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### Title

Recovery Horizons: Nature-based Activities as Adjunctive Treatments for Co-occurring Post-Traumatic Disorder and Substance Use Disorders

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**Title:**

**Recovery Horizons: Nature-based Activities as Adjunctive Treatments for Co-occurring Post-Traumatic Disorder and Substance Use Disorders**

Running Title: Nature-based Activities for Treatment of Co-occurring PTSD and SUDs

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66 **Abstract:**

67 Posttraumatic stress disorder (PTSD) and substance use disorders (SUDs) have a high rate of co-  
68 occurrence, and those with co-occurring PTSD and SUD often face a more complex treatment  
69 course with less favorable outcomes than those with either disorder alone. Integrative  
70 approaches that target PTSD and SUDs are the favored treatment model and include  
71 pharmacological and non-pharmacological methods. Complementary interventions have been  
72 gaining attention for their widespread appeal and proposed therapeutic effects in augmenting  
73 the current treatments for PTSD and SUDs. In this paper, we review the literature to highlight  
74 the evidence for the effectiveness of various aspects of nature-based activities in treating  
75 PTSD/SUD and the interventional research in the existing literature. Furthermore, we discuss  
76 the research gap and limitations of the current studies on this topic and suggest future  
77 directions.

78 Keywords: Nature, PTSD, Substance Use Disorder, Addiction, Complementary and Integrative  
79 Health

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87 **Background**

88 Posttraumatic stress disorder (PTSD) and substance use disorders (SUDs) have a high rate of co-  
89 occurrence. Patients with PTSD have been reported to be up to 14 times more likely to have  
90 SUD and nearly half (46.4%) of those with PTSD also meet the criteria for a SUD. [1-3] PTSD and  
91 SUDs are chronic disorders associated with significant distress and functional impairment.  
92 Individuals with co-occurring PTSD and SUD have poorer social functioning, higher rates of  
93 suicide attempts, violence, and legal problems, and less favorable treatment course than those  
94 with either disorder alone. [4]

95 The interaction between PTSD and SUDs involves multifaceted mechanisms. [5-7] The historical  
96 treatment model that treats SUD first, deferring PTSD management until after abstinence,  
97 undermines the significant interplay between the two disorders. Integrative approaches  
98 involving psychosocial and pharmacological methods have emerged as the favored treatment  
99 model. [8, 9] Among psychotherapies, trauma-focused therapies are associated with greater  
100 efficacy but also higher dropout rates compared to non-trauma-focused approaches. [10]  
101 Furthermore, resources for maintaining psychotherapy are limited. Exploring accessible and  
102 sustainable interventions to enhance current treatments and engage patients during and after  
103 treatment is essential. Complementary practices that fall outside traditional Western medical  
104 practice and are used in conjunction with traditional practices have gained increasing attention  
105 as part of a holistic approach that considers personal preferences and accessibility in the  
106 treatment of PTSD and SUDs. [11, 12] With existing evidence suggesting physical

107 exercise/activity [16-18] and exposure to natural environments [13-15] as complementary  
108 treatment approaches for PTSD and SUDs, we searched PubMed using the terms “hiking,”  
109 “biking,” “walking,” “running,” “jogging,” “surfing,” “sailing,” “kayaking” “climbing,” “nature,”  
110 “forest,” “adventure,” “outdoor,” “PTSD,” and “SUD” to review the literature on nature-based  
111 activities. This paper discusses various aspects of nature-based activities, including exposure to  
112 natural spaces, mindfulness, [16] physical activity[17-21], biophilia, social engagement, and  
113 hobby development in treating PTSD and SUD. We review previous interventional research on  
114 nature-based activities, discuss the research gap and limitations of the existing studies on this  
115 topic, and suggest future directions.

116 **Interactions between Psychological Wellness and Nature/Green Spaces:** Evidence largely  
117 suggests that exposure to green spaces is associated with improved psychological wellness. [22]  
118 For example, exposure to green space during childhood has been linked to a lower risk of  
119 psychiatric disorders into adulthood. [23] In this nationwide study in Denmark, the presence of  
120 green space was assessed using high-resolution satellite data within a 210 x 210 m square  
121 surrounding each person’s residence before age 10. Results showed that children raised in areas  
122 with the least green space faced up to 55% higher risk of developing a psychiatric disorder after  
123 accounting for other established risk factors. [23]

124 Additionally, exposure to green spaces has been shown to enhance SUD outcomes. As one  
125 example, access to gardens and allotments and residential green views of more than 25% have  
126 been associated with reduced cravings for a range of addictive substances. [24] Other studies  
127 have found that neighborhoods with high green space have higher smoking cessation and lower

128 smoking prevalence. [25] Residential greenness was also associated with lower odds of tobacco  
129 use and frequent binge drinking but higher odds of marijuana use. [14] Exposure to natural  
130 sceneries--through photos, 3D images, virtual reality, and videos of natural landscapes--has also  
131 been shown to lead to psychological benefits and more relaxed body responses compared to  
132 viewing matched controls. [26] In another study, participants who viewed natural scenery  
133 before a delay discounting task were observed to be less impulsive than those who viewed built  
134 environments. In other words, the latter group tended to prefer immediate, smaller rewards  
135 over larger, delayed rewards, placing less value on the future--a behavioral trait linked to  
136 addiction. [27] In another study, women with SUD residing at a treatment facility started their  
137 days by either viewing a nature video or engaging in mindfulness-based activity for the first 10  
138 minutes of their daily programming. The study concluded that watching natural scenery was  
139 similarly beneficial to mindfulness practices, and both interventions resulted in significant  
140 decreases in heart rate and negative affect and improved overall mood. [28]

141 **Nature-Based Mindfulness:** One of the critical mechanisms in the therapeutic effects of nature-  
142 based activities on psychological wellness may be mindfulness. [29, 30] Mindfulness  
143 encourages increased awareness of surroundings, emotions, thoughts, and bodily sensations in  
144 the present moment and without judgment.[31] Natural environments may enhance  
145 mindfulness through their inherent qualities, such as sensory engagement and calming effects,  
146 while mindfulness may amplify nature's restorative effects through increased awareness of and  
147 a deeper connection to the natural surroundings. [32]

148 The potential synergy between mindfulness and exposure to nature has led to the development  
149 of unique nature-based mindfulness interventions. [37, 38] Shinrin-yoku, a Japanese practice of  
150 “bathing in the forest,” involves engaging the five senses by focusing on different elements, such  
151 as the range of colors of leaves and sounds of streams. Shinrin-yoku (above is different  
152 spelling)u has been shown to reduce depression, stress, and anxiety and is suggested by  
153 previous research as a potential treatment for addiction that warrants further exploration. [39]  
154 Similarly, a mindfulness-based sailing intervention in veterans with psychiatric disorders (SUD  
155 76% and PTSD 72%) was found to be enjoyable and effective, enhancing psychobiological  
156 flexibility and state mindfulness.[40]

157 Not only does exposure to nature have similar beneficial effects on symptoms as mindfulness,  
158 but brain imaging findings with exposure to nature parallel the effects of mindfulness practice.  
159 As a primary example, amygdala activation in response to fearful faces and a social stress task  
160 was reduced after walking in nature as opposed to in an urban setting. [33] This finding is very  
161 similar to the effect of mindfulness on amygdala activation. [34-36]

162 **Outdoor Exercise:** Physical activity is often an integral part of nature-based activities and has  
163 been proposed as an effective intervention to improve outcomes of PTSD and SUD. [41-43]  
164 Potential mechanisms by which aerobic exercise positively impacts PTSD symptoms include  
165 improved cognitive function and neuronal, endocrinological, and immunological modulation.  
166 Another potential mechanism is the reduction of sensitivity to internal physiological arousal  
167 cues, such as increased heart rate, through repeated exposure and association of such bodily  
168 sensations with non-trauma-related situations. [44, 45] Exercise-induced bodily sensations that



169 are similar to unpleasant PTSD-related symptomatology may contribute to non-adherence to  
170 these interventions, highlighting the importance of using a multimodal approach that includes  
171 psychotherapeutic strategies to navigate such challenges.

172 Several biopsychosocial mechanisms have been suggested for the role of exercise in the  
173 treatment of SUDs. Formation of exercise habits has been proposed as a replacement for  
174 habitual substance use by tapping into the dopaminergic neural pathway of “craving-driving-  
175 behavior-reward” and facilitating the recovery of the dopamine system after chronic drug use  
176 [43] [19] Research on neurobiological pathways suggests that regular aerobic exercise training  
177 induces neuroadaptation within the central opioid receptor system [46] and increases  
178 endocannabinoids, [47, 48] warranting further research to assess the effectiveness of aerobic  
179 exercise for treating opioid and cannabis use disorders.

180 One could hypothesize that in co-occurring PTSD and SUDs, exercise could replace self-  
181 medicating with substances as a way to relieve PTSD-related feelings as well as withdrawal  
182 symptoms, as evidence from prior research supporting the effectiveness of physical exercise in  
183 reducing withdrawal, anxiety, and depression symptoms in those with SUD. [17]

184 Findings that outdoor exercise may have even greater psychological benefits [49] highlight the  
185 importance of exploring nature-based activities as adjunctive treatments for PTSD and SUDs. In  
186 a systematic review of longitudinal trials comparing the effects of indoor and outdoor exercise,  
187 all statistically significant differences in outcomes favored outdoor exercises, with enhanced  
188 positive emotions, tranquility, and restoration in the psychological domains. [49-52]

189

190 **Biophilia:**

191 The notion of “biophilia,” or human innate affinity with the natural world, was first introduced  
192 by Wilson in 1984. [53] With our ancestors having survived in the wilderness by being  
193 connected to nature, this theory provides an evolutionary-based explanation for the positive  
194 psychological effects of nature. Supporting the role of connectedness to nature, mediational  
195 analysis results in Meyer et al.’s study indicated that positive effects of exposure to nature are  
196 partially mediated by increases in connectedness to nature. [54] Tapping into this innate affinity  
197 has potential implications for healing and enhancing resiliency. In a study of bushfire disasters  
198 ?which were traumatic?, results indicated that stronger attachment to the natural environment  
199 was associated with higher resilience, post-traumatic growth, and reduced psychological  
200 distress and fire-related PTSD symptomatology. [55] Similarly, in a study of combat-related  
201 trauma, Westlund et al. analyzed in-depth interviews with four veterans, highlighting the  
202 importance of interconnection with nature and how it helped them in their recovery journey by  
203 providing alternative experiences to post-traumatic distress manifestations. Quotes from  
204 veterans in the study provide insight into the profound impact of connecting with the rhythm of  
205 the natural environment: “There’s something about the outdoors that’s helped me move on  
206 from my service and look inside. And to become – I wouldn’t say whole again, but just not so  
207 military, if you will.”, “You’re more aware of the things around you than having to respond to  
208 every circumstance. Day turns to night, you stop. Light comes in the morning; you get up.

209 There's a rhythm that's much different than somebody yelling at you to do this or that. Or  
210 you've got to punch a clock at a certain time." [56]

### 211 **Community Building and Engagement:**

212 Public? gardens are well-known sites for community building and psychological well-being. [57,  
213 58] As part of the "Green Social Prescribing" NHS initiative in the UK, healthcare professionals  
214 prescribe nature-based activities, such as community gardening, to those who could benefit  
215 from them. [59, 60] Community engagement has been recognized and recommended as an  
216 effective and essential component in substance use prevention and treatment by the U.S.  
217 Substance Abuse and Mental Health Services Administration (SAMHSA). [61] In the context of  
218 substance use recovery, the formation of "recovery communities" and the establishment of  
219 social bonds through substance-free activities are essential, helping to reduce social isolation  
220 and sustain sobriety. [62] Similarly, social isolation is commonly experienced in patients with  
221 PTSD, and social support and a sense of belonging have been associated with improved  
222 resiliency and PTSD symptomatology in prior research. [63, 64] An 8-year longitudinal study  
223 showed that perceived social support has protective effects against the development of PTSD  
224 symptoms after exposure to physical assault. [65] These findings highlight the promise of  
225 incorporating nature-based activities in a multidimensional and integrative approach to the  
226 treatment of co-occurring PTSD and SUDs.

### 227 **New Hobbies and Substance-Free Reinforcements:**

228 The formation of new habits and routines is an essential aspect of care during recovery, as  
229 patients with SUDs are no longer occupied with substance-related activities (obtaining, using,  
230 recovering). Unused time is one of the most challenging periods for patients with SUDs,  
231 highlighting the need for developing structured routines. [66] Therefore, in addition to  
232 eliminating substance use, treatment should focus on facilitating greater access to and more  
233 time spent in enjoyable and rewarding experiences to sustain abstinence. [67] Individuals with  
234 SUD have reported that engagement in substance-free activities is a critical component of  
235 successful recovery. [68]

236 Similarly, in PTSD, the regularity of daily living routine could promote psychological resilience  
237 during and after potentially traumatic events. [69] Due to avoidance symptoms in patients with  
238 PTSD, it is essential to identify and develop opportunities for activity engagement that are not  
239 difficult for patients with PTSD to tolerate. As one veteran shared in Westlund’s study about his  
240 experience in nature “[It] allowed us [veterans] to create some space outside that essentially is  
241 a safe space for us to just talk about [experiences of post-combat stress reactions]. I’ve spent a  
242 lot of time with veterans in other situations . . . but not being outdoors, and the same types of  
243 conversations don’t happen.” [56] Another veteran in a mindfulness and nature-based program  
244 in a forest therapy garden said, “Sometimes, when I have too many things to think about, I have  
245 this inner dialog with myself and my brain works far too hard ... then, being here, it doesn’t  
246 stop, but, it feels like a part of my head is more relaxed.”[70]

247

248 **Nature-Based Intervention Research in PTSD/SUDs**

249 A neuroimaging study showed that amygdala activity decreased after one hour of walking in  
250 nature, while it remained the same after one hour in an urban setting. [33] In this study, the  
251 fMRI scanning procedure included various tasks. The results mentioned above were consistent  
252 regardless of the tasks, suggesting a global beneficial effect on increasing the amygdala's  
253 threshold for activation. [33] Similarly, after a one-hour walk in nature, patients with SUD  
254 showed significantly reduced craving levels compared to pre-walk values and compared to  
255 craving levels after the city walk. [71] Enhanced recovery outcomes in SUD patients who  
256 participate in these activities may also be attributable to gaining a sense of accomplishment and  
257 belonging within the program, as reported by participants in a walking/running program with  
258 race events. [72]

259 In another study of nature versus urban hiking, veterans with PTSD showed a greater reduction  
260 in PTSD symptom scores (PTSD Checklist-5) at 12 weeks and 24 weeks among those who walked  
261 in a natural setting. Littman et al. [73] demonstrated that the heightened impact of nature  
262 versus urban hiking might be attributable to the positive effects of green spaces on PTSD  
263 symptoms. [74, 75] Achabaeva et al.'s study showed that the addition of mountain walks and  
264 thermal baths to the standard treatment for PTSD patients enhanced their psychoemotional  
265 status. [76] This was a controlled clinical trial in which the control group received physical  
266 training, individual psychotherapy, and pharmacological treatments, and in the intervention  
267 group, walking in the mid-mountain Natural Park and nitrogen-thermal baths were additionally  
268 prescribed. [76] Another study of patients with severe anxiety/PTSD that included a control  
269 group of social contact, however, found no additional therapeutic effects of exercise (climbing  
270 and Nordic walking) on the change of psychological outcomes. [77] In a program of trauma-

271 focused therapy for veterans with PTSD, optional outdoor activities, including hiking, cycling,  
272 and climbing, were offered to participants. The study found that greater time outdoors  
273 correlated with decreased PTSD symptomatology within persons. The more time each  
274 individual spent outdoors on any given day, the greater the reduction in PTSD symptoms for  
275 that individual on the subsequent day. [78] One study assessed the feasibility and acceptability  
276 of outdoor walking during trauma-focused psychotherapy sessions. The intervention was highly  
277 acceptable amongst patients and therapists, with patients demonstrating a clinically significant  
278 PCL-5 score reduction after 12 weeks. [79] Future studies comparing seated and walking  
279 therapy can clarify if any psychotherapeutic benefits could be attributed to walking.

280 Similarly, nature-based activities in “blue” spaces (i.e., water) have shown promising results.  
281 [40, 80, 81] Surfing as an adjunctive treatment for PTSD has been assessed to be feasible, with  
282 preliminary results suggesting therapeutic effects on PTSD symptoms.[82] Another study of  
283 integrated mindfulness and sailing programs resulted in increased psychological flexibility and  
284 mindfulness compared to the control group, which did not receive this intervention. Participants  
285 had SUD or at least one psychiatric disorder, with the most common being SUD (76%) and PTSD  
286 (72%). [40] These findings were in line with the results of other sailing studies showing  
287 significant improvement in symptomology, [80] perceived control over illness, and daily  
288 functioning in patients with PTSD. [81] Increased psychological flexibility and a higher rate of  
289 residential treatment completion was also found in patients with SUD. [83]

290 Results of other studies that explored wild-life immersion [84], gardening [70, 85], fishing [86],  
291 angling, equine care, archery, falconry, [87] cycling, kayaking, pickleball, [88] and camping [89]  
292 [90] are summarized in Table 1.

293 In the study of a camping intervention, 13 patients in substance use treatment participated in a  
294 3-day residential program with an integrated approach that included outdoor adventure  
295 therapy, therapeutic camping, and relapse prevention. The control group consisted of 18  
296 participants who received the usual relapse prevention program. Significant reductions were  
297 observed with the integrated approach in autonomic arousal, frequency of negative thoughts,  
298 and alcohol craving. Additionally, ten months after the 3-day intervention, the relapse rate was  
299 31% in the intervention group and 58% in the comparison group. [89] Similarly, a 3-day river  
300 rafting/hiking/camping trip for a group of veterans with PTSD was positively impactful. This  
301 study integrated no structured and formal therapy sessions into the intervention. Each day  
302 started by rising at sunrise and dismantling the camp and ended with setting up camp and  
303 evening campfire, with river floats and day hikes in between. Participants were instructed to  
304 keep a journal and record their thoughts throughout the trip to be collected upon completion.  
305 Paddling and kayaking seemed to alleviate avoidance and numbness symptoms, highlighted by  
306 veterans' reports of regaining the capacity to experience joy. Several participants reported  
307 needing fewer medications throughout the trip, "At home, I usually take anxiety pills and  
308 sleeping pills at night. Out here, I haven't had to take either one. The music around the campfire  
309 was enough to lull me right to sleep. And we are so active during the day with rafting and hiking  
310 and such that I have no trouble going to sleep at night. That makes me very happy". [90] Early  
311 into the trip, re-experiencing symptoms occurred at various times and places for some of the

312 veterans. The terrain reminded them of a war zone, and one had noted continually scanned the  
313 horizon for the enemy. With acclimatization to the river experience, these symptoms appeared  
314 to dissipate as almost all reported a sense of peace and relaxation. These reports underscore  
315 the importance of a support system including trauma-informed individuals along with effective  
316 coping strategies to help those with PTSD manage their symptoms during nature-based  
317 activities. Another example of a triggering event in a nature-based intervention was a female  
318 patient with a history of sexual assault by a male experiencing difficulty with physical touch  
319 during belaying in climbing. The symptoms were managed by switching from a male to a female  
320 rope partner. [77] It is essential to be similarly aware of potential substance-related cues when  
321 implementing nature-based programs for patients with SUDs.

322 Incorporating therapeutic approaches such as mindfulness and psychotherapy into nature-  
323 based experiences might have the advantage of helping participants overcome the challenges  
324 they might experience in natural environments. One study offered combined mindfulness  
325 activities, nature-based activities (including planting trees, splitting wood, performing routine  
326 tasks with a gardener), and individual therapeutic sessions (seated in a sheltered area or during  
327 walks in the garden) in a forest therapy garden. The program was 3 hours of therapy, 3 times per  
328 week for ten weeks. The veterans experienced the natural environments as a comfortable place  
329 to be, and a change of preference from locations that offered refuge to more open areas was  
330 observed throughout the study. For most veterans, nature was still highlighted in their lives in  
331 different ways after one year. One reported: "I found someone to do those things in nature  
332 with. We are 4-5 veterans and stay in nature for 2-3 days. The breathing ... to breath, and feel  
333 the ground under my {feets} | I become more conscious of it when I am in nature." [70] Similarly,



334 another study found that veterans with PTSD highly positively received other immersive  
335 experiences in nature, such as birdwatching, assisting with wildlife rehabilitation care, and  
336 observing wildlife sanctuaries. [84]

337 **Key Considerations for Prescribing Nature-Based Activities:**

338 When recommending nature-based activities in clinical practice, we suggest a collaborative  
339 approach to determine the most beneficial activity for each patient. This collaboration should  
340 consider personal preferences, accessibility, symptomatology, potential trauma-related triggers,  
341 substance-related cues, physical ability, and treatment goals. For patients in earlier stages of  
342 PTSD treatment who are experiencing significant avoidance and heightened sensitivity to social  
343 triggers, solo activities such as walking, hiking, and surfing in preferred natural environments  
344 during less crowded times may be the most suitable starting point, with a gradual transition to  
345 more stimulating environments and group activities such as climbing and group camping as they  
346 progress in their treatment course. Depending on the severity of symptoms, it might be  
347 beneficial for the therapist to assist the patient with initial attempts, such as engaging in walking  
348 therapy or holding the sessions in a natural environment, if circumstances allow.

349 For those who are sensitive to physiological changes of exercise, such as increased heart rate,  
350 beginning with less strenuous activities such as walking and gardening is essential, gradually  
351 advancing to more intense activities such as running and river rafting. For patients unable to  
352 engage in these activities due to physical limitations, more passive activities such as  
353 birdwatching and viewing natural sceneries—even through videos and images—can be  
354 beneficial. When selecting an activity and community, it is critical to address potential

355 substance-related cues and establish pre-coping strategies. It is important to be aware that  
356 some group settings may involve substance use and to ensure that the chosen community will  
357 provide a safe and supportive environment. Incorporating nature-based activities into  
358 residential SUD treatment programs can help patients become familiar with the potential  
359 challenges while gaining coping skills in a structured environment, ensuring a smoother  
360 transition to post-discharge. Additionally, assisting patients to learn mindfulness practices to  
361 use in nature may enhance the therapeutic effects of nature-based activities.

362

<p><b>Prescription for Nature-Based Activities</b></p> <p>Patient Name: _____ Date: _____ Prescribed by: _____</p> <p>-----</p> <p>Nature-Based Activity Options</p> <p>1. Accessibility and Preference:</p> <ul style="list-style-type: none"><li><input type="checkbox"/> Blue Space (e.g., Oceans, Lakes, Rivers)</li><li><input type="checkbox"/> Green Space (e.g., Forests, Parks, Gardens)</li></ul> <p>2. Activity Setting:</p> <ul style="list-style-type: none"><li><input type="checkbox"/> Group Activity (e.g., Camping with friends, Pickleball)</li><li><input type="checkbox"/> Solo Activity (e.g., Running, Biking)</li><li><input type="checkbox"/> Combined (e.g., Hiking, Camping)</li></ul> <p>3. Type of Activity:</p> <ul style="list-style-type: none"><li><input type="checkbox"/> Active (e.g., Hiking, Biking, Kayaking, Running)</li><li><input type="checkbox"/> Passive (e.g., Meditation, Bird Watching, Nature Journaling, Nature Videos)</li></ul> <p>4. Time of Activity:</p> <ul style="list-style-type: none"><li><input type="checkbox"/> Morning (e.g., Surfing, Gardening, Viewing nature videos)</li><li><input type="checkbox"/> Afternoon (e.g., Picnic in the Park, Kayaking)</li><li><input type="checkbox"/> Evening (e.g., Stargazing, Camping)</li></ul>
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5. Community Involvement:

Engaged Community: Volunteering for Conservation, Community Gardening

Minimal Interaction: Solo Exploration, Quiet Reflection in Nature

**Established Goal:**

Activity:

Location:

Frequency:

Community:

Potential Triggers/Cues:

Coping Skills and Safety Planning:

363 **Suggestions for Future Directions**

364 Despite the need for the development of treatments for co-occurring PTSD and SUDs and  
365 evidence indicating the potential therapeutic effects of nature-based interventions, there is a  
366 notable research gap in the implementation and evaluation of the impact of such interventions,  
367 particularly in SUDs. We suggest future clinical trials with larger sample sizes to include  
368 individuals with SUDs and co-occurring PTSD and SUDs to assess and compare the effects of  
369 these interventions. There appears to be therapeutic potential in nature-based activities in both  
370 blue and green spaces and when integrated with other therapeutic interventions such as  
371 mindfulness and psychotherapy. We suggest that the integration of other psychotherapeutic  
372 models with nature-based activities, or before engaging in such activities, may be helpful to  
373 address and cope with potential challenges that patients with PTSD/SUDs may face, such as  
374 exposure to trauma and substance-related issues when engaging in these activities. Additionally,  
375 models that offer both individual and group-based activities appear to be beneficial for patients  
376 with PTSD/SUDs, allowing for flexible shifts between self-reflection in solitude and social

377 interaction. Future studies would be particularly useful if they assess how the effects of  
378 integrated approaches in group and individual settings compare to either therapeutic model  
379 alone.

380 Additionally, identifying potential therapeutic mechanisms and risks of nature-based  
381 interventions for this population may guide clinicians in adopting a personalized approach and  
382 identify key considerations when recommending these interventions as an integrative approach  
383 for the treatment of co-occurring PTSD and SUDs. Furthermore, the results of such studies may  
384 guide policymakers and practitioners to develop initiatives and improve existing programs [59,  
385 91] to benefit patients with co-morbid PTSD and SUDs.

386

Article	Participants	Intervention	Results/conclusion
<b>Substance Use Disorder (SUD) Studies</b>			
Benvegnù G et al, 2024	24 SUD patients divided into three groups of 8 (nature walk, urban walk, and staying at the residential center)	Nature walks vs. urban walks vs staying at the residential center	Craving decreased significantly from pre- to post- nature walk, and lower post-nature than post-urban walk
Dai CL et al., 2020	109 patients residing in a treatment facility for SUD	Walking/Running program + racing	Positive impact on recovery, sense of achievement, and belonging
Marchand WR et al., 2022	25 veterans with psychiatric disorders (SUD 76%, PTSD 72%) 25 in the matched control group (retrospectively obtained from medical records)	Mindfulness-based therapeutic sailing	Increased psychological flexibility and mindfulness. The intervention was perceived as pleasurable by the participants.
Bennett LW,	31 patients with SUD (camping=13, usual care=18)	Therapeutic camping program vs. usual care	Significant improvements in autonomic arousal, frequency of negative thoughts, and alcohol craving in the camping group
Marchand WR et al, 2018	44 veterans with SUD (sailing=22, control=22)	Sailing adventure therapy	Significant increase in psychological flexibility Greater likelihood of completing residential SUD treatment. No effect on rate of psychiatric and SUD readmissions in the 12 months after discharge
<b>Post-Traumatic Stress Disorder (PTSD) Studies</b>			
Littman AJ et al, 2021	26 veterans with PTSD (nature hike=13, urban hike =13)	Nature vs. urban hiking	Acceptability of both nature and urban hiking was high. In the nature hiking group, median PTSD symptom scores (PTSD Checklist-5) improved more at 12 and 24 weeks compared to the urban hiking group.
Achabaeva AB et al, 2023	74 PTSD patients (main group =36, and control group=38)	Tx as usual vs tx as usual +controlled walking in the mid-mountain Natural Park and nitrogen-thermal baths	Significant improvement in psycho-emotional status with the added natural therapy
Bichler CS et al, 2022	73 patients with anxiety/PTSD (climbing =27, nordic walking =23, social contact =23)	Climbing exercise vs. Nordic walking (outdoor if weather allowed) vs social contact (movie watching and discussion group)	Anxiety decreased in all groups
Bettmann JE et al, 2021	49 veterans with PTSD	hiking, cycling, and rock climbing	The more time spent outdoors, the greater the reduction in PTSD symptoms.
Koziel N et al, 2022	20 female patients in an outpatient trauma therapy program	Walking during psychotherapy sessions	Feasible and acceptable to incorporate outdoor walking during trauma therapy sessions for patients and therapists. Significant decrease in PTSD symptoms (PCL 5) at 12 weeks
Detweiler MB et al, 2015	49 veterans randomly assigned to two groups	Horticultural therapy vs non-horticultural occupational therapy	Trends suggested that horticultural therapy may modulate stress. No statistically significant difference observed.
Rogers CM et al, 2014	14 veterans with PTSD symptoms	Ocean therapy (surfing)	Clinically meaningful improvement in PTSD and depressive symptoms

Perry DJ et al, 2024	19 veterans with PTSD symptoms	Nature and wildlife immersion experiences	Nature and wildlife immersion intervention was acceptable and feasible and perceived as greatly enjoyable by participants
Poulsen DV et al, 2016	8 veterans with PTSD symptoms	Mindfulness activities+ Nature-based activities+ individual therapy sessions in a forest therapy garden	Participants gained tools to manage stress and showed improvement in PTSD symptoms.
Gelkopf M et al,2013	42 veterans with PTSD (sailing =22, control=20)	Nature Adventure Rehabilitation (sailing)	Significant improvements in PTSD symptoms, depression, social and emotional quality of life, daily functioning, hope and perceived control over illness in the sailing group
Vella JE et al, 2013	74 veterans with PTSD	Outdoor recreation intervention (fly-fishing)	Significant improvement in sleep quality and reductions in perceptual stress and PTSD symptoms from baseline to follow-up periods
Walter KH et al, 2023	74 veterans (PTSD=20, no PTSD=54)	Recreational activity (cycling, surfing, sailing, kayaking, and archery/pickleball)	Those with PTSD experienced significant improvements in PTSD symptoms from pre to post-program, effect was lost at 3-month follow-up
Zabag R et al, 2020	39 patients with PTSD diagnosis (sailing =17, no sailing = 22) 38 healthy controls (sailing=18 who no sailing=20)	Sailing vs. no-sailing and a performance-based reversal learning paradigm to assess cognitive flexibility	Significantly lower PTSD and trait anxiety symptoms in the PTSD-sailing group (vs. PTSD-no-sailing group) selective impairment in reversing the outcome of a negative stimulus in PTSD- no sailing group selective impairment in reversing the outcome of a positive stimulus in PTSD-sailing group
Dustin D et al, 2011	13 veterans coping with PTSD	3-day river rafting/hiking/camping + journaling	Qualitative data suggested that therapeutic recreation service is well-suited to contribute to the rehabilitation of veterans coping with PTSD

387 Table 1. Intervention Research of Nature-based Activities in Treatment of PTSD and SU

- 390    1.    Pietrzak, R.H., et al., *Prevalence and Axis I comorbidity of full and partial posttraumatic stress*  
391        *disorder in the United States: results from Wave 2 of the National Epidemiologic Survey on*  
392        *Alcohol and Related Conditions*. J Anxiety Disord, 2011. **25**(3): p. 456-65.
- 393    2.    Kessler, R.C., et al., *Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the*  
394        *National Comorbidity Survey Replication*. Arch Gen Psychiatry, 2005. **62**(6): p. 593-602.
- 395    3.    Ford, J.D., E.M. Russo, and S.D. Mallon, *Integrating Treatment of Posttraumatic Stress Disorder*  
396        *and Substance Use Disorder*. Journal of Counseling & Development, 2007. **85**(4): p. 475-490.
- 397    4.    McCauley, J.L., et al., *Posttraumatic Stress Disorder and Co-Occurring Substance Use Disorders:*  
398        *Advances in Assessment and Treatment*. Clin Psychol (New York), 2012. **19**(3).
- 399    5.    Brady, K.T., S.E. Back, and S.F. Coffey, *Substance Abuse and Posttraumatic Stress Disorder*. Current  
400        Directions in Psychological Science, 2004. **13**(5): p. 206-209.
- 401    6.    Leeies, M., et al., *The use of alcohol and drugs to self-medicate symptoms of posttraumatic stress*  
402        *disorder*. Depress Anxiety, 2010. **27**(8): p. 731-6.
- 403    7.    Somohano, V.C., et al., *PTSD Symptom Clusters and Craving Differs by Primary Drug of Choice*. J  
404        Dual Diagn, 2019. **15**(4): p. 233-242.
- 405    8.    Flanagan, J.C., et al., *Concurrent Treatment of Substance Use and PTSD*. Curr Psychiatry Rep,  
406        2016. **18**(8): p. 70.
- 407    9.    Allen, J.P., E.F. Crawford, and H. Kudler, *Nature and Treatment of Comorbid Alcohol Problems and*  
408        *Post Traumatic Stress Disorder Among American Military Personnel and Veterans*. Alcohol Res,  
409        2016. **38**(1): p. 133-40.
- 410    10.    Lewis, C., et al., *Dropout from psychological therapies for post-traumatic stress disorder (PTSD) in*  
411        *adults: systematic review and meta-analysis*. Eur J Psychotraumatol, 2020. **11**(1): p. 1709709.
- 412    11.    Niles, B., A. Lang, and M. Olf, *Complementary and integrative interventions for PTSD*. Eur J  
413        Psychotraumatol, 2023. **14**(2): p. 2247888.
- 414    12.    Junyue, J., et al., *Complementary and Alternative Medicine for Substance Use Disorders: A*  
415        *Scientometric Analysis and Visualization of Its Use Between 2001 and 2020*. Front Psychiatry,  
416        2021. **12**: p. 722240.
- 417    13.    Wiley, E.R., et al., *Green space and substance use and addiction: A new frontier*. Addict Behav,  
418        2020. **100**: p. 106155.
- 419    14.    Wiley, E.R., et al., *Residential greenness and substance use among youth and young adults:*  
420        *Associations with alcohol, tobacco, and marijuana use*. Environ Res, 2022. **212**(Pt A): p. 113124.
- 421    15.    Berry, M.S., et al., *Promoting Healthy Decision-Making via Natural Environment Exposure: Initial*  
422        *Evidence and Future Directions*. Front Psychol, 2020. **11**: p. 1682.
- 423    16.    Félix-Junior, I.J., et al., *Mindfulness-based interventions in inpatient treatment for Substance Use*  
424        *Disorders: A systematic review*. Addict Behav Rep, 2022. **16**: p. 100467.
- 425    17.    Wang, D., et al., *Impact of physical exercise on substance use disorders: a meta-analysis*. PLoS  
426        One, 2014. **9**(10): p. e110728.
- 427    18.    Linke, S.E. and M. Ussher, *Exercise-based treatments for substance use disorders: evidence,*  
428        *theory, and practicality*. Am J Drug Alcohol Abuse, 2015. **41**(1): p. 7-15.
- 429    19.    Robertson, C.L., et al., *Effect of Exercise Training on Striatal Dopamine D2/D3 Receptors in*  
430        *Methamphetamine Users during Behavioral Treatment*. Neuropsychopharmacology, 2016. **41**(6):  
431        p. 1629-36.

- 432 20. Salem, B.A., et al., *Craving among individuals with stimulant use disorder in residential social*  
433 *model-based treatment - Can exercise help?* Drug Alcohol Depend, 2022. **231**: p. 109247.
- 434 21. Lynch, W.J., et al., *Exercise as a novel treatment for drug addiction: a neurobiological and stage-*  
435 *dependent hypothesis.* Neurosci Biobehav Rev, 2013. **37**(8): p. 1622-44.
- 436 22. Tran, I., O. Sabol, and J. Mote, *The Relationship Between Greenspace Exposure and*  
437 *Psychopathology Symptoms: A Systematic Review.* Biol Psychiatry Glob Open Sci, 2022. **2**(3): p.  
438 206-222.
- 439 23. Engemann, K. et al., *Residential green space in childhood is associated with lower risk of*  
440 *psychiatric disorders from adolescence into adulthood.* Proc Natl Acad Sci U S A, 2019. **116**(11):  
441 p. 5188-5193.
- 442 24. Martin, L., et al., *Natural environments and craving: The mediating role of negative affect.* Health  
443 Place, 2019. **58**: p. 102160.
- 444 25. Martin, L., et al., *Neighbourhood greenspace and smoking prevalence: Results from a nationally*  
445 *representative survey in England.* Soc Sci Med, 2020. **265**: p. 113448.
- 446 26. Jo, H., C. Song, and Y. Miyazaki, *Physiological Benefits of Viewing Nature: A Systematic Review of*  
447 *Indoor Experiments.* Int J Environ Res Public Health, 2019. **16**(23).
- 448 27. Van der Wal, A.J., et al., *Do natural landscapes reduce future discounting in humans?* Proc Biol  
449 Sci, 2013. **280**(1773): p. 20132295.
- 450 28. Reynolds, L., et al., *Virtual Nature as an Intervention for Reducing Stress and Improving Mood in*  
451 *People with Substance Use Disorder.* J Addict, 2020. **2020**: p. 1892390.
- 452 29. Kang, M., et al., *The mechanisms of nature-based therapy on depression, anxiety, stress, and life*  
453 *satisfaction: examining mindfulness in a two-wave mediation model.* Front Psychol, 2023. **14**: p.  
454 1330207.
- 455 30. Howell, A.J., et al., *Nature connectedness: Associations with well-being and mindfulness.*  
456 Personality and Individual Differences, 2011. **51**(2): p. 166-171.
- 457 31. Kabat-Zinn, J., *An outpatient program in behavioral medicine for chronic pain patients based on*  
458 *the practice of mindfulness meditation: theoretical considerations and preliminary results.* Gen  
459 Hosp Psychiatry, 1982. **4**(1): p. 33-47.
- 460 32. Van Gordon, W., E. Shonin, and M. Richardson, *Mindfulness and Nature.* Mindfulness, 2018. **9**(5):  
461 p. 1655-1658.
- 462 33. Sudimac, S., V. Sale, and S. Kühn, *How nature nurtures: Amygdala activity decreases as the result*  
463 *of a one-hour walk in nature.* Molecular Psychiatry, 2022. **27**(11): p. 4446-4452.
- 464 34. Taren, A.A., et al., *Mindfulness meditation training alters stress-related amygdala resting state*  
465 *functional connectivity: a randomized controlled trial.* Soc Cogn Affect Neurosci, 2015. **10**(12): p.  
466 1758-68.
- 467 35. Kral, T.R.A., et al., *Impact of short- and long-term mindfulness meditation training on amygdala*  
468 *reactivity to emotional stimuli.* Neuroimage, 2018. **181**: p. 301-313.
- 469 36. Leung, M.-K., et al., *Meditation-induced neuroplastic changes in amygdala activity during*  
470 *negative affective processing.* Social Neuroscience, 2018. **13**(3): p. 277-288.
- 471 37. Djernis, D., et al., *A Systematic Review and Meta-Analysis of Nature-Based Mindfulness: Effects*  
472 *of Moving Mindfulness Training into an Outdoor Natural Setting.* Int J Environ Res Public Health,  
473 2019. **16**(17).
- 474 38. Kaplan, S., *Meditation, Restoration, and the Management of Mental Fatigue.* Environment and  
475 Behavior, 2001. **33**(4): p. 480-506.
- 476 39. Kotera, Y. and C. Rhodes, *Commentary: Suggesting Shinrin-yoku (forest bathing) for treating*  
477 *addiction.* Addict Behav, 2020. **111**: p. 106556.
- 478 40. Marchand, W.R., et al., *Mindfulness-based Therapeutic Sailing for Veterans With Psychiatric and*  
479 *Substance Use Disorders.* Mil Med, 2022. **187**(3-4): p. e445-e452.



- 480 41. Crombie, K.M., et al., *Aerobic exercise in the treatment of PTSD: An examination of preclinical*  
481 *and clinical laboratory findings, potential mechanisms, clinical implications, and future*  
482 *directions*. J Anxiety Disord, 2023. **94**: p. 102680.
- 483 42. Björkman, F. and Ö. Ekblom, *Physical Exercise as Treatment for PTSD: A Systematic Review and*  
484 *Meta-Analysis*. Mil Med, 2022. **187**(9-10): p. e1103-e1113.
- 485 43. Zhang, Z. and X. Liu, *A Systematic Review of Exercise Intervention Program for People With*  
486 *Substance Use Disorder*. Front Psychiatry, 2022. **13**: p. 817927.
- 487 44. Ley, C., M. Rato Barrio, and A. Koch, *"In the Sport I Am Here": Therapeutic Processes and Health*  
488 *Effects of Sport and Exercise on PTSD*. Qual Health Res, 2018. **28**(3): p. 491-507.
- 489 45. Hegberg, N.J., J.P. Hayes, and S.M. Hayes, *Exercise Intervention in PTSD: A Narrative Review and*  
490 *Rationale for Implementation*. Front Psychiatry, 2019. **10**: p. 133.
- 491 46. Saanijoki, T., et al., *Aerobic Fitness Is Associated with Cerebral  $\mu$ -Opioid Receptor Activation in*  
492 *Healthy Humans*. Med Sci Sports Exerc, 2022. **54**(7): p. 1076-1084.
- 493 47. Brellenthin, A.G., et al., *Psychological and endocannabinoid responses to aerobic exercise in*  
494 *substance use disorder patients*. Subst Abus, 2021. **42**(3): p. 272-283.
- 495 48. Matei, D., et al., *The Endocannabinoid System and Physical Exercise*. Int J Mol Sci, 2023. **24**(3).
- 496 49. Noseworthy, M., et al., *The Effects of Outdoor versus Indoor Exercise on Psychological Health,*  
497 *Physical Health, and Physical Activity Behaviour: A Systematic Review of Longitudinal Trials*. Int J  
498 Environ Res Public Health, 2023. **20**(3).
- 499 50. Calogiuri, G., H. Nordtug, and A. Weydahl, *THE POTENTIAL OF USING EXERCISE IN NATURE AS AN*  
500 *INTERVENTION TO ENHANCE EXERCISE BEHAVIOR: RESULTS FROM A PILOT STUDY*. Percept Mot  
501 Skills, 2015. **121**(2): p. 350-70.
- 502 51. Calogiuri, G., et al., *Green exercise as a workplace intervention to reduce job stress. Results from*  
503 *a pilot study*. Work, 2015. **53**(1): p. 99-111.
- 504 52. Lacharité-Lemieux, M., J.P. Brunelle, and I.J. Dionne, *Adherence to exercise and affective*  
505 *responses: comparison between outdoor and indoor training*. Menopause, 2015. **22**(7): p. 731-  
506 40.
- 507 53. Wilson, E.O., *Biophilia: The Human Bond with Other Species*. Harvard University Press,  
508 Cambridge, MA., 1984.
- 509 54. Mayer, F.S., et al., *Why Is Nature Beneficial?: The Role of Connectedness to Nature*. Environment  
510 and Behavior, 2009. **41**(5): p. 607-643.
- 511 55. Block, K., et al., *The role of the natural environment in disaster recovery: "We live here because*  
512 *we love the bush"*. Health & Place, 2019. **57**: p. 61-69.
- 513 56. Westlund, S., *'Becoming human again': Exploring connections between nature and recovery from*  
514 *stress and post-traumatic distress*. Work, 2015. **50**: p. 161-174.
- 515 57. Ward, K.S., S. Truong, and T. Gray, *Connecting to nature through community engaged*  
516 *scholarship: Community gardens as sites for collaborative relationships, psychological, and*  
517 *physiological wellbeing*. Front Psychiatry, 2022. **13**: p. 883817.
- 518 58. Boffi, M., et al., *Nature Experiences of Older People for Active Ageing: An Interdisciplinary*  
519 *Approach to the Co-Design of Community Gardens*. Front Psychol, 2021. **12**: p. 702525.
- 520 59. Sun, Q., et al., *Green Social Prescribing in Practice: A Case Study of Walsall, UK*. Int J Environ Res  
521 Public Health, 2023. **20**(17).
- 522 60. Sirisena, M. and M. Cheetham, *"You're sort of building community in a bigger way": exploring*  
523 *the potential of creative, nature-based activities to facilitate community connections*. Arts  
524 Health, 2024: p. 1-16.
- 525 61. Engagement:, S.A.a.M.H.S.A.S.C., et al.
- 526 62. Anderson, M., et al., *'It's not 9 to 5 recovery': the role of a recovery community in producing*  
527 *social bonds that support recovery*. Drugs (Abingdon Engl), 2021. **28**(5): p. 475-485.

- 528 63. Pietrzak, R.H., et al., *Psychological resilience and postdeployment social support protect against*  
529 *traumatic stress and depressive symptoms in soldiers returning from Operations Enduring*  
530 *Freedom and Iraqi Freedom*. *Depress Anxiety*, 2009. **26**(8): p. 745-51.
- 531 64. Stanley, I.H., et al., *Perceptions of belongingness and social support attenuate PTSD symptom*  
532 *severity among firefighters: A multistudy investigation*. *Psychol Serv*, 2019. **16**(4): p. 543-555.
- 533 65. Johansen, V.A., et al., *The Relationship Between Perceived Social Support and PTSD Symptoms*  
534 *After Exposure to Physical Assault: An 8 Years Longitudinal Study*. *Journal of Interpersonal*  
535 *Violence*, 2022. **37**(9-10): p. NP7679-NP7706.
- 536 66. Kitzinger, R.H., Jr., et al., *Habits and Routines of Adults in Early Recovery From Substance Use*  
537 *Disorder: Clinical and Research Implications From a Mixed Methodology Exploratory Study*. *Subst*  
538 *Abuse*, 2023. **17**: p. 11782218231153843.
- 539 67. McKay, J.R., *Making the hard work of recovery more attractive for those with substance use*  
540 *disorders*. *Addiction*, 2017. **112**(5): p. 751-757.
- 541 68. Meshesha, L.Z., et al., *Patient Perspective on the Role of Substance-Free Activities During Alcohol*  
542 *Use Disorder Treatment: A Mixed-Method Study*. *Alcohol Treat Q*, 2023. **41**(3): p. 309-321.
- 543 69. Liang, L., et al., *Everyday life experiences for evaluating post-traumatic stress disorder symptoms*.  
544 *Eur J Psychotraumatol*, 2023. **14**(2): p. 2238584.
- 545 70. Poulsen, D.V. et al., *'Everything just seems much more right in nature': How veterans with post-*  
546 *traumatic stress disorder experience nature-based activities in a forest therapy garden*. *Health*  
547 *Psychol Open*, 2016. **3**(1): p. 2055102916637090.
- 548 71. Benvegnù, G., et al., *Nature-based experience in Venetian lagoon: Effects on craving and*  
549 *wellbeing in addict residential inpatients*. *Front Psychol*, 2024. **15**: p. 1356446.
- 550 72. Dai, C.L. et al., *Managing Substance Use Disorder through a Walking/Running Training Program*.  
551 *Subst Abuse*, 2020. **14**: p. 1178221820936681.
- 552 73. Littman, A.J., et al., *Nature versus urban hiking for Veterans with post-traumatic stress disorder:*  
553 *a pilot randomised trial conducted in the Pacific Northwest USA*. *BMJ Open*, 2021. **11**(9): p.  
554 e051885.
- 555 74. Li, D., et al., *Coping with post-hurricane mental distress: The role of neighborhood green space*.  
556 *Soc Sci Med*, 2021. **281**: p. 114084.
- 557 75. Ventimiglia, I. and S. Seedat, *Current evidence on urbanicity and the impact of neighborhoods on*  
558 *anxiety and stress-related disorders*. *Curr Opin Psychiatry*, 2019. **32**(3): p. 248-253.
- 559 76. Achabaeva, A.B., et al., *[Natural healing factors of Nalchik resort in medical rehabilitation of the*  
560 *patients with post-traumatic stress disorder. (Randomized controlled trial)]*. *Vopr Kurortol*  
561 *Fizioter Lech Fiz Kult*, 2023. **100**(6): p. 59-65.
- 562 77. Bichler, C.S., et al., *Climbing as an Add-On Treatment Option for Patients with Severe Anxiety*  
563 *Disorders and PTSD: Feasibility Analysis and First Results of a Randomized Controlled*  
564 *Longitudinal Clinical Pilot Trial*. *Int J Environ Res Public Health*, 2022. **19**(18).
- 565 78. Bettmann, J.E., et al., *The effect of time outdoors on veterans receiving treatment for PTSD*. *J Clin*  
566 *Psychol*, 2021. **77**(9): p. 2041-2056.
- 567 79. Koziel, N., et al., *Walking Psychotherapy As a Health Promotion Strategy to Improve Mental and*  
568 *Physical Health for Patients and Therapists: Clinical Open-Label Feasibility Trial*. *Can J Psychiatry*,  
569 2022. **67**(2): p. 153-155.
- 570 80. Zabag, R., et al., *Cognitive flexibility in PTSD individuals following nature adventure intervention:*  
571 *is it really that good?* *Stress*, 2020. **23**(1): p. 97-104.
- 572 81. Gelkopf, M., et al., *Nature adventure rehabilitation for combat-related posttraumatic chronic*  
573 *stress disorder: a randomized control trial*. *Psychiatry Res*, 2013. **209**(3): p. 485-93.

- 574 82. Rogers, C.M., T. Mallinson, and D. Peppers, *High-intensity sports for posttraumatic stress disorder*  
575 *and depression: feasibility study of ocean therapy with veterans of Operation Enduring Freedom*  
576 *and Operation Iraqi Freedom*. *Am J Occup Ther*, 2014. **68**(4): p. 395-404.
- 577 83. Marchand, W.R., et al., *Safety and psychological impact of sailing adventure therapy among*  
578 *Veterans with substance use disorders*. *Complement Ther Med*, 2018. **40**: p. 42-47.
- 579 84. Perry, D.J., et al., *The feasibility of wildlife immersion experiences for Veterans with PTSD*. *Front*  
580 *Vet Sci*, 2024. **11**: p. 1290668.
- 581 85. Detweiler, M.B., et al., *Horticultural therapy: a pilot study on modulating cortisol levels and*  
582 *indices of substance craving, posttraumatic stress disorder, depression, and quality of life in*  
583 *veterans*. *Altern Ther Health Med*, 2015. **21**(4): p. 36-41.
- 584 86. Vella, E.J., B. Milligan, and J.L. Bennett, *Participation in outdoor recreation program predicts*  
585 *improved psychosocial well-being among veterans with post-traumatic stress disorder: a pilot*  
586 *study*. *Mil Med*, 2013. **178**(3): p. 254-60.
- 587 87. Wheeler, M., et al., *Outdoor recreational activity experiences improve psychological wellbeing of*  
588 *military veterans with post-traumatic stress disorder: Positive findings from a pilot study and a*  
589 *randomised controlled trial*. *PLoS One*, 2020. **15**(11): p. e0241763.
- 590 88. Walter, K.H., et al., *The effectiveness of the National Veterans Summer Sports Clinic for veterans*  
591 *with probable posttraumatic stress disorder*. *Front Psychol*, 2023. **14**: p. 1207633.
- 592 89. Bennett, L.W., S. Cardone, and J. Jarczyk, *Effects of a therapeutic camping program on addiction*  
593 *recovery. The Algonquin Haymarket Relapse Prevention Program*. *J Subst Abuse Treat*, 1998.  
594 **15**(5): p. 469-74.
- 595 90. Daniel Dustin, N.B., Joseph Arave, Wendy Wall, George Wendt, *The Promise of River Running as*  
596 *a Therapeutic*  
597 *Medium for Veterans Coping with*  
598 *Post-Traumatic Stress Disorder*. *Therapeutic Recreation Journal*.
- 599 91. Maier, J. and S. Jette, *Promoting Nature-Based Activity for People With Mental Illness Through*  
600 *the US "Exercise Is Medicine" Initiative*. *Am J Public Health*, 2016. **106**(5): p. 796-9.

601