

Review

# Nature-Based Interventions for Adults with Developmental Disabilities: A Scoping Review Centering Autistic Adults

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**Abstract:** Autistic adults often face higher levels of depression, anxiety, and stress and reduced levels of quality of life and employment in comparison to their neurotypical peers. Nature-based interventions (NBIs), which utilize outdoor environments and activities for health and wellbeing outcomes, could provide possibilities to meet these various needs. This study therefore aims to identify the extent of academic literature examining NBIs for autistic adults. A scoping review of peer-reviewed articles published between 1985 and 2023 was conducted. Ten databases were systematically searched, and additional hand searching was conducted. Studies involving substantial engagement with an NBI and involving autistic adults (age  $\geq 18$ ), or developmental disability if specific diagnosis was not identified, were included. A total of seven studies were identified; however, three studies did not refer to autism specifically, identifying developmental disability more broadly. NBIs were conducted in a variety of international locations and involved a diverse range of activities and outcomes. While NBIs can provide outcomes relevant to employment, health, and wellbeing, multiple limitations and literature gaps are noted. The findings indicate a strong need for further research specific to autism.

**Keywords:** autism; developmental disability; adults; nature-based interventions; therapeutic horticulture; employment; mental health; quality of life



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## 1. Introduction

Recent literature has identified that research and services addressing mental health, quality of life (QoL), and social wellbeing are important for autistic adults [1]. These are key areas to address, as there is evidence that this group experiences lower QoL in comparison to non-autistic adults [2]. Autistic adults can also experience higher levels of stress, and can commonly experience co-occurring depression, anxiety, as well as other co-occurring disabilities such as ADHD or intellectual disability [3–5]. Wellbeing and QoL for autistic adults is complex and may differ from neurotypical expectations and norms [6]. Unique factors can be involved, including sensory experience, autistic identity, societal acceptance of autism, and access to services [7,8].

Barriers to employment for autistic adults have also been reported [9,10], and though employment as a normative outcome should be problematized, it is often also related to QoL and wellbeing in autistic individuals [6,8]. A priority-setting stakeholder consultation with autistic adults found that participants had strong interest and preference for interventions and approaches to mental health and wellbeing such as art therapy, music therapy, physical activity, and animal-assisted therapy [1]. Nature-based interventions (NBIs) could also be of interest to this group as a similar modality providing multiple vocational, health, and wellbeing outcomes.

The broad umbrella of NBIs and their many applications have been the subject of a growing amount of literature in recent years, with multiple reviews establishing the

relevance of exposure to nature for health and wellbeing [11–13]. Although a unified definition of NBIs is not yet well established, it appears widely accepted that the essential elements of an NBI include an attempt to improve health and wellbeing through exposure to, or engagement with, elements of nature [14]. This is underpinned by theories of nature's ability to restore attention and reduce cognitive demand and stress [15], as well as the human compulsion towards nature through the biophilia hypothesis [16]. NBIs can include not only activities but also the alteration and qualities of the natural environment to enhance wellbeing outcomes, such as purposeful landscape design [14].

A multitude of activities are covered under the umbrella of NBIs, such as gardening, forest bathing (*shinrin yoku*), and wilderness therapy [17]. Animal-assisted interventions such as equine therapy are also encompassed by the umbrella of NBIs [18]. Various terms such as therapeutic horticulture, ecotherapy, green care, blue care (water-based natural settings), and care farming are also subsumed into the concept of NBIs [12,19,20]. Therapeutic horticulture (TH) (also sometimes termed horticulture therapy or social and therapeutic horticulture) in particular has similarities to arts therapy modalities, using gardening and outdoor activities and settings to facilitate the therapeutic process [21]. Vocational horticulture can also be seen as a form of NBI, in which employment-related horticultural skills are developed within the context of therapeutic intervention. In this way, vocational horticulture offers potential employment and meaningful activity, particularly for populations facing barriers to traditional job markets [22–24]. Additionally, TH is frequently delivered in a group community setting, giving it a strong social and relational element that aligns with calls for community-accessible services [1,21].

NBI research spans countless configurations of specific interventions or activity types with a wide range of target groups [18]. A number of reviews have found NBIs to be worthy of exploration for health and psychosocial wellbeing [25–27], stress reduction [28], for vulnerable youth [29], multiple long-term conditions [30], and people with dementia [31], to name a few. Some sources have explored the delivery and outcomes of NBIs for adults with various developmental disabilities [32], as well as garden design for autistic adults [33]. Various studies have also explored NBIs for autistic children [34–37]. Findings that nature can be beneficial for neurodivergent children have also gained recent attention in the media [38]. However, there does not yet appear to be a review of NBIs for autistic adults. Given the potential of NBIs to improve social connection, health, and psychosocial wellbeing—areas of interest and importance for autistic adults—the exploration of the use of NBIs for this population group is warranted.

As the extent of research in this area is unclear, the aim of this scoping review was to document existing peer-reviewed research on nature-based programs and interventions for autistic adults and to identify research gaps. Previous reviews of NBIs for other user groups report generally positive outcomes from engagement with nature but also a need for more rigorous research [29]. Chief among these needs is a more detailed description of the types of interventions used, given the heterogeneity of NBI activities [20]. As a multidisciplinary field, NBIs are also often delivered by professionals with a wide variety of qualifications across healthcare and horticulture [12]. Staff qualifications, intervention funding, and program duration are important elements that can impact intervention implementation and outcomes but are also often absent in the literature [14,29]. Three research questions were therefore identified to guide this review: 1. What types of nature-based programs and interventions have been studied in relation to autism? 2. What methods have been used to conduct this research? 3. What outcomes have been reported?

## 2. Method

A scoping review was considered the best format in which to provide an overview of the extent and types of academic research in the area, particularly where a wide variety of study designs may apply [39]. This review was conducted in accordance with PRISMA guidelines [40,41], following the five-step methodology outlined by Arksey and O'Malley [39] and expanded by Levac et al. [42] and Lockwood and Tricco [43]. Firstly,

research aims and questions (outlined above) were developed by the authors. Articles were identified through systematic database searches outlined in Table 1, as well as citation searching of included studies.

**Table 1.** Databases and search strategy.

Databases	Search Block	Search Strategy
CINAHL Complete; Environment Complete; Garden, Landscape & Horticulture Index; Global Health; MEDLINE Complete; APA PsycInfo; SocINDEX with Full Text; Academic Search Complete; GreenFILE; Embase	Nature-based interventions	(horticulture or garden* or nature or eco) N3 (social* or therap* or healing or intervention or program*) OR “forest bathing” or “shinrin yoku” or “care farm*” or “community garden*” or “ecotherapy”
	Autism	autis* or asperger* or neurodevelopmental or neuro-developmental or neurodiver* or neuro-diver* or ASD or PDD-NOS OR developmental NEAR/3 (disab* OR disorder*).

Note: Relevant search functions were adapted to suit specific database search conventions (e.g., N3 swapped for ‘NEAR’ to complete the same function). Search function ‘AND’ used to combine search blocks. Asterisks denote standard command used for truncated terms in database searching.

As a journal that is highly relevant to the topic, the *Journal of Therapeutic Horticulture* was also hand searched via JSTOR, as comprehensive records of this journal were not available in the above listed databases.

Relevant studies were selected based on pre-determined inclusion and exclusion criteria outlined in a review protocol registered with Open Science Framework (<https://doi.org/10.17605/OSF.IO/7B2E4>, accessed on 14 April 2022) and outlined in Table 2. Due to a lack of specific details about participant characteristics in many studies, in addition to the original protocol inclusion criteria, studies referring to developmental disability more broadly were also included if it was possible that they could pertain to autism (i.e., did not specifically state otherwise). Books and all academic journal articles were also originally included in the search protocol but later excluded in favor of primary research studies.

**Table 2.** Inclusion and exclusion criteria.

Category	Included	Excluded
Populations of interest	Adults (including where ages range from under 18 to over 18 years old) Autism as a primary or secondary disability Unspecified developmental disability	Children or adolescents only (all participants under 18 years old) Specified developmental disabilities without autism Disability group not substantially reported on
Intervention type	Purposeful, structured, or facilitated activities with, or in, nature (green and/or blue space), including indoor plants	Animal-assisted interventions NBI not substantially reported on
Study types	Peer-reviewed journal articles of any primary research type	Gray literature Books Non-empirical articles
Publication dates	1985 to 2023	-
Publication language	English	-

Results of all searches (run on 17 January 2022 and updated on 11 February 2023) were imported to reference management software (Zotero by Corporation for Digital Scholarship, USA, version 6.0.21) and systematic review software (Covidence by Veritas Health Innovation Ltd., Australia). Duplicates were then removed within Covidence [44]. Abstracts and titles were then screened by the lead author for eligibility for full-text screening. Eligible full-text articles were then screened separately, with each article requiring the agreement of two researchers’ votes to be included. Conflicts in voting were resolved through meeting with the research team. Included studies were further interrogated in forwards and backwards searching of reference lists and cited by results. Cited by searches were completed in

Scopus, Web of Science, and Google Scholar (9 September 2022), before being screened as per the above process in Covidence.

Following study selection, the relevant data from the included studies were charted into a table of study characteristics (author, year, participants, methodology, outcomes), and NBI characteristics (location, aim, activities, duration, attendance, facilitation, funding), drawing on data extraction tables from other similar NBI-related reviews (e.g., Gritzka et al. [20]). A quality assessment was completed using the Mixed Methods Appraisal Tool (MMAT) [45]. Finally, the results were then summarized and reported as they relate to the research questions and placed into the context of broader research and practice [42].

### 3. Search Results

From the initial identification of 790 articles and subsequent screening, a total of nine articles were included. Reference lists of these included studies were then searched for relevant articles, as well as searched in Scopus, Web of Science, and Google Scholar for further cited by articles. A comprehensive search through reference lists and cited references resulted in a further 62 articles, which were submitted to the same screening process after removing duplicates. Following this process, an additional two articles were identified. Full-text studies were then screened, and a quality appraisal was conducted. Studies that did not meet MMAT screening criteria (not empirical research) were then also excluded. Following this process, the final number of included articles came to eight, as illustrated in Figure 1.

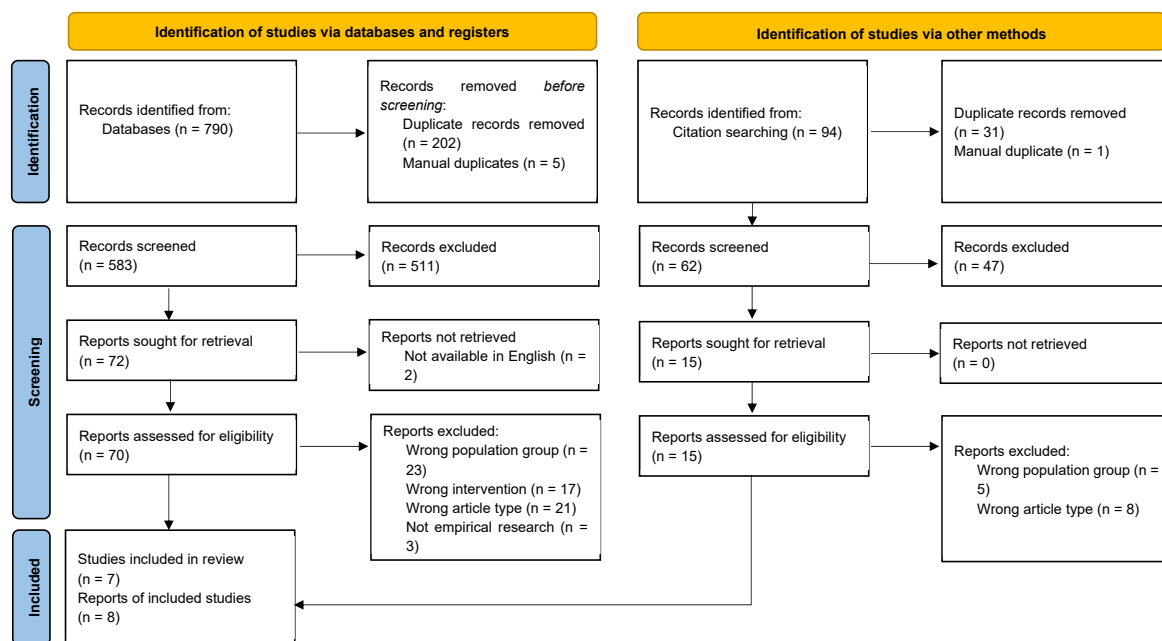


Figure 1. PRISMA flow chart.

#### 3.1. Description of Studies

A total of eight articles were included in this review. However, due to the combination of two articles related to the same study [46,47], seven studies will be referred to throughout this paper and are mapped in Table 3. As shown in Table 3, four of the included studies referred to autistic participants specifically. The remaining studies included participants with developmental disability but did not specify the type and therefore could not be excluded. One study included a variety of participants from a range of different groups—some groups involved autistic individuals, whereas others were comprised of people with various mental health concerns [48]. More detailed participant characteristics were also reported in some instances, including participants with multiple disabilities or specific communication capacities [49].

**Table 3.** Summary of included studies.

Reference and Location	Year	NBI Sample	NBI Description	Study Design	Outcome of Interest	Results	Quality Appraisal (MMAT)
Uehara [47]; Uehara and Itoh [46] Japan	1999	Developmental disability 36 to 46 years old <i>n</i> = 3 (male)	Forest walking, gardening activities, producing mushrooms, attended for 2–3 h, 2–4 times per week over 1.5 years, facilitated by residential facility staff	Quantitative longitudinal	Alpha waves (stress/relaxation), physical ability, communication ability, emotional stability, and activities of daily life	Reduction in stress, reduction in injurious behaviours, improvement in physical ability, communication, emotional stability	****
Himmelheber et al. [50] USA	2018	Intellectual and developmental disability <i>n</i> = unclear, gender not specified Age unclear: “young adults and adolescents”	Summer camp, hiking, gardening, music, games, arts and crafts, attended for one week annually, facilitated by camp staff and volunteers	Qualitative process program evaluation	Process and impacts of horticulture therapy camp	Program provided community-building opportunity, self-efficacy, and exposure and interaction with natural world	*****
Uehara [49] Japan	1999	Autism 14–26 years old (mean age 19.5) <i>n</i> = 22 (17 males and 5 females)	Forest activities including recreational walking and producing mushrooms, attended for 4–6 h weekdays over 3 years, facilitated by facility staff	Quantitative longitudinal	“Working ability, communication ability, ease of autistic conditions, behaviour, and basic life ability”	Improvement in working ability and communication. Also reported that “panic reactions” were very rare in outdoor environment. Improved emotional stability after forest session. Also noted improved sleep in some participants.	**
O’Brien [48] UK	2018	Various groups (autism, mental health, youth, drug and alcohol rehabilitation, older adults). Autism groups including adults: <i>n</i> = 13 (gender not specified). Age 17 to 28 years old	Woodland management, arts and sensory activities, outdoor cooking, attended for 5 h per week or fortnight, facilitated by forest management staff and volunteers	Qualitative multimethod	Reported and observed wellbeing	Wellbeing related to themes of social engagement, woodland craft engagement, creative and sensory engagement, and the importance of repeat visits	*****
Scartazza et al. [51] Italy	2020	Autism 15 to 23 years (mean = 17.8 years; SD = 3.2). <i>n</i> = 8 (male)	Biodiversity conservation in the community, attended for 4 h once a week over two years, facilitated by healthcare professionals, researchers, and volunteers	Quantitative pre-post comparison	Health and wellbeing	Improvement across all target areas: intention, interaction, and regulation, “initiative in expressing will”, “shared action”, “reaction to another’s presence”, and “behavioural unpredictability”	***
Mattson et al. [52] USA	1986	Developmental disability <i>n</i> = 7 (gender not specified) 20 to 47 years (mean age 32.6 years)	Apple harvesting, attended for one month, facilitated by vocational trainer and orchard manager	Quantitative within group comparison	Job skill and productivity	Higher levels of productivity and higher wages for participants in apple orchard as opposed to training center	***
Schleien et al. [53] USA	1991	Autism 16–20 years <i>n</i> = 3 (2 male, 1 female)	Planting seeds, transplanting seedlings, and repotting plants, attended for 3 h once a week for 9 weeks	A-B case study	Retention and generalizability of horticultural skills	Development and retention of vocational horticulture skills. Skills not generalized to new environment.	***

Note: Each star represents 20% of MMAT quality criteria met, with five stars indicating 100%, or full criteria met [54].

Most research came from the US, with additional studies from Japan, the UK, and Italy. Dates of the research studies ranged from 1986 to 2020, with a nearly 10-year gap in dates between 1999 and 2018.

### 3.2. Types of Nature-Based Interventions

A wide variety of NBIs were represented in the literature, including a range of active and passive activities, as well as indoor and outdoor horticultural activities. Forest-based activities were most common among the studies found. A number of NBIs also integrated cooking, arts, and crafts. Horticulture activities were mostly connected to studies relating to vocational skills. Additionally, some studies also noted the connection between the NBI setting or activity and the importance of sustainability and conservation.

#### 3.2.1. Forest-Based Activities

Studies from Japan focused on forest-based activities at institutions and were facilitated by staff at the site of the program (e.g., residential facility staff). Both studies described walking in a forest environment connected to the facilities, and both studies included using mushroom-growing activities by collecting logs and injecting mushroom spores [46,47,49]. The two studies did differ, however, in group size, time spent in the forest, and the number of additional activities. At a residential facility, the group consisted of up to 10 regular attendees with differing disabilities. These attendees spent a few hours in the forest two to four times a week. In addition to walking in the forest, this group undertook other activities such as mowing and planting trees, flowers, and vegetables [46,47]. By comparison, Uehara [49] described forest activities taking place at a specialized autism treatment center, with a larger group of 22 people attending more regularly (four to six hours each weekday). Additional activities were not reported for that study, but it was noted that activities ran in all weather conditions [49].

O'Brien [48] similarly discussed forest-based activities in the UK; however, the forest location and program were not attached to any particular institution, and the program was open to a wide variety of user groups. The program was run at a large public arboretum involved in environmental conservation. A community shelter with a fire pit and wood oven was built specifically for the program to host participants from five youth groups and five adult groups. The community shelter was reported to be an important feature that facilitated a sense of belonging among participants [48]. Of the groups attending, two included autistic participants of adult age: one group of 10 from a residential facility (with support from carers) and another group of three. Visits to the program were weekly or fortnightly for approximately five hours, and groups were attended between four and eight times. Participants could walk in the arboretum and across a treetop walkway that was accessible to wheelchair users. Other forest-based activities included woodland management, such as clearing brambles, fencing, and planting trees. Activities were facilitated by the forestry commission staff, described as trained youth and community workers. Staff and volunteers also attended an autism awareness course and an inclusion training day.

#### 3.2.2. Integrating Cooking, Arts, and Crafts

While centered in nature, some NBIs also integrated additional activities, such as cooking, arts, and crafts. These could utilize natural elements, such as sound mapping, carving, or using leaves to make prints [48]. Cooking and eating as a group was also described by O'Brien [48] as a key activity that facilitated social connection and teamwork, by roasting marshmallows over the fire or preparing and cooking pizzas in the outdoor oven.

Himmelheber et al. [50] also highlight arts and crafts as important activities. The program is described as an intensive horticultural therapy camp in the U.S., in which small groups of 10–12 annual campers attend for one week. Although labeled as a horticultural therapy camp, there is little description of horticultural activities, with most focus



given to arts and crafts, including games, music, hiking, herb gardening, and carpentry (e.g., building birdhouses) and painting.

### 3.2.3. Horticultural Activities

Studies relating to horticultural activities took the form of discrete horticultural skills such as repotting plants, as well as work placements [52,53]. One study describes participants attending an outdoor education training center set on a large farm in the US with the aim of teaching horticultural skills [53]. Activities were conducted indoors in the greenhouse, where three participants were taught three key horticultural skills: planting seeds, transplanting seedlings, and repotting larger plants. Participants attended for three hours, once a week for nine weeks. Other studies focused on employment capacity and productivity. Mattson et al. [52] compared the productivity of employee participants in apple harvesting in contrast to an indoor training center. Guided by horticultural vocational training staff, 30 participants from a nearby vocational training center learned standard apple harvesting techniques. Following this, they spent a month engaged in apple picking, supported by the orchard manager.

### 3.2.4. Sustainability

The possibility of mutual human and nature benefits and opportunities for sustainability and conservation in NBIs were noted across three of the included studies. Scartazza et al. [51] describe an NBI that actively involves conservation and sustainability at the heart of its purpose. The authors describe the importance of biodiversity for human health and wellbeing, particularly in light of biodiversity loss and climate change. Set in a dedicated garden in Italy, the program was conceived by an interdisciplinary team of professionals, researchers, and local community members and used to improve the wellbeing of people and the local environment. Eight young autistic adults and adolescents were given the role of “Biodiversity Custodians” and connected with farmers and elders in the community to conserve the local area through landrace planting (genetically diverse native plants suited to the conditions of the local environment). The landrace plants in the program are chosen for their adaptive characteristics, such as needing less water and being hardier than commercial counterparts, therefore needing less use of pesticides and providing a more sustainable crop. Over a period of two years, participants attended once a week for four hours at a time and were supported with a 1:1 ratio. Along with assisting in the selection and planting of the landraces, the custodians also collected and saved landrace seeds. These were saved in a seedbank as well as being distributed to the community, furthering the program’s aim to support biodiversity conservation.

Furthermore, Uehara [49] notes that many forests in Japan are in need of care and maintenance, and that there is a possibility for mutual benefit for the environment as well as participants when engaging in forest activities. O’Brien [48] also described their NBI as being located in an arboretum involved in conservation efforts. Participants in the program are actively involved in woodland management and maintaining the grounds through fencing and clearing bramble. O’Brien notes, “A key aspect of engaging with and shaping nature is also the concept of relational values; people do not only receive benefits from engaging with nature but shape it themselves through caring about nature and taking action to care for nature” [48] (p. 2).

### 3.3. Nature-Based Intervention Outcomes

Outcomes from NBIs were diverse in nature and related to social connection as well as personal outcomes. In the study by Uehara and Itoh [46,47], three men with various developmental disabilities showed improvement after participating in forest-based activities. Improvements were reported in their behavior across emotional stability, communication, and “life rhythm”, described by the authors as “basic life activities such as eating, sleeping, behavior, interactions, and so forth” (p. 24). These categories were measured by observation of staff on a three-point scale, and with interobserver agreement, but it is unclear how these

were defined. One participant had a noted an improvement in their walking ability and a decrease in monthly injuries, dropping from 10 incidents at the start of the program to two after one year. Alpha brain waves were also measured to compare between the indoor environment and forest environment. An increase in alpha brainwaves was noted in the three participants when in the forest, indicating a more relaxed state of mind in the forest than indoors. However, statistical procedures for this result were also not clearly defined.

Similarly, Uehara [49] found improved communication in a group of autistic adults following forest activities. Improved work attitude was reported in 13 of 22 participants, as well as a reduction in “panic reactions” (a term not explained or defined) following forest activities. The authors noted that “panic reactions had occurred mostly indoors and they seldom occurred in the forest environment.” (p. 63). Some participants showed improved sleep patterns. As with Uehara and Itoh [46], these outcomes were also measured by observation of staff on a three-point scale, and with interobserver agreement, but again, it was unclear how these were defined. Tables of findings were also difficult to interpret with limited explanation.

In a qualitative study, O’Brien [48] explored experiences of forest-based and arts and crafts activities for a variety of different user groups, including participants with autism, mental health conditions, mental psychosis, drug and alcohol rehabilitation, debt, addiction, and those with low wellbeing and social isolation issues. Observations and interviews were analyzed according to three types of nature engagement in green mind theory [55]. Observations and interviews supported all three types of engagement: social engagement, woodland craft engagement, and creative and sensory engagement. The significance of repeat visits was also identified as a theme, with participants expressing a desire for more time to engage in the program. They noted that their confidence and familiarity with the site and other participants increased with each visit. As analysis was conducted across combined groups, and supporting quotes/examples are mostly attributed to the other cohorts, it is difficult to identify outcomes specific to the autism group. The experience of one autistic woman is described in more detail, in which her experience of building a fire moves from fear to something that she wanted to do more of (p. 11).

In the only quantitative study to use validated measures, Scartazza et al. [51] found improvements across both scales. Three autistic participants were evaluated using the International Classification of Functioning, Disability, and Health version for Children and Youth (ICF-CY) and the Observational Rating Scale of Basic Functions (SVFB) following their involvement in horticultural and community activities as biodiversity custodians. In the ICF-CY, significant improvements were reported for tasks such as undertaking a single task independently (75% improvement) and engaging in complex interpersonal interactions (100% improvement). Improvements were also found using the SVFB scale, in initiative in expressing will, shared action, reaction to another’s presence, and behavioral unpredictability.

Vocational outcomes were discussed in two studies. Mattson et al. [52] compared differences in productivity in an indoors training center against apple harvesting in an orchard. The study found significant differences in productivity between clients with developmental disabilities. Focus was given to six of the seven participants studied, who showed higher levels of productivity in the orchard than in the training center, and who also received a higher wage for their work. Schleien et al. [53] found that targeted horticultural skills (planting seeds, transplanting seedlings, and repotting plants) were successfully acquired by three autistic young adults over a nine-week period. Additionally, these skills were mostly retained seven weeks later with no additional training in between. However, mixed results were reported in transferring these skills from the initial training environment (a greenhouse) to a new environment (the adjacent farm) immediately after the training period.

As a process evaluation of a one-week horticulture therapy camp, Himmelheber et al. [50] did not report on participant outcomes but instead outlined key aspects of the program’s delivery. Three key themes from observations and focus groups with camp staff and



volunteers and parents of participants were identified. The first theme identified was “community building”, where the camp environment is reported to be a welcoming and safe place that is playful, supported by positive attitudes of staff that encourage participants to try new things, and emphasizes flexibility and inclusion for campers. The second theme was identified as “promoting self-efficacy” and included providing opportunities for leadership where campers help each other, developing and demonstrating confidence, and teamwork and problem solving. Specific praise from staff was also mentioned. The final theme identified was “exposure to natural world”, described as organized experiences and reactions to nature. Participants developed knowledge of the natural world around them, including bird types and habits, knowledge of plants, and the properties of certain herbs. The authors noted that across all themes, the skills that participants were developing would be useful in daily life.

### 3.4. Challenges and Limitations of NBI Research

Multiple challenges and limitations were found within the NBI studies included here. Though this review aimed to explore autistic participant groups, the results of the review indicated only three studies focusing exclusively on autism [49,51,53], as well as one study that identified autistic youth as a sub-group of a widely accessed program [48]. The remaining three studies identified developmental disability more broadly.

MMAT results (shown in Table 3) found a wide variation in study quality. Research methods and design were mostly quantitative. Two qualitative studies were also found. However, regardless of study design, all studies involved observation as the primary method. Quantitative studies largely observed changes in pre- and post-engagement with the program, or over a period of time; however, very limited detail was provided on the scales and process used to make and interpret these observations [46,47,53]. Comparisons between productivity at different locations were also analyzed quantitatively [52]. The only quantitative study to utilize validated instruments was Scartazza et al. [51], who assessed participants pre- and post-NBI engagement using the International Classification of Functioning, Disability, and Health version for Children and Youth (ICFCY) and the Observational Rating Scale of Basic Functions (SVFB). Sample sizes in these quantitative studies were quite small, with four out of five quantitative studies having less than 10 participants.

MMAT results for quantitative studies ranged in quality but were commonly rated lower due to a lack of key details about participants and sampling criteria, as well as not accounting for confounding factors. The two qualitative studies ([48,50]) were higher in quality based on MMAT criteria. However, only O’Brien [48] provided a theoretical framework as well as explicating thematic analysis of observations ( $n = 53$ ) and interviews ( $n = 29$ ) in relation to the “five ways of wellbeing” framework.

Despite methodological quality and MMAT rating, key details were often missing across all studies. Participant details such as gender and age were often missing (e.g., Himmelheber et al. [50]). Where gender was reported, male participants were more common in the research, with some all-male studies [46,47]. Race/ethnicity and socioeconomic status were also not reported in any study. Co-occurring health conditions and disabilities were only sometimes identified, including physical disability, intellectual disability, mental health, and conditions such as epilepsy [46,47]. Communication type and abilities were only described in one study [49]. Overall, participant characteristics beyond broad diagnosis were often not described in detail.

Details regarding the nature of the NBI were also often missing. Information regarding attendance at the NBI was often only partially reported. Complete details on the duration of the NBI and session length and session frequency were not reported consistently. Details on the ratio of staff to participants were often not reported in detail. Where discussed, small groups of participants to facilitators appeared common, with ratios ranging from 1:1 [51] to up to 30 participants with two staff [52].

#### 4. Discussion

This scoping review aimed to outline the available peer-reviewed evidence for NBIs for autistic adults. The authors addressed three research questions: 1. What types of nature-based programs and interventions have been studied in relation to autism? 2. What methods have been used to conduct this research? 3. What outcomes have been reported?

The results of this review indicate that only a small number of studies have been conducted in this area with this user group in mind, with only four studies specifying autistic adults as target participants and the remaining studies involving participants with unspecified developmental disabilities. Specific participant characteristics were only sporadically reported, but where described, participants were mostly male, perhaps reflecting gendered discrepancies in autism recognition and diagnosis [56,57]. Studies included in this review were from Japan, the UK, and Italy but were mostly from the USA, and they were predominantly published prior to the 2000s.

The types of programs described in the literature varied widely in terms of the programs' aims, how they were delivered, and how long the program was attended by participants. Activities in these NBIs ranged from camps with cooking and arts and crafts, spending time in the forest, to discrete horticultural activities like potting up, planting for biodiversity conservation, or harvesting fruit, landscaping, and maintenance activities. Green exercise NBIs were not present in the studies found [14], and the role of exercise in health and wellbeing from nature-based activities was not considered. Increasing physical activity through outdoor and gardening activities has been recommended in a recent review of exercise and physical activity for young autistic adults [58], and it has been shown as an area of possible benefit for autistic children and adolescents [59,60]. The latest research has begun to explore autistic adults' experiences of green exercise [61], and this is an area worthy of further exploration in terms of health and wellbeing outcomes.

Many programs were operated in small groups, with few participants to a facilitator/staff member; however, some programs operated on a 1:1 basis, or up to 30 participants to two staff. Staff qualifications in these circumstances were also rarely reported. Given the wide variety of disciplines involved in delivering NBIs and the possibility that ratios and staffing qualifications could impact outcomes, this is important information for future research to include.

An array of different timeframes for NBIs was also found, but these were also only sporadically reported across the literature. Some programs had been established for several years but only ran once a year for a week. Others did not specify how long the program or site of the program had been established but indicated regular or semi-regular attendance by participants for multiple sessions. Session length also ranged from a few hours to a full day. Recent evidence suggests that the length of time spent engaging with nature can have an impact on outcomes [14,62]. Therefore, clarity around timeframes spent engaging with an NBI will be important to consider as a factor in their delivery and evaluation.

NBIs were found to support social engagement and community building [48,50,51], areas that align with autistic adults' self-reported priorities for mental health [1]. However, many studies did not relate to subjective wellbeing but instead focused on observed behaviors [46,47,49,51] or job productivity and skill development [52,53]. Given the pressing need for services to address the mental health, QoL, and wellbeing needs of autistic adults [1,2] and the wealth of literature linking NBIs to improved health and wellbeing [11–13], these are outcomes that future research into NBIs should explore for this population.

Future research should also be aware of ensuring the inclusion of autistic adults in the research process, for example, employing a wider variety of methods beyond observation to engage autistic adults as informants of their own experience of NBIs. Participatory methodologies such as photovoice have been found to be effective in engaging autistic participants [63]. The inclusion of autistic perspectives throughout the research process should also be addressed [64], and research should move beyond measuring autistic traits and behaviors [65]. Research methods that accurately engage with unique aspects of autistic wellbeing and QoL should also be considered [6–8]. Researchers should also

be mindful of outdated ideas and terminology towards autistic individuals and people with developmental disabilities, which were noted in many of the studies included in this review. This was clear in older studies (e.g., Mattson et al. [52]) but also in more recent studies (e.g., Scartazza et al. [51]), in which participants were described with high- or low-functioning labels that can be misleading and perpetuate stereotypes [66].

#### 4.1. Limitations

Limitations of this review should be noted. Firstly, the findings of this review cannot be specifically attributed to autistic adults, as many of the included studies did not name autism specifically, instead referring to developmental disability more broadly. Secondly, as this review only included studies published in English, research completed in other languages was excluded. It is acknowledged this could have restricted the number of articles included from countries such as Japan, which has a notable contribution to NBIs through the practice of *shinrin yoku* or ‘forest bathing’. This review also excluded animal-assisted interventions (AAIs), which are sometimes categorized under the NBI umbrella and are the subject of their own systematic reviews [67]. Finally, as noted by Overbey et al. [29] in a similar review, many NBIs may exist that are not represented in the literature, and due to the highly local and unique nature of many NBIs, the generalizability of these studies is limited. As interest in NBIs grows, further research capturing outcomes and types of NBIs is needed.

#### 4.2. Conclusions

Nature-based interventions for autistic adults currently appear scarce in the peer-reviewed literature. However, this review uncovered seven studies focused on this population or adults with developmental disability more broadly. Evidence from these studies suggests that NBIs for autistic adults vary widely in their aims, activities, attendance, and outcomes. NBIs appear to be an area worthy of further exploration, with generally positive outcomes in domains of both health and wellbeing and employment. However, many methodological limitations were noted.

Generating detailed and standardized reporting of NBI features and characteristics of participants will be important for future research to consider in order to create a robust body of evidence for NBIs that are often highly unique and individualized. Inclusive methods will also be important for future research to consider the perspectives of autistic adults to reduce the reliance on external observation, as well as emphasis on behavioral and vocational outcomes. Though the current available research on NBIs for autistic adults is limited, the results of this review indicate that NBIs could provide an important and accessible means to assist autistic adults with various elements of mental health, quality of life, and employment. Further research is needed to provide a deeper and more detailed understanding of how NBIs can be of benefit to the lives of autistic adults.

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