exercise was to ascertain a general representation of the working environment and the subjective experiences of heat, sun, and chemical hazards in the workplace by participants, as well as identifying where and how exposures were occurring. Each group presented their maps and discussion of these hazard maps preceded the structured focus group discussions. Figure 3 displays two examples of the resultant maps.

**Box 1.** Mapping codes used by study participants to draw their working environment.

The following instructions for using different colored markers in the maps were provided to each of the mapping participants:

- Black marker: draw typical work site environment
- Green marker: show places of work, rest, and where water, food, and herbicides are kept
- Red marker: show where there is *sun* exposure causing health risks
- Blue marker: show where there is *heat* exposure causing health risks
- Orange/purple markers: show where herbicide exposure occurs

### 2.3. Analysis Methods

The eight hazard maps were photographed and then analyzed in relation to heat, sun, and chemical exposures documenting the physical context and drawn information into themes. The different focus group sessions were recorded, and each researcher (n = 5) in attendance took notes. These notes were consolidated, and the recordings were transcribed. The notes and transcription results were imported into Excel for assessment by theme. Focus group excerpts were tagged according to respondent group type, survey category, and topic and, as far as possible, related to a specific question. Columns with additional themes that may also be relevant to a particular response (such as challenges, factors affecting exposure, and actions) were added to characterize each excerpt from a different angle. One of the challenges experienced during this process was that in many cases the responses did not relate directly to the question that was posed.

### 2.4. Ethics

The study entitled “Health risks of chemicals and sun exposure among outdoor workers in a changing climate in South Africa” was granted ethics approval by the University of Cape Town Human Research Ethics Committee (HREC reference: 323/2014) and the CSIR Research Ethics Committee (CSIR REF: 89/2014).

## 3. Findings and Discussion

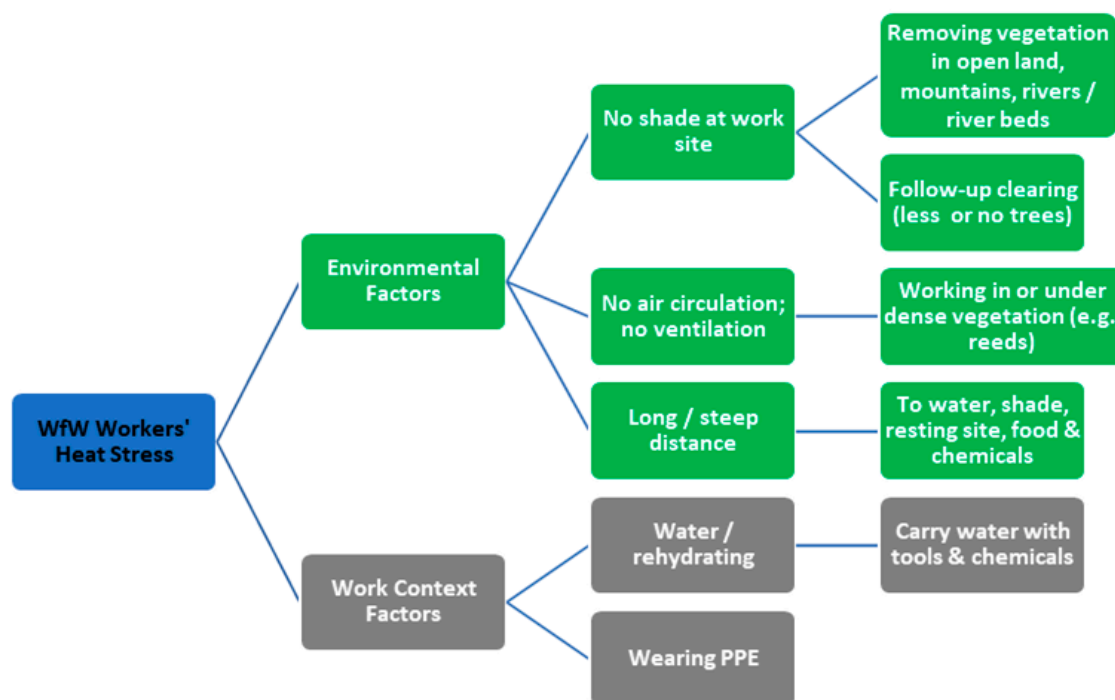
The findings are discussed below in relation to worker and contractor perceptions of exposure pathways as well as health risks, while also identifying relevant practices that impact on exposures or are prevention behaviors.

### 3.1. Heat and Sun Exposure Pathways

WfW workers did not clearly differentiate between sun and heat exposures initially. Through mapping discussions workers began to express a difference; in that sun exposure relates to all rays from the sun, while heat exposure is in part due to infrared rays, but also pertains to thermal comfort from behavior, clothing, location outdoors, etc. Understanding the difference is key in relation to exposure prevention strategies. Oftentimes people seek out heat-reducing responses to feel cooler, while sun exposure that includes solar UVR exposure can occur in cool wind, midsummer/mid-day conditions and induce sunburn without the feeling of ‘heat’.

Figure 4 presents the key environmental and work context factors from heat and sun exposures identified during the mapping exercise that resulted in worker heat stress. The varied work environment

can also be seen pictorially in Figure 3. Environmental factors included the lack of shade during initial clearing, as well as during follow-up once shade vegetation had been removed (Figure 3A). Workers described the difficulties in clearing alien vegetation and using herbicides in dense reed environments with no airflow and intense temperatures (Figure 3B). A range of working conditions (i.e., open land, mountains, rivers) lead to different exposure scenarios, and difficulties in access to water and shade (Figure 3B).



**Figure 4.** Heat stress exposure pathways participants identified through mapping.

Although productivity decreases in the heat [1], work schedules are often time-bound and linked to vegetation growth. Contracts also restrict the capacity to shift schedules to minimize heat and sun exposures. WfW programme contractors are only paid (and can only pay their workers) once they have cleared a site as agreed to with DEA, hence there is intense pressure to work irrespective of weather conditions.

### 3.2. Perceptions of Heat

This part of the focus group discussion concerned perceptions of the impacts of heat exposure, as well as what workers were doing to protect themselves. When asked what was ‘too hot’, some respondents in both contractor and worker groups gave temperature ranges between 35 °C and 42 °C. However, it was acknowledged that work sometimes continued in these conditions when options to lose a day of work were limited. Contractors acknowledged the pressure to meet deadlines but indicated that they had flexibility in work hours (e.g., start early, longer lunch breaks, etc.) on “red days” (i.e., hot days). However, not all workers agreed that the teams would start early when it was “too hot” outside.

The contractors and workers’ groups did note that days that were “too hot” impacted productivity; contractors observed that productivity was lower in summer, and workers stated that it was harder to work on “too hot” days, especially in the full sun. Contractors and workers also stated that when it was hot, workers felt lethargic, exhausted, and tired, which impacted work output and workers’ health (Table 2). Workers stated that when it is “too hot” they, “...get upset, but must finish”, that the “mood

is not good”, that “everything is heavy”, and that sometimes they sweat so much that when they wipe their faces, they feel like the skin is being removed.

**Table 2.** Health effects reportedly experienced by workers when it was hot.

Reported Health Effects Experienced When It Was Hot	
Contractor-Reported Symptoms Experienced by Workers	Worker-Reported Symptoms Experienced
<ul style="list-style-type: none"> <li>• headaches</li> <li>• nose bleeds</li> <li>• fainting</li> <li>• sweating profusely</li> <li>• exhaustion</li> <li>• no desire to work</li> <li>• tired</li> <li>• dizzy</li> <li>• bad mood</li> <li>• suffocating</li> <li>• fits</li> <li>• sore feet</li> <li>• vomit</li> <li>• nausea from drinking warm water</li> <li>• heat rash</li> <li>• skin rashes</li> <li>• stressed</li> <li>• sunburn</li> </ul>	<ul style="list-style-type: none"> <li>• headaches</li> <li>• nose bleeds</li> <li>• fainting</li> <li>• sweating</li> <li>• exhaustion</li> <li>• no energy</li> <li>• tired</li> <li>• dizzy</li> <li>• bad mood</li> <li>• suffocating</li> <li>• fits</li> <li>• sore feet</li> <li>• vomit when drinking hot water</li> <li>• see stars</li> <li>• palpitations, irregular heart</li> <li>• loss of appetite</li> <li>• heat stroke</li> <li>• If drink too much water or cold water, causes asthma</li> <li>• dehydration</li> </ul>

Participants’ experiences of adverse health effects and symptoms from heat exposure are summarized in Table 2. In general, the groups experienced very similar health effects, which are also commonly cited in the literature [52,53]. Workers mentioned that it was not uncommon for workers to faint when it was hot, particularly while wearing and using a backpack sprayer. The Afrikaans-speaking women felt that women fainted more often than men, and some of them had themselves fainted. The workers were well-informed on what to do if someone fainted; they would give first aid, water, have them sit under a tree, take off clothing (within reason), and sponge down the person’s body.

Heat exposure symptoms (e.g., headaches, fainting) were sometimes reported in the work-related injury report but were seldom reported further. With climate change resulting in increasing temperatures, it is important that workers are taught about heat-related symptoms and that these are properly monitored to inform prevention strategies.

### 3.3. Heat Stress Reduction Practices

Many participants said that they shared a 2-litre bottle of water between a few workers, which was refilled from a communal container at base camp that was sometimes distant from where teams worked. Workers indicated a preference for having their own water bottles, which is advisable for hygienic reasons too. It was agreed that there is usually adequate water, and that the teams rarely ran out of water; in the case of water running out, contractors sourced potable water for the teams.

When it was too hot, workers took regular breaks (i.e., on average five in summer and three during winter months), rested in the shade, drank water, swam or wet shirts, and shared workloads. Trees were generally removed during the first clearing session; thus, on follow-up sessions, the remaining small shrubs did not provide enough shade (shown in example hazard map Figure 3A).

The follow-up sessions often occurred during the summer when exposure to sun, heat, and herbicides was highest.

Herbicides are applied with 25-litre backpack sprayers, as well as handheld sprayers for “cut stumping” (i.e., applying herbicide directly to stump top immediately after cutting the plant). In extreme heat, workers preferred handheld sprayers, as the backpack application requires workers to wear heavy chemical-resistant aprons. Backpack spraying also releases a larger plume of small particles into the air than a handheld sprayer. Given that increased temperatures lead to increased pesticide degradation, switching to a handheld sprayer may be good practice, but may also be impractical for the vegetation requiring removal (e.g., thick or tall scrub, bushes and trees).

PPE worn to protect workers from hazardous chemical exposures (including long-term low dose exposures) can also be affected by high temperatures. Respirators, for example, become damaged and have reduced effectiveness when used in temperatures above 30 °C. Workers were also provided with long-sleeved shirts and trousers to reduce dermal exposures to pesticides; yet these may increase the metabolic temperature of the worker. This points to the need to reduce work in high temperatures, as much as possible, as no PPE is available that would work in these hot conditions.

#### 3.4. Perceptions of Sun Exposure

Workers responded in a variety of ways to the question, ‘Is a person with dark skin less or more likely to have sun effects than light skin?’. A few workers responded that a person with light skin will be more affected; others responded that “both are affected but dark maybe more” and “the sun will burn both of them”. Contractors indicated that the sun can affect your skin causing cancer, as well as affect your eyes, and that ozone depletion (‘hole in ozone layer’) will make ‘sun’ exposure worse. There was a consensus that sun exposures are going to worsen in the future. It was acknowledged that it depends on the individual to prevent excess exposure to the sun. However, workers’ prevention strategies are linked to their perceptions, work conditions, and prevention options provided to them.

#### 3.5. Sun Protection Practices

Workers said that they protect their faces from the sun in various ways: with Vaseline oil, fish oil, normal hand lotion, camphor cream, ochre or “cooling cream” (a natural clay earth pigment worn by the Xhosa women), red paste or “gentle magic” worn by some men, and with hats and hardhats. Xhosa women insinuated that if they did not put on the ochre during the summer, their skin gets itchy and develops dark spots. The effectiveness of these measures is largely unknown and hence requires further research [54].

Sunscreen is not currently provided to workers. When asked if they had used it before, workers said “definitely not”, “nobody has”, “don’t have money [to buy]”, or “if available, would wear it”. Workers who do use sunscreen apply it at home prior to coming to work and do not reapply regularly after sweating. The reason provided for using sunscreen was to protect their skin, according to the workers, and to protect their eyes and skin, according to the contractors. The contractors indicated that workers sometimes did not apply sunscreen as they thought the smell of the lotion attracts bees, and that it causes them to sweat more. While sunscreen is not currently provided to employees, some groups indicated they would use it if provided. Workers indicated they do not use any sun protection or seek shade when it was “cooler and cloudy” as they believe they “can’t burn when it is cloudy”. Exposure risks to UVR are thus not well understood by workers and further interventions to protect from exposure risks are required, even in cloudy conditions.

Some workers indicated that they used the UVR protective goggles that are provided, others used their own dark sunglasses, and others not at all because of difficulty seeing where they are walking. Contractors indicated that they only had tinted goggles, but workers recommended clear glasses with UVR protection instead.

Some of the workers wore jackets to protect from sun exposures but sometimes took these off when they became too hot. Others indicated that they felt hot with jackets and long-sleeves but

“have no option”. One Xhosa worker said, “No, I feel hot, but I am protecting my skin”. It was not stated by the workers if they took their jackets or long-sleeve shirts off during breaks. Previous work has found that workers do not undress during breaks, and sometimes even leave their PPE on [43]. Thus, protection measures to reduce sun exposures may increase the workers’ risk of heat stress from increasing metabolic temperatures.

When asked whether they must always wear their helmets to protect from head injuries, the Xhosa men responded affirmatively and said they were not allowed to wear anything for sun protection underneath their hardhats. The Afrikaans men agreed, but said they could wear hats only during follow-up activities. The Afrikaans women, however, indicated that permission was granted to wear sun hats underneath their hardhats. The reason for this discrepancy is unclear.

Contractors were asked if they ever discussed sun and heat exposure risks with workers. Some said that they do during morning “toolbox talks” before the team began working at a site clearing alien invasive vegetation. Some discussions focused on starting times and that workers were encouraged to start work between 5 and 6 am on hot days. However, workers said that transport and family responsibilities can make this difficult to comply with.

### 3.6. Perceptions of Herbicide Exposure in Relation to Heat and Sun

Participants were asked, in relation to their herbicide use, what PPE they wore and how that impacted them when it was hot. Participants indicated that they felt “*benoud*” (Afrikaans word for tight-chested) and like they were suffocating from using a respirator in the heat. Many indicated that they could smell the herbicides when it was hot, which was confirmed by contractors saying, “when it is too hot, the smell of the herbicide is stronger, and it affects them inside”. General workers who do not wear respirators seem most affected. One Xhosa worker explained that, “the hottest time is 12-3pm. There is a lot of evaporation that happens around this time so you must not work around this time.” The concern is that intensified evaporation both increases inhalation of herbicides [55], as well as potentially rendering the herbicides less effective in controlling or killing the target vegetation.

Goggles were provided to protect from eye exposures to herbicides. Workers, however, indicated that they take these off in the heat as they regularly steamed up. Although workers were aware of the requirement to wear respirators and goggles when spraying herbicides, this equipment was viewed as hot and uncomfortable to wear in extreme heat, particularly when working in the mountains or in thick reeds. Contractors confirmed that workers removed their respirators due to discomfort, and that the goggles made workers sweat. Work schedules should therefore be assessed to reduce increasing metabolic heat and heat stress linked to having to wear PPE while applying herbicides.

Participants said that the backpack sprayers feel heavier in the heat, and they therefore prefer handheld sprayers. Contractors and some workers noted that when they apply herbicides in the heat, “the leaves quickly fold, and the herbicide does not go to the stem and roots, so the plant does not die”.

Most workers indicated that herbicides cannot be used in the winter because of the rainy and wet conditions. Although herbicides are used in winter against different vegetation that grows then, workers said that use was higher in summer when temperatures are higher. They also indicated that they must take more breaks in summer, and, therefore, it takes longer to finish.

As Gatto and colleagues [55] point out, higher temperatures linked to climate change may increase use of pesticides because of changes in plant development (e.g., increased atmospheric CO<sub>2</sub> concentration could increase leaf thickness making them less permeable to herbicides), in pest populations (e.g., earlier appearance, increased generation cycles, increased activity), and in the effectiveness of pesticides (e.g., decreased effectiveness linked to increased pest resistance in high temperatures, higher volatilization). They point out that these factors will in turn lead to increased negative short- and long-term occupational health risks for pesticide applicators from increased exposures. Gatto et al. [55] also note that workers may be unable to endure elevated temperatures because of the physical impacts of prolonged exposures to toxic chemicals.

### 3.7. Knowledge of Climate Change

The focus groups concluded with discussions that gauged participants' knowledge of climate change. The facilitator first asked in English if participants had heard of the word "climate change". After the participants responded, the question was repeated with a translation of "climate change" in Afrikaans or IsiXhosa. Some understood the translated word better than the English word. While some participants had heard of it (mostly from news, radio, or TV), most could not describe well what it was or what it meant to them. Some workers referred to increased rain and hotter temperatures. When asked if there is climate change, one worker responded that they "smoke less when hot". Contractors tended to have a more nuanced understanding of climate change, saying: "changes in atmosphere and heat and cold", "changes in seasonal temperature and rainfall patterns", and "an increase in heat". One contractor confused the hole in the ozone layer with climate change.

A better understanding by workers of the impact of climate change on their health will not necessarily reduce the effects. Rather, what is needed is interventions from a work operations and standards perspective with management, including prevention strategies, as well as national adaptation policies including risk reduction measures.

### 3.8. Recommendations

The workers and contractors identified some recommendations that could be used by WfW to decrease exposure. These included providing individual water bottles, sunscreen, and clear glasses with UVR protection to workers, and flexible work hours during hot days. A detailed cost estimate of these interventions is difficult, especially without further detailed information on needs and use of workers of sunscreen per year. However, a high-level estimate of costs to provide water bottles and clear glasses with UVR protection annually to all WfW workers (~30,000 workers annually [56]) is on the order of R6 million to R8 million annually (approximately, \$400,000–\$600,000). It must be noted that previous studies have found that the uptake of preventative strategies (including wide-brimmed hats, long-sleeved shirts and pants, sunglasses, and sunscreen) among outdoor workers from different countries was low [57]. Thus, a follow-up study is recommended to test the uptake and assess the costs and benefits from such interventions.

In general, the perceptions documented in this study illustrate a need for more information for workers on the risks of heat and sun exposure (e.g., cataracts, cloudy day UVR risks, herbicide inhalation). Changes are needed in worker and contractor behavior, as well as standard operating procedures set by higher level management. Management should also schedule the follow-up visits (when there is no shade) to cooler times of the year, if possible. Workers should be allowed to wear sun hats under hardhats if there is not a risk to safety.

Another recommendation came from the discrepancy between the workers and contractors stating that they do report heat-related illnesses and symptoms on the company injury report, and provincial upper management stating in an informal discussion before the focus groups that they did not receive such symptoms in high numbers on their injury reports. Consistent and accurate data on the incidence of health impacts is critical, and the data gathering process should be improved. Workers should be provided with the means to identify heat-related illnesses and to document their symptoms on hot days. There is an opportunity to provide workers with the means to document these on their mobile phones, as most workers have one, and to build their confidence to report these to their employer (i.e., the contractor).

Further research to characterize the metabolic workloads of other outdoor workers, such as those in agriculture associated with WfW practices of herbicide (pesticide) use during mixing and application activities [24], and to quantify the health impact of these multiple hazards, is needed to inform interventions, such as planning vegetation removal times to minimize health risks. A better understanding of the potential risks to workers will help develop evidence-based risk-mitigation interventions that are responsive to a changing climate, and this should inform both occupational specific strategies and national climate change adaptation strategies.

#### 4. Conclusions

Climate projections for Africa point to an increase in the occurrence of extreme temperature events, such as heat waves, and related adverse health effects. The risks associated with exposure of outdoor workers in a warming climate are multiple and complex, with those who require additional work-related protective equipment particularly at risk of heat and sun exposure. Evidence of the exposure and risk perceptions of workers and its implications should, therefore, be incorporated into risk reduction strategies and approaches, particularly national climate change adaptation strategies.

In this study, both workers and contractors had knowledge of the potential health impacts associated with heat and sun exposure, although they were not necessarily able to differentiate between the two. In addition, in all groups, some protective actions were taken to decrease exposure and impacts. However, these actions do not seem to be adequate, nor were they consistently applied across the groups. There is a need for a more formal structure to ensure reporting and implementation of remedial practices to decrease exposure to these hazards. Innovative measures are required to improve knowledge of the health risks related to heat, sun, and pesticide exposure require to both employers and outdoor-working employees (e.g., in forestry and agriculture). While this study focuses on South African workers in one site, these findings do show that this is a vulnerable group that is experiencing negative health impacts from exposure to heat and sun. This highlights the need for additional research in South Africa and internationally on impacts, perceptions, exposure, and preventative measures. More studies on the impact of heat and sun risks for occupational workers should include the characterization of workers' perceptions in order to inform occupational standards and national climate adaptation strategies.

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