STUDENT PROJECT An investigation into the components of conservation horticulture projects

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Abstract

Targets have been set within the Global Biodiversity Framework to increase *in situ* and *ex situ* conservation activities to address the biodiversity crisis and impacts of climate change. This paper highlights the horticultural skills and facilities held in botanic gardens that can make an essential contribution to these conservation activities and that are often termed 'conservation horticulture'. Previously published research identified a lack of cohesion in the use of this term. This research seeks to explain the reasons for this through analysis of both previously published data and new data. New data presented was collected through semi-structured interviews with practitioners involved in conservation horticulture programmes in Europe, Asia, Australasia and North America. Key findings include the need for an understanding of conservation and horticultural principles, and the importance of research, teamwork and communication to deliver conservation horticulture projects. A theme map of the findings is presented as are factors to be considered when planning conservation horticulture projects.

Introduction

The term 'conservation horticulture' was first used by Affolter (1997) and defined as 'the application of the techniques and knowledge base of horticulture to rare plant conservation', even though activities fitting the definition were practised prior to that (Wallace, 1992). While it should be noted that Rae (1995) termed the phrase 'horticulture for conservation' a few years earlier in his survey of 1,457 botanic gardens to explore the roles of living collections in gardens, Affolter's definition provided the basis for subsequent refinements (Gratzfeld, 2017; Meyer *et al*., 2024). Gratzfeld (2017) added that conservation horticulture in botanic gardens relates to *ex situ* living collections that represent the genetic diversity of the wild target populations. They are also associated with other germplasm collections such as seedbanks and can be used for *in situ* conservation. These collections are often also used for education and raising awareness about conservation issues and/or species under threat. Meyer *et al.* (2024) provided a more comprehensive definition of conservation horticulture and reported quantitative and qualitative data about awareness and usage of that definition (Appendix 1). The data published by Meyer *et al*. (2024) identified not only a reluctance by horticulturists to name many of their activities as 'conservation horticulture' (even though these are consistent with the definition provided by Affolter), but also a lack of resources available to

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horticulturists who want to apply their skills to the conservation of species. In addition, the term is regularly used in a range of contexts, some of which do not reflect the activities identified in Affolter's definition (Ganeshamurthy *et al*., 2016). There continue to be issues with the term's meaning and use.

There is a growing body of literature that demonstrates the central role of horticulture in botanic gardens to conserve plants (Smith, 2021; Westwood *et al.*, 2021; Cano *et al.*, 2025; Smith, 2025). Gardner (2021) lists priority actions for botanic gardens with endangered species in their collections and highlights the return to its place of origin of genetically diverse material, where human actions have caused its depletion, as the 'ultimate contribution' that botanic garden horticulture can make. Collection managers and horticulturists, in collaboration with other professions, are at the forefront of the potential for this significant contribution to conservation.

Even in botanic gardens and arboreta (hereafter referred to as gardens), which have conservation as part of their mission, the horticultural facilities and skills essential for *ex situ* conservation are sidelined in terms of resource allocation and investment (Smith, 2021). Added to this, students of horticulture tend not to be educated in the role of horticulture in conservation, something highlighted by the absence of 'horticulture for conservation' modules in horticulture training programmes (BGCI, 2022).

The urgency generated by the biodiversity crisis affecting the survival of plant species globally (Díaz *et al.*, 2019) requires clarity among practitioners and users of the term 'conservation horticulture' (Entwisle, 2023). Its distinction from other types of horticulture and the key activities involved need to be better understood. This study explores reasons why horticulturists who are undertaking conservation horticulture do not give this title to their work, and the tools horticulturists need to contribute to conservation programmes. The paper also identifies priority components needed for projects, courses or development mechanisms such as gap analyses that could aid implementation and resourcing. These components are presented as a theme map.

Horticulture and conservation in gardens

Heywood in Bramwell *et al.* (1987) describes how gardens have changed since the establishment of large and overwhelmingly western institutions since the 19th and early 20th centuries, and the crucial role that gardens across the world must play in conservation. More recently Mounce *et al*. (2017) provide statistics on the diversity of threatened species in garden collections. As a grouping of organisations that can vary enormously in size, governance, history and expertise, gardens are a good starting point from which to investigate the application of horticultural principles for conservation.

Gardens have been building conservation expertise since the 1990s (Rae, 1995; Lusby & Wright, 1996; Wallace, 1992). However, as identified in Meyer *et al.* (2024), information to help institutions wishing to expand their conservation work or to understand how conservation horticulture is different from traditional horticulture is not readily available. To address this, a compilation of the key requirements for conservation horticulture in gardens could help institutions transition to activities to meet Global Biodiversity Framework (GBF) targets (CBD Secretariat, 2025), make the best use of living collections and positively impact

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the number of species under threat (Mounce *et al*., 2017).

Smith (2021) states that horticulturists and the skills they have are essential to conserve plants, and that in gardens, despite holding a unique combination of resources, the management of these collections has not been effective in conserving species over the last 100 years. Cano *et al*. (2025) identified that most plants have an average life expectancy of only 15 years in botanic gardens. For species assessed as threatened, life expectancy rises to 18 years because additional resources may be allocated to plants with a threat status. Smith (2025) describes Cano's findings as a 'rude awakening' and suggests the solution is to 'fully mainstream conservation horticulture into the horticultural community'.

So what is required to increase the amount and quality of conservation horticulture and how should conservation horticulturists be trained to enable them to deliver this?

Use of living collections in botanic gardens

Key principles for effective conservation are described in Given (1997):

- The importance of genetic diversity in species populations
- Plant health and resistance to pest and disease
- The importance of record-keeping and storage of origin data for plant material and germplasm
- The maintenance of collections in sufficient diversity and numbers used for conservation projects.

The definition provided by Wyse-Jackson (1999) of a botanic garden as 'an institution holding documented collections of living plants for the purposes of scientific research, conservation, display and education' aligns with the requirement for documentation identified by Given (1997). Rae (2004) argued that the facilities and activity typical of many horticulture departments also align with the principles outlined in Given (1997) and that these departments were needed to realise the potential of the Global Strategy for Plant Conservation (GSPC).

In summary, collections in gardens are used in a variety of ways and contribute to conservation targets:

- To maintain genetic diversity (Finger *et al*., 2024): cultivated plants can play an important role in augmenting dwindling natural populations if appropriate studies are carried out on the genetic composition of cultivated collections and if these are compared with wild genotypes (Allnutt *et al*., 1998; Gardner, 2000; Etisham-Ul-Haq *et al*., 2001; Gardner *et al*., 2019)
- To reduce plant health problems and understand biosecurity requirements in threatened species (Frachon, 2013; Summerell & Liew, 2020)
- To observe and understand species behaviour in an accessible environment (Wallace, 1992; Hirst *et al*., 2020)
- To research the morphology and taxonomy of threatened groups (Möller *et al*., 2019; Edwards *et al*., 2022)
- To identify appropriate cultivation techniques (Hughes *et al*., 2014; Gilbert, 2023)
- To apply commercial techniques to manage large numbers of plants effectively with garden facilities (Kay *et al*., 2011; Hirst *et al*., 2019)

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- To inform and engage non-professionals and visitors in biodiversity conservation (Rae, 1995; Hirst *et al*., 2023).

Resources to support conservation

Meyer *et al*. (2024) exposed the need to support understanding of conservation horticulture, in particular how it differs from other types of horticulture and the resource required to implement it. Standards, toolkits and guidelines can provide a framework for activities, improve accurate usage and embed universal recognition of a term. For example, the creation of a standard for nature-based solutions has helped to establish a common language and guide research into sustainable landscape management (E. Bush, pers. comm.). Yamada *et al*. (2015) described a toolkit as a type of knowledge transmission, providing guidelines to maximise successful outcomes.

The development of a conservation horticulture toolkit could help by:

- providing an agreed definition of the term 'conservation horticulture'
- identifying key features required to develop conservation horticulture programmes
- supporting communication with users and communities to demonstrate value and improve recognition.

Conservation horticulture education

The need to raise the profile of conservation horticulture and the role that education can play in doing so was recognised at a Conservation Horticulture workshop at the 7th Global Botanic Gardens Congress (BGCI, 2022). Degree-level modules have been developed at some horticulture training institutions such as the Royal Botanic Garden Edinburgh (RBGE) (W. Ritchie, pers. comm.). However, these are not widespread, and the topic does not readily appear on curricula in horticultural colleges. Indeed, even horticulturists in training are often unaware of the term (Dan Crowley, pers. comm.).

Aim and objectives of the study

Aim

To create a toolkit[2] of the capacities and resources required to conserve plant species using horticultural techniques.

Objectives

1. Analysis of the contexts in which the term 'conservation horticulture' is used
2. Identification of the horticultural activities, skills and resources that enable conservation of species in botanic gardens and arboreta
3. Compilation of a list of the knowledge and physical resources required for botanic gardens using living collections for conservation.

Methods

Data collection

Primary data was collected through semi-structured interviews using the inductive grounded theory approach in Clark *et al*. (2021). Interviews were chosen to examine practitioners' use and understanding of language about conservation and horticulture. As stated by Clark *et al*. (2021)

[2] Definitions of 'toolkit': 'a set of skills, abilities, knowledge, or other things needed in order to do a particular task or job' and 'a fixed set of procedures, guidelines, criteria, etc, established to ensure a desired or required result or prevent oversights' (HarperCollins, 2025).

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interviews are an effective way to gather information about resources. Data collected by Meyer *et al.* (2024) was subjected to secondary analysis.

Sampling

Organisations in different countries were invited to participate in an interview to ensure maximum representation of a range of viewpoints and experiences within the timescale and scope of the project. These were selected from global gardens listed on the GardenSearch database (BGCI, 2024).

Search criteria were filtered for 'Botanic garden/Arboretum' and 'Conservation institution', with further filters for full-time equivalent staff: 1–10, 10–50 and 50– >250. Lists of gardens were compiled by size and location. Botanic gardens on these lists were then reviewed for suitability for inclusion in the sample. Information about the organisations on both the GardenSearch database and their respective institutional websites was reviewed. A shortlist of 15 organisations as sources of interviewees was drawn up based on language spoken and completeness of information available about the institution and its activities. Only organisations with conservation activities and a contact point (to which to send the invitation) were included on the shortlist.

An invitation to participate containing information about the project was sent to 17 contact points. Seven of these responded positively. The timescale of the project and requirement to seek contributions from an even spread of organisations based on size and location precluded sending invitations to a larger number of institutions.

Primary data

Online meeting requests were sent to eight interviewees at seven institutions. Two interviewees attended a single meeting at the Hong Kong garden (Table 1), resulting in a total of nine interviews and eight responses to the Likert scale questions.

An interview guide including questions and a short script for the interviewer was created using the General Interview Guide approach described by Turner (2010) (Appendix 2). Results of five questions asked by Meyer *et al*. (2024) about the respondent's understanding of the term 'conservation horticulture' and learning inputs to their work (Questions 4, 12, 13, 14 and 19 in Meyer *et al.*, 2024) were considered during the creation of the interview guide (Appendix 3). The guide ensured each interview started with the same questions but allowed flexibility to explore the topic as the interview progressed.

Interviews were recorded using the Microsoft Teams online meeting recording function. The audio recording produced a transcript which was then reviewed in conjunction with the recording to ensure transcription accuracy.

Likert scale questions

Quantitative data was collected through three Likert scale questions asked during the interview (Appendix 3). Likert scale questions ask respondents to rate their responses, such as 'strongly agree' or 'strongly disagree', and allocate a numerical value to these responses. These responses enable the collection of quantitative data on opinions and attitudes. The Likert questions also provided an opportunity for free text comments to aid collection of qualitative data. A pilot interview was conducted, and amendments subsequently made to the Likert scale questions to improve clarity and distinction between the scaled response options.

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Secondary data

Anonymised raw data collected by Meyer *et al*. (2024) was provided by the authors, and thematic coding was carried out on responses in that survey to the following questions:

- Question 4: Before considering the official definition, do you consider yourself a conservation horticulturist? Yes, No, Unsure
- Question 5: Which of the following are part of your current job description or regular job duties: Horticulture, Plant conservation, Outreach/education, None of the above?
- Question 19: Having reflected on the definition of conservation horticulture and your work, do you consider yourself a conservation horticulturist? Yes, No, Unsure

An analysis was undertaken of those who answered 'Horticulture' to question 5, and also 'No' or 'Unsure' to questions 4 and 19, plus responses of 'No' or 'Yes' to question 4 that switched to 'Unsure' for question 19. This was done to examine responses from horticulturists who indicated they did not think their work aligned with the definition of conservation horticulture.

Analysis

Both sets of data were thematically coded. Codes are fragments of the data that are of interest to the researcher. Braun & Clarke (2006) quote Boyatzis's (1998) explanation that 'codes … refer to "the most basic segment, or element, of the raw data or information that can be assessed"'. The process of coding entails taking recurring elements that seem important to the research topic, then defining and labelling them (Priya, 2021). Themes are units of analysis compiled as the researcher interprets the codes; they are often broader than codes (Braun & Clarke, 2006).

Primary data

Thematic coding was carried out on interview transcripts. These were read several times to identify a first set of codes (Supplementary materials table S2). Three code groups were established, based on the activities, knowledge and resources required to do conservation horticulture. Codes were tabulated, reviewed for duplication and consolidated (Braun & Clarke, 2006). Themes were then developed from consolidated codes (Supplementary materials tables S3–5). Codes with fewer than three responses were not developed into themes. Themes and the relationships between them were compiled into a theme map (Fig. 12) using mind-mapping software (Braun & Clarke, 2006; Canva, 2025).

Secondary data

Thematic coding was carried out on responses in Meyer *et al*. (2024) as described under 'Likert scale questions' above (Supplementary materials table S1). Codes were then grouped into themes (Supplementary materials table S1). The process of analysing secondary data informed the development of questions for the collection of primary data and results for Objective 1.

Results

Objective 1 Analysis of the contexts in which the term 'conservation horticulture' is used

Primary data

Nine semi-structured interviews were conducted with horticulturists working in six gardens and one arboretum (Table 1). The average length of interview was 65.5 minutes (Table 1). The length of responses and corresponding length of interview varied with

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the character of the interviewee and response style, except for one that was shorter due to time constraints.

Formal qualifications attained by interviewees ranged from technical qualifications and diplomas in horticulture to an MSc in Plant Diversity and a PhD in Ecology. The years of experience in horticulture ranged from 4 to 37, with an average of 18.5 years.

Questions 2, 4 and 5 in the semi-structured interviews related to the interviewee's definition and use of the term 'conservation horticulture'.

Question 2: What do you think about the definition of conservation horticulture?
All responded that it described their work accurately. Five thought no changes were required. Three interviewees made one suggestion each for the inclusion of additional points:

1. the importance of *ex situ* collections to support flora native to the institution location
2. the role of *ex situ* collections as 'life support' for species that are extinct or severely depleted in the wild
3. a brief definition of 'conservation' (with acknowledgement that the term has been defined elsewhere).

Question 4: Do you consider yourself to be a conservation horticulturist?
The term is not in the job title of any of the respondents. However, all respondents defined themselves as conservation horticulturists in conjunction with other roles. For one respondent usage depends on the audience, while another noted growing use of the term in peer meetings and conversations.

Question 5: How do you think conservation horticulture is different from traditional horticulture?
Responses were sometimes lengthy and fed into the creation of themes (see Discussion). Two respondents said there is no difference in the basic horticultural principles employed and the main difference is the outcome.

Table 1 List of institution countries and their size, location, interview identifier and length.

Country	Number of full-time equivalent staff	Number of interviews	Interview identifier	Interview identifier in full	Interview length (minutes)
Australia	>200	1	ABG	Australia Botanic Garden	83
Hong Kong	>50<200	2	HK1 & HK2	Hong Kong Botanic Garden	96
Nepal	<10	1	NBG	Nepal Botanic Garden	28
UK	>200	2	UKN1 & UKN2	UK North Botanic Garden	94 & 61
UK	<50	1	UKA	UK Arboretum	67
UK	<10	1	UKW	UK West Botanic Garden	72
USA	>10<50	1	USA	USA Botanic Garden	23

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Six differences between conservation and traditional horticulture were given. Conservation horticulture:

1. is less predictable due to the lack of information about species
2. affords less priority to ornamental or aesthetic considerations
3. requires additional, often specialist, information that includes provenance and ecological data
4. requires documentation of information
5. is more vulnerable to pest, disease and weed contamination
6. requires more resources including space and time.

Secondary data

Twenty-seven responses (11.3% of the total) to the Meyer *et al.* (2024) data were analysed**.** Twenty of these responses included free text explanations. Eighteen of the free text responses showed that participation in activities was included in the definition of conservation horticulture (Appendix 1). Sixty-seven per cent (18 out of 27) described aspects of conservation horticulture in their work and yet do not define themselves as conservation horticulturists. These 18 respondents are 7.5% of the total survey respondents who do conservation horticulture but also answered 'No' to the question asking whether they were conservation horticulturists.

Thirteen per cent of respondents changed their opinion of whether they described themselves as a conservation horticulturist after they were given the definition (Meyer *et al.*, 2024). Analysis of the free text comments and post-survey responses collected by Meyer *et al.* (2024) identified that a further 7.5% of horticulturist respondents are doing conservation horticulture but do not identify their role as a conservation horticulturist. Thirteen per cent identified by Meyer *et al.* (2024) plus 7.5% of respondents identified by this study show that 20.5% of respondents who are doing conservation horticulture did not consider themselves to be conservation horticulturists.

Three codes were identified in the free text responses given by the 18 respondents explaining why they do not consider themselves to be conservation horticulturists (Fig. 1 and Supplementary materials table S1).

Objective 2 Identification of the horticultural activities, skills and resources that enable conservation of species in botanic gardens and arboreta

Questions 6–10, 13 and 15–20 in the interview guide (Appendix 2) were designed to explore the activities, skills and resources that enable conservation in gardens. Dominant ideas and patterns were identified by reading interview transcripts. Forty-one codes were listed (Supplementary materials table S2). These were categorised and separated into activities, skills and resources (Supplementary materials tables S3–S5). Codes were consolidated into a smaller number to reduce repetition (Supplementary materials tables S3–S5) and developed into 24 themes.

Activities of conservation horticulturists

The activities stated to be important for conservation horticulture by most respondents are working in teams (Fig. 2); sharing knowledge; and experimentation and research.

Eighty-nine per cent of interviewees believed that working in teams and sharing

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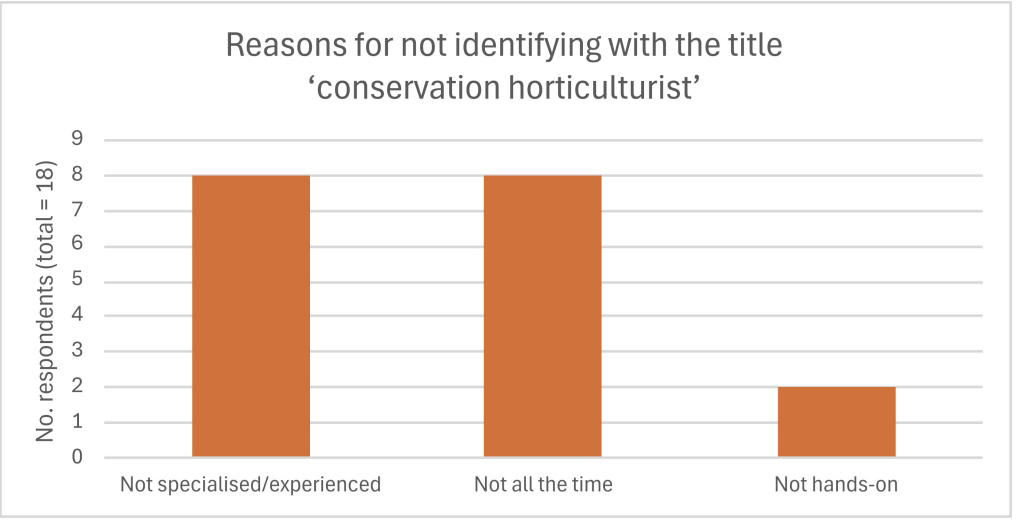

Fig. 1 Reasons why conservation horticulturists do not use the term to describe their role.

> *One of the beauties of it [the structure of the organisation] is that it means the scientists, the ecologists and the botanists sit in the same office as the horticulturalists, which is very rare in a botanic garden. So there's direct daily interaction between the two disciplines. It does mean that everything that we're talking about here, conservation horticulture … that they permeate one another within our department.*

Fig. 2 A quote from a respondent on working in teams and with other professions.

knowledge are vital activities for conservation horticulture projects. Fifty-six per cent believe that experimentation and research are similarly vital.

Skills, knowledge and qualities of conservation horticulturists

The skills, knowledge and qualities that conservation horticulturists need were explored in questions 7–14 in the interview guide. Those attributes identified are listed below and the total responses for these attributes shown in Fig. 3.

1. A passion for plants and aptitude for horticulture
2. A knowledge of the fundamentals of horticulture (especially propagation skills and an understanding of growing media)
3. An understanding of the principles of conservation
4. A growth mindset (Fig. 4)
5. An understanding of plant diversity and functions
6. An understanding of ecology
7. Communication skills

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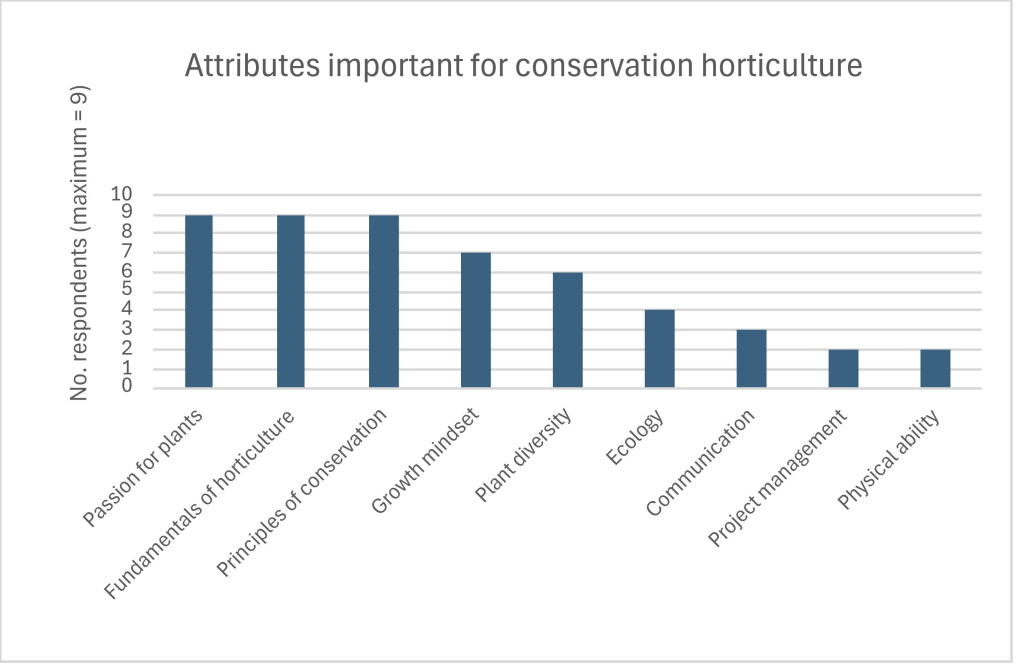

Fig. 3 Number of responses for each attribute highlighted by conservation horticulturists.

8. Project management skills
9. Physical ability.

Resources and information sources that horticulturists need to contribute to species conservation

The resources required for conservation horticulture were explored in questions 7 and 11–15 in the interview guide. Those resources identified are listed below. Total responses for these resources are shown in Figs 5 and 6.

1. Time to observe and document species behaviour
2. Time and space to manage large volumes of genetically diverse plants (Fig. 6)
3. Space to cultivate and store collections (Fig. 6)
4. Access to a range of facilities and materials for experimentation with unfamiliar methods or taxa, particularly propagation facilities and a range of growing media (Fig. 6)

> *I think it's not always possible to train somebody into being a good grower. It's like they have to have the mindset themselves. And that they latch on to observing and experimenting and searching for success, and applying things that they've learned. So you can empower somebody with some formal training.*

Fig. 4 A quote from a respondent on the importance of a growth mindset.

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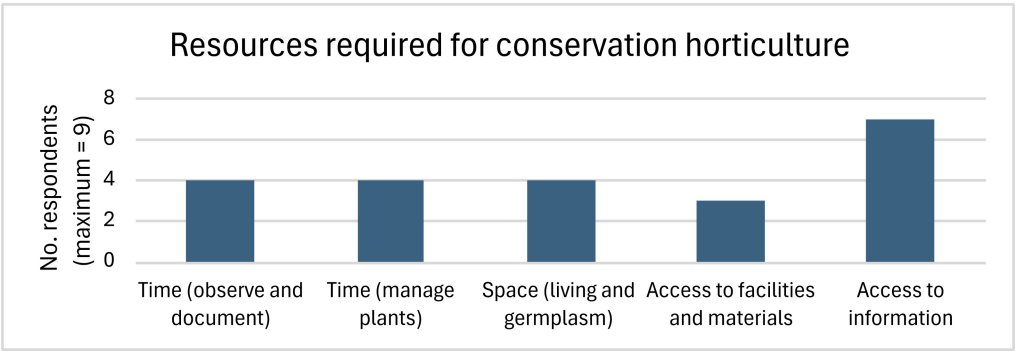

Fig. 5 Number of responses for each resource required for conservation horticulture.

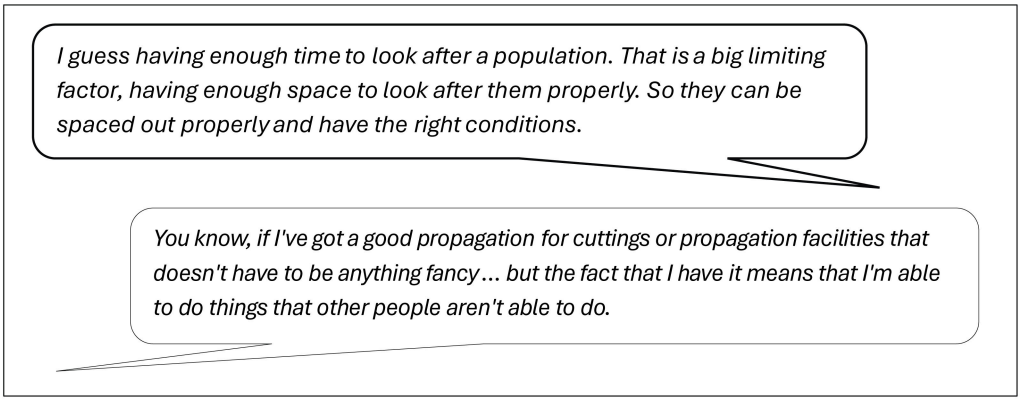

Fig. 6 Quotes from respondents on the importance of time, space and facilities.

5. Access to information from a variety of sources including indigenous cultures, historical sources, websites, databases and publications including those behind paywalls (Fig. 17).

Results of responses to Likert questions

Question 8: What learning experiences or similar input have been most valuable for developing your conservation work?
Hands-on experience in the nursery (*ex situ*) and field (*in situ*), and communication with others were identified as the most important learning inputs (Fig. 7).

Question 13: Other than funding, what type of resource such as training, publications or another resource do you consider might be useful to you to help improve conservation outcomes in future?
The most common response from respondents on how to improve conservation outcomes was training (Fig. 8). Fifty per cent referred to the value of workplace and modular training courses rather than full-time formal studies. Mentorship was considered 'essential' or 'very valuable' by seven (87.5%) respondents.

Information from a range of sources including taxonomic databases, climate

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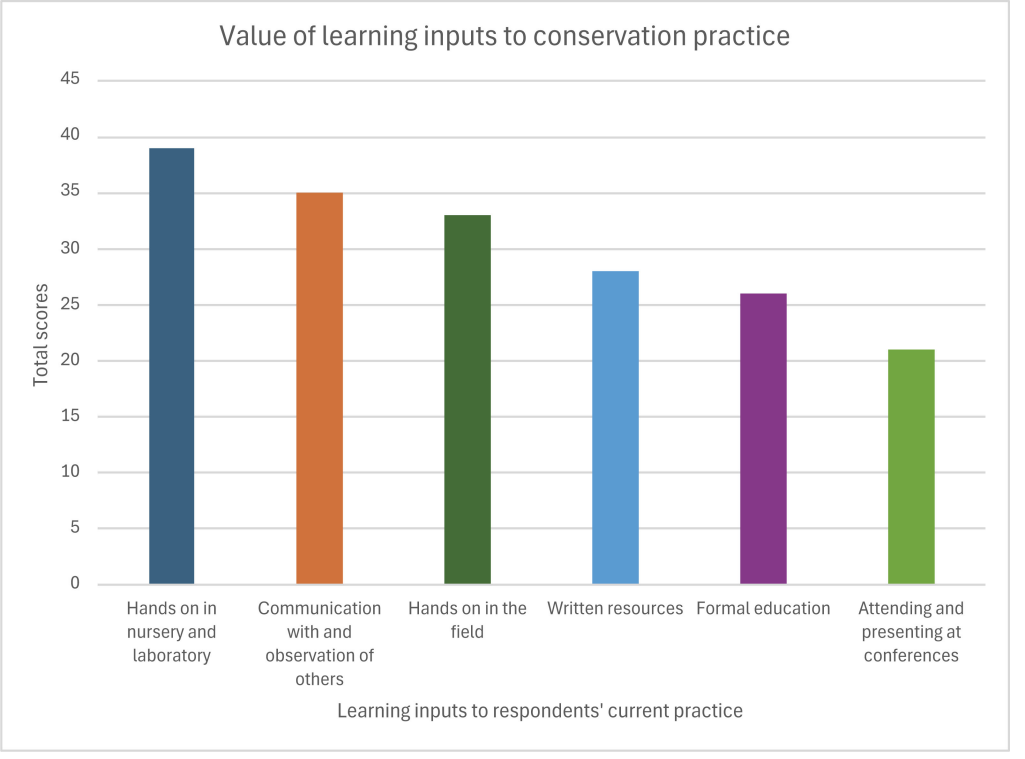

Fig. 7 Scores (from 1 to 5) allocated to the value of learning inputs by interviewees.

and weather projections, research papers, historical records and local or indigenous knowledge were 'quite useful' for 62.5%, and 25% considered them 'essential'. Opinions varied on whether a formal community for conservation horticulture would be useful.

Question 18: In your opinion and personal experience how recognised is the value of horticulture for conservation by i) your peers, ii) your organisation leaders and iii) your field of activity, such as professional affiliations?

Respondents felt that peers were most ready to recognise the importance of their work in contrast to organisation leaders and in wider society (Fig. 9). One respondent thought that while some peers were engaged and passionate about the conservation activity of their colleagues, an equal number of colleagues did not recognise its importance, and the score given reflected this variation for their garden. All respondents expressed a society-wide lack of recognition or understanding of the value of horticulture in their respective socio-cultural environments.

Objective 3 Compilation of a list of the knowledge and physical resources required for botanic gardens using living collections for conservation

A theme map (Fig. 12) was developed following interpretation of the codes identified from primary data and their subsequent classification into themes. The

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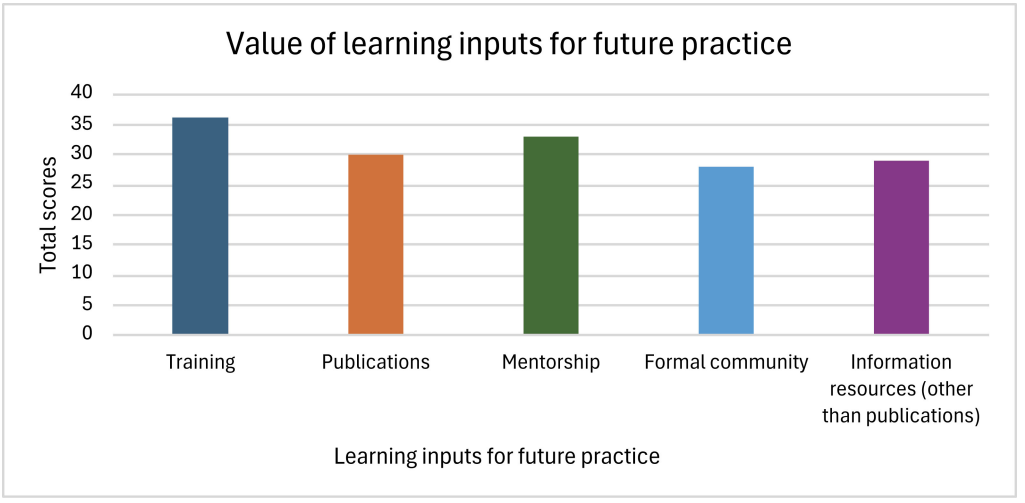

Fig. 8 Scores (from 1 to 5) allocated to the value of learning inputs for conservation practice in the future.

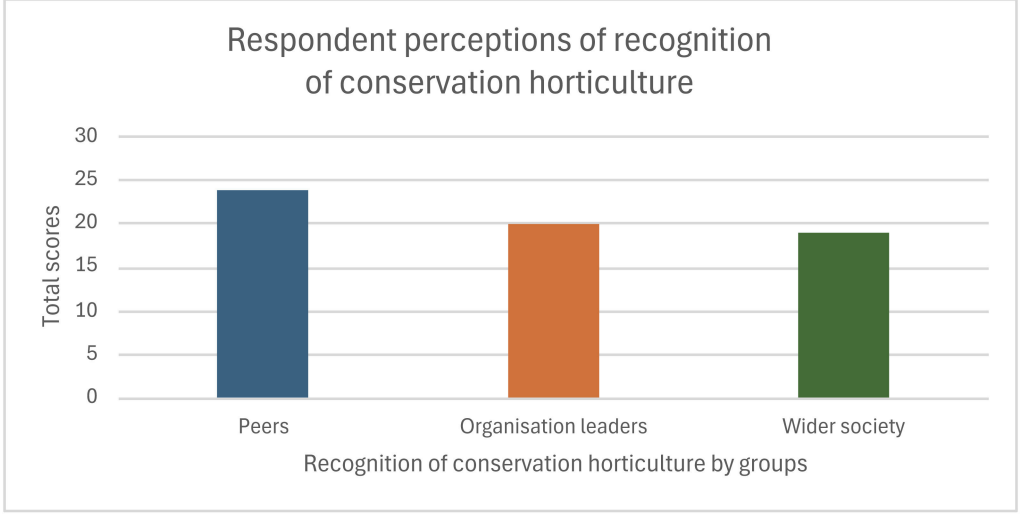

Fig. 9 Scores (from 1 to 5) allocated to the recognition by others of the importance of conservation horticulture.

development of themes and their synthesis into a graphic format demonstrates the significance allocated by interviewees to each theme.

Discussion

Analysis of primary data collected in the form of semi-structured interviews supported conclusions made by Meyer *et al.* (2024) that there is a lack of awareness of the differences and similarities between traditional and conservation horticulture in the horticultural community. Secondary analysis of data collected by Meyer *et al.* (2024) and examination of primary data collected as part of this project identified some of the reasons why horticulturists do not use the term widely, even though they practise the activity.

Primary data reinforced what is considered common knowledge: that

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horticulturists need practical experience to develop their skills. It also identified other key qualities and skills required by horticulturists to deliver conservation projects.

Use of the term 'conservation horticulture'

Primary data

All interviewees stated that their work fell within the definition of conservation horticulturist (albeit some with hesitation), however none have the term in their job title. A hesitancy to use the term despite aligning with it was also identified in secondary analysis of Meyer *et al*. (2024) data. For two respondents, their educational attainment and job titles were more closely tied to other disciplines (arboriculture and seed ecology) while another, with over 30 years' experience of looking after rare plants every day, said that they were '70% a conservation horticulturist'.

Recent literature has seen a rise in the use of the term 'conservation horticulture' (Zale & Testa, 2023; Smith, 2025; Cano *et al*., 2025). The term is most often used by people working in large gardens with long histories and global conservation activities and is not common across the horticultural community. However, there were some signs that the term is now becoming more commonly used, with some respondents observing increased use at professional meetings and others noting that conservation horticulture degree modules are being developed in some education programmes.

Horticulturists have the skills and are doing the work required to conserve species and meet GBF targets (Rae, 2004; Smith, 2021) but they are not using the term 'conservation horticulturist' or talking about it widely. As articulated by Linnaeus (Stafleu, 1971) and more recently by Meyer *et al.* (2024), if we do not name an activity, in this case conservation horticulture, how can we talk about it? This study has found that the lack of familiarity with the definition and a reticence to name it contributes to the difficulty in communicating what is involved and its value. Difficulty in succinctly defining or communicating the term limits awareness beyond the horticulture industry to organisation leaders and funders. This tension was expressed by interviewees and has also been highlighted in the literature (Smith, 2021; Meyer *et al*., 2024).

Several interviewees noted that talking about conservation horticulture to those outside the profession is important for successful conservation outcomes and to gain support for their activities (Fig. 10).

Secondary data

Responses to question 1 'Are you a conservation horticulturist?' demonstrated that respondents use the term in a more restrictive way than the actual activities carried out in their work might suggest. The secondary analysis of Meyer *et al*. (2024) data supports this, highlighting that there is a lack of awareness, cohesion and consensus surrounding the term amongst those who practise the activity (Fig. 11).

Activities, skills and resources required to do conservation horticulture

The data gathered in this study was coded and then classified into themes and a theme map produced. A theme map is a commonly used medium to visualise conclusions of social research (Braun & Clarke, 2006). Fig. 12 lays out the experiences shared by interviewees as components of successful conservation programmes. It shows how these components feed into the activity

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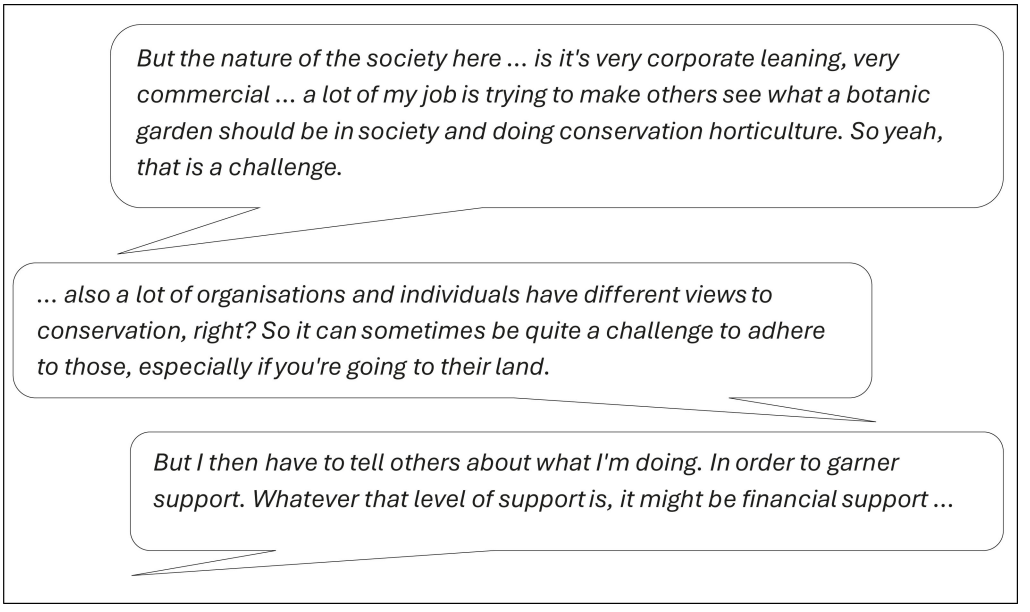

Fig. 10 Quotes from respondents on the need to communicate with others beyond the horticultural community.

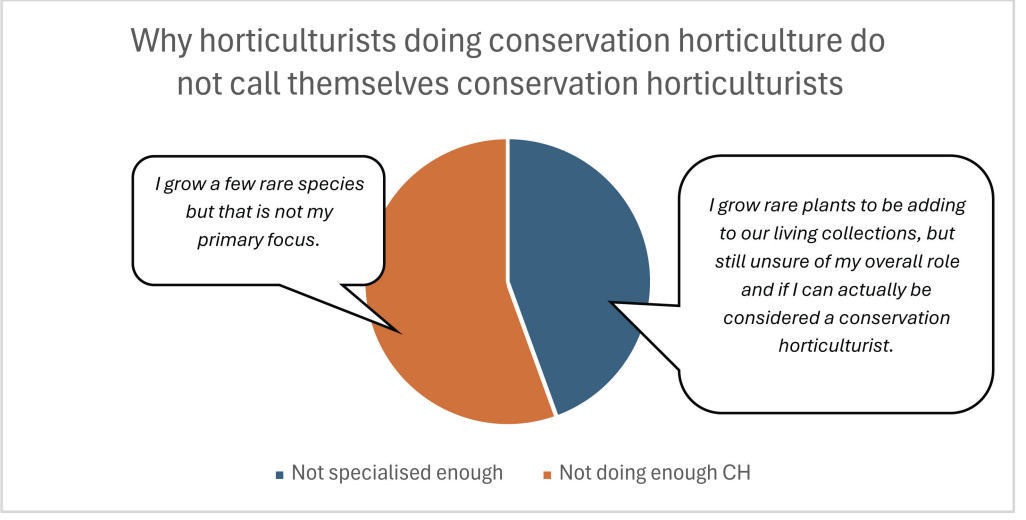

Fig. 11 Reasons conservation horticulturists give for not identifying with the title 'conservation horticulturist'.

of conservation horticulture and the relationships between them.

Inputs to conservation horticulture

This study supports the findings of several authors (Wallace, 1992; Gardner, 2000; Rae, 2004; Magdalena, 2010; Cruse-Sanders, 2017; Hirst *et al.*, 2023; Gilbert, 2023) that an understanding of the principles of conservation, horticultural skills and teamwork are required to use living collections to support conservation. However, this study also found that a love of plants

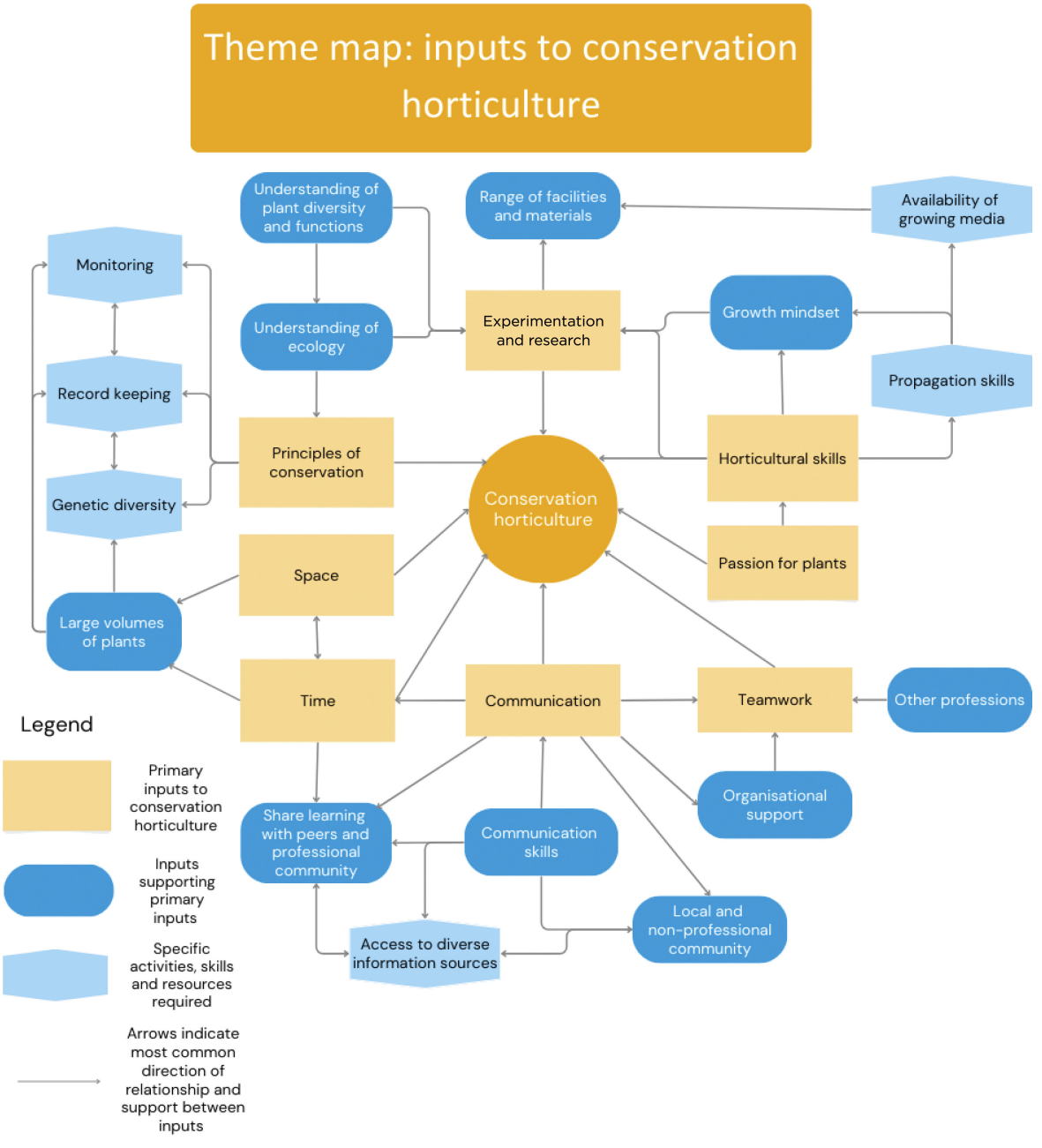

Fig. 12 Graphic representation of inputs to conservation horticulture projects identified by respondents. Inputs are collectively referred to as themes during the thematic coding process, leading to the composition of a theme map. Map drawn in Canva by Kate Hughes.

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and the natural world (synthesised here as 'Passion for plants'), and the space and time required to research, store, cultivate, document and monitor large volumes of genetically diverse plants are also essential to support conservation activities.

Passion for plants

All respondents referred to the passion for plants that fuels their conservation work and helps them to overcome challenges and failures. The importance of this quality is not yet the subject of peer-reviewed publications and was one of three themes expressed unanimously by respondents in this study (Fig. 13).

Space and time

The lack of space and time were often mentioned together during interviews and have similar implications for the establishment of conservation projects. Respondents often referred to the time required to implement the principles of conservation (Fig. 14), including maintaining documents and data, and managing additional staff and meetings. The importance of adequate space to house genetically diverse collections was highlighted, referencing the potential impacts on plant health and diversity when space to cultivate plants runs out.

Questions about funding were not included in the interview guide, as this was covered by Meyer *et al.* (2024). However, funding has an impact on the space and time available for conservation horticulture. Recent research identified the relatively short lifespan of threatened species in living collections globally due in part to financial constraints (Cano *et al.*, 2025) and has prompted calls for greater financial commitment to conservation horticulture (Smith, 2025). This was emphasised by one respondent in this study (Fig. 15).

Teamwork

The importance of teamwork and the communication skills required to ensure

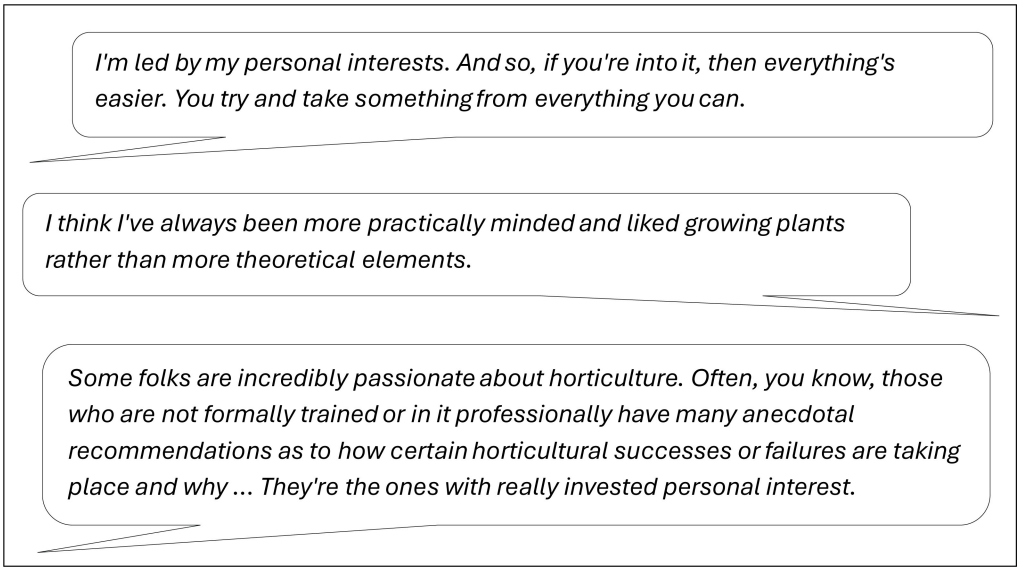

Fig. 13 Quotes from respondents on the personal commitment that contributes to success.

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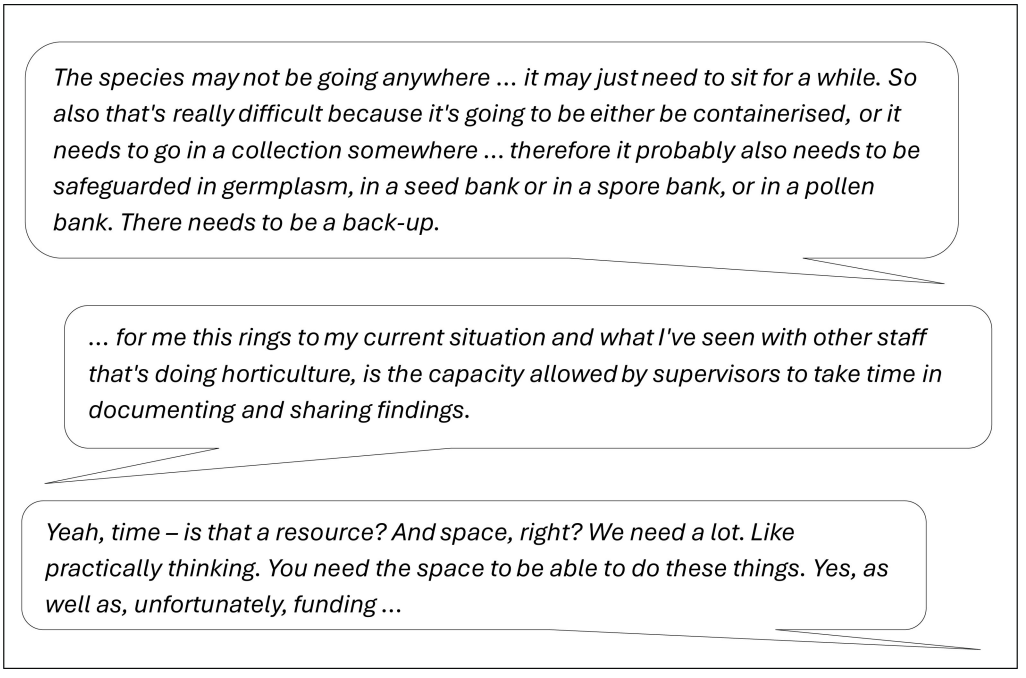

Fig. 14 Quotes from respondents on the requirements of space and time to do conservation horticulture.

conservation horticulture success is occasionally, but not frequently, found in the literature. Cruse-Sanders (2017) describes the value of partnerships for *in situ* conservation, while Meyer *et al*. (2024) made an important addition to the definition of conservation horticulture by stating that 'conservation horticulture can also be manifested among a team of people'. This is corroborated by the data collected in this study.

The importance of teamwork was frequently mentioned by interviewees and is closely linked with communication in the theme map (Fig. 12). Both are dependent on support from other professions, communities and organisation leaders, and the skills required to communicate with all these groups. Ecologists, molecular biologists, taxonomists, landowners and agencies, and even sniffer dogs (for detection of species) were highlighted as essential. Communication skills to work across disciplines and beyond the individual's core work, sharing outcomes and gaining support, from funders and others, underlined that communication is a vital part of conservation work and that

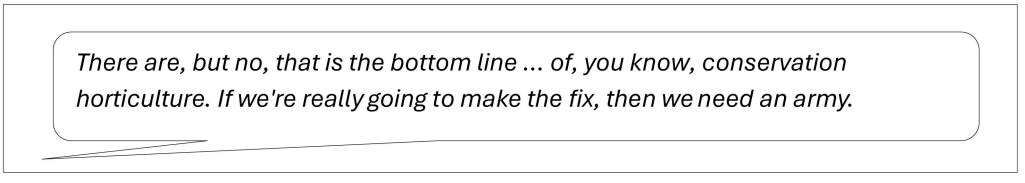

Fig. 15 Quote from a respondent on the resource requirements to conserve plants.

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conservation horticulturists need the skills to communicate effectively.

Biosecurity

Plant health is one of the principles of conservation (Given, 1997), and small, genetically poor populations are particularly vulnerable to pests and diseases (Frachon, 2013; Stanley & Dymond, 2020). It is interesting that the subject did not come through as a distinct pattern in the data. It was mentioned once in the context of a training need, once as an issue relating to space requirements and once as a collection management issue. Biosecurity is a global concern and locally variable in its impacts (Barham *et al*., 2015). It is not evident from the data whether respondents are simply not aware of the importance of biosecurity, or whether a larger sample size would have highlighted this topic differently.

Specific activities, skills and resources

Many practical details of conservation using living collections were highlighted during this study, and the frequency and emphasis given to these by respondents warrants their inclusion on the theme map (Fig. 12) and discussion here.

Availability of growing media

The importance of propagation skills for species that are endangered is well documented (Magdalena, 2010; Blackhall-Miles, 2019; Gardner, 2021). However, respondents referred to different types of growing media for experimentation and the creation of bespoke mixes for species that are difficult to cultivate. These links between propagation skills, facilities, and experimentation and research are shown in the theme map (Fig. 12). Large gardens in countries with developed horticultural industries may have access to a range of substrates, but equivalent access for gardens in regions where the horticulture industry is less developed or differently equipped is not always possible (Fig. 16). It is also worth noting that the literature often describes work in large gardens with access to a range of materials and facilities (Zale & Testa, 2023; Gilbert, 2023).

Access to diverse information sources

Access to useful information is largely from journals and books, often found online.

> *One thing that being educated in the XX and then sort of doing stuff in YY. The growing media that are used were very different in both places. And then coming here, it's another set of growing media and then you quite quickly see that for certain species they need their own mix. Certainly, what's used in European botanic gardens is absolutely … There's learning to be had from it for growing things in pots, but when it comes to planting things in the ground, it's pretty useless, I would say.*

Fig. 16 Quote from a respondent on the variability of growing media in different regions.

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However, several respondents referred to the value of other sources, often not online, for conservation projects (Fig. 17). These sources include the wealth of knowledge held by indigenous and local communities, and historical (non-digitised) records and journals.

Responses to Likert questions

The responses to the Likert questions were consistent with findings in Meyer *et al*. (2024) and indicate unity in views across the horticultural community. A useful aspect of these questions was the opportunity they generated to add comments about specific inputs in a consistent way. The responses made a substantial contribution to the development of the theme map (Fig. 12), particularly relating to the key inputs of horticultural skills, communication and teamwork.

The establishment of a formal conservation horticulture community could help improve recognition and understanding of the subject as identified in this study and by Meyer *et al*. (2024). However, opinions on this varied, and more consultation is required to ascertain whether horticulturists want access to a formal conservation horticulture community. Access to and use of such networks is dependent on geography, culture, existing networks and communication systems, and these vary between regions. It would be important that a new community established for this purpose considered these factors to maximise involvement.

Towards a toolkit

An aim of this study was to identify the components needed for a toolkit for conservation horticulturists. The theme map (Fig. 12) shows a hierarchy of inputs that could form the basis of a toolkit. The inputs identified could guide the creation of a detailed set of guidelines for garden managers to support gap analysis and decision-making. These guidelines could also be used for education leaders when developing conservation horticulture courses.

Most of the experiences shared in this study came from medium to large gardens in the global north with a history in the western garden tradition. A larger sample drawn from gardens new to conservation horticulture in developing countries may have highlighted different requirements for inclusion on the

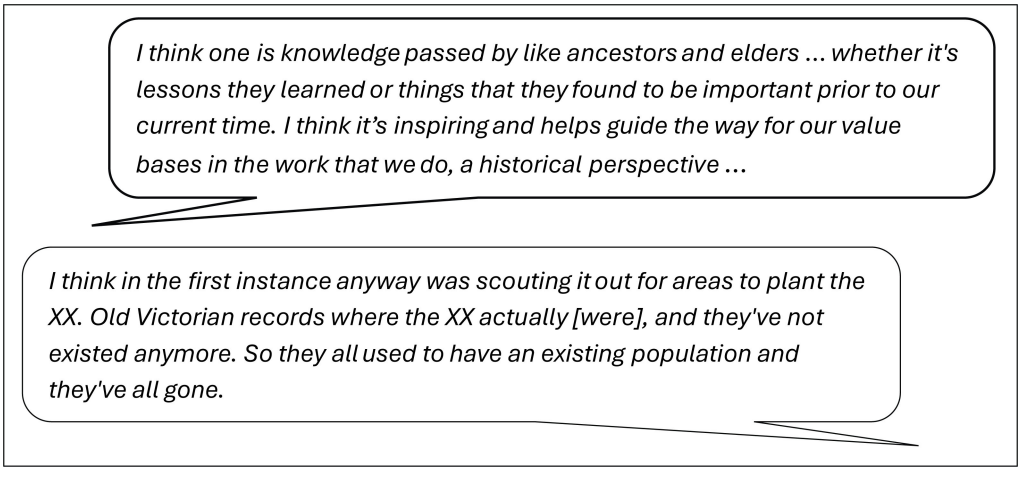

Fig. 17 Quotes from respondents about the value of a range of information sources.

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theme map. Further consultation with a sampling from the global south needs to be undertaken before developing a toolkit to ensure that it reflects global needs, especially where threats are greatest (Mounce *et al.*, 2017). The exploration of practices of other non-profit and commercial horticulture and conservation organisations could also yield useful information.

Recommendations

- More data should be gathered from gardens new to conservation horticulture in developing countries to enable the creation of tools that reflect global needs where threats to biodiversity are greatest.
- Investigation should be made into practices of other non-profit and commercial horticulture and conservation organisations to support the creation of a toolkit.
- Further investigation into biosecurity considerations for conservation projects is required.
- Wider consultation on the establishment of a formal community for conservation horticulturists is required.
- Development of strategies to raise the profile of conservation horticulture with non-professional audiences could improve access to funding and other forms of support.
- Communication skills should be included on horticulture training programmes.
- Training courses and professional development for horticulturists should continue to include practical, hands-on experience.

Conclusion

Conservation horticulture is not a commonly used term but there is a growing awareness that horticulture is one of the main mechanisms by which plants can be saved from extinction. There is familiarity with the term within the horticultural community but less enthusiasm to use it as a collective term. Greater consensus on its use could positively impact recognition, improve advocacy and secure additional resources for plants and conservation.

A passion for plants and adequate space and time to cultivate plants are crucial to success as are the skills required to access, gather and share information.

The theme map produced in this study provides a basis for the creation of toolkits to help gardens establish conservation programmes or identify priorities and gaps in programmes already underway. It can also aid the development of education materials for future conservation horticulturists.

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Appendices

Appendix 1 Definition of 'conservation horticulture'

Conservation horticulture is a term that was first used to highlight the application of horticultural knowledge and skills to the conservation of rare and threatened plants (Affolter, 1997). In 2017 Gratzfeld added to Affolter (1997) that it often happens 'within the context of development and management of *ex situ* collections that:

- are genetically diverse and representative of the target populations in the wild;
- provide plant material for *in situ* conservation and reintroduction programmes; and
- support conservation education and environmental awareness.

In botanic gardens, conservation horticulture is often practiced by staff along a spectrum of intensity and with varying degrees of formality, and conservation horticulture can also be manifested among a team of people working together' (Meyer *et al.*, 2024).

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Appendix 2 Interview guide

Interview duration: estimated 1–1.5 hours

Project objectives

1. Analysis of the contexts in which the term 'conservation horticulture' is used
2. Identification of the horticultural activities, skills and resources that enable conservation of species in botanic gardens and arboreta
3. Compilation of a list of the knowledge and physical resources required for botanic gardens using living collections for conservation.

Questions from Meyer *et al*. (2024) that my interview questions should align with:

Question 4: Before considering the official definition, do you consider yourself a conservation horticulturist?

Question 12: Considering the definition of conservation horticulture given, what learning experiences have been most important for helping build your knowledge and skills relevant to conservation horticulture?

Question 13: Considering the definition of conservation horticulture given, what types of training would help to further develop your or others' skills relevant to conservation horticulture?

Question 14: Considering the definition of conservation horticulture given, what support (not including training) would be helpful for your work relevant to conservation horticulture (e.g. information resources, mentorship, funding)? Please describe.

Question 19: Having reflected on the definition of conservation horticulture and your work, do you consider yourself a conservation horticulturist? Yes, No, Unsure. Please describe why.

Interview script and table of questions

Introduction: I would like to hear your thoughts and experiences about the horticultural work you do, particularly in relation to conservation of plants. I would like to understand the terminology used to describe this work, how you have learned to do this work and what support or other developments would be useful for you, those you work with and others seeking to conserve plants with *ex situ* collections.

My questions are aimed to align with some of the questions asked in a survey sent out by BGCI-US in 2022. One of the free text responses from that survey was as follows, and this quote reflects my aims for this project and what I want to explore:

> One respondent said: 'For organizations that have horticulture experience but are new to conservation horticulture, it would be great to have resources that introduce them to the concept and how it's different from traditional horticulture.' This could be the case for leadership at botanic gardens as well. (Meyer *et al*., 2024)

There are 20 questions, some of which may require longer answers than others. Short answers are fine – do not feel you have to say more than is true or necessary, and if you have something to say on the topic that is not covered specifically by the question feel free to elaborate at any point.

Thank you for answering these questions. If you think of anything you would like to add after today, please just email me at the address on the information sheet and let me know.

I will create a transcript and will send it to you to check that you are still happy for your answers to be used in the study.

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Table 2 Questions for interviewees and links with study objectives and Likert scale questions.

No.	Question	Objective (Obj) and question (Q) in Meyer *et al.* (2024) survey
1	Introductory for sampling: organisation, department, formal education, no. years in horticulture, no. years in conservation. How many staff in the organisation?	Sampling
2	Thinking about the definition of conservation horticulture, what do you think about the definition given in the information sheet? Do you think the definition of conservation horticulture is useful to describe your activities?	Obj 1
3	Would you add or take away anything from this definition if you were to use it?	Obj 1
4	Do you consider yourself to be a conservation horticulturist?	Obj 1, Q4 & Q19
5	How do you think conservation horticulture is different from traditional horticulture (if you agree that it is)?	Obj 1, Q4 & Q19
6	What do you consider to be the three most important principles or approaches for conserving species using horticultural methods? (idea of theory)	Obj 2 & Obj 3
7	What do you consider to be the three most important activities or resources for conserving species using horticultural methods and why? (idea of practice)	Obj 2, Q14
8	Thinking now about what you as a professional bring to the activity of conservation horticulture, what learning experiences or similar input have been most valuable for developing your conservation work?	Obj 2, Q12 Likert question
9	Are there any learnings or life experiences that you have had that might not be considered directly relevant to the area of horticulture that you have found useful? What are these?	Obj 2 & Obj 3, Q12
10	How have they been useful to your work in horticulture or conservation?	Obj 2 & Obj 3, Q13 & Q14
11	What are the top three most useful pieces of equipment, facilities or physical resources that enable you to do conservation work (or would do if you had them)?	Obj 2 & Obj 3, Q14
12	Are there any written resources or publications that you find, or have found, useful in your practice?	Obj 3, Q14
13	Thinking now about future practices, either your own or those of others, apart from funding, what type of resource such as training, publications or another resource do you consider might be useful to you to help improve conservation outcomes in future? What kind of resource would you like to see?	Obj 2 & Obj 3, Q13 & Q14 Likert question
14	Is there anything else physical or knowledge-based that you think would help to advance the field of horticulture for conservation?	Obj 3, Q14
15	What are the biggest challenges to the conservation horticulture work you are doing?	Obj 2 & Obj 3
16	Have you experienced setbacks or failures using horticulture for conservation?	Obj 2 & Obj 3
17	What was the main reason for the lack of success? What might have helped to reduce the setback?	Obj 2 & Obj 3
18 if time	Thinking now about the perceptions of others of conservation horticulture and your work, do you feel that the importance of horticulture for conservation is appropriately recognised by your peers, your organisation leaders and/or your field of activity?	Obj 1 & Obj 2 Likert question (optional)
19	Is there anything else you would like to add to this topic that we have not covered, or any other comments you want to make?	Obj 1, Obj 2 & Obj 3
20 if time	Thinking about your most fruitful outcomes, do you work alone or solely in horticulture teams, or do you work with other professions? Tell me more about these collaborations.	Obj 2

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Appendix 3 Likert scale questions and scaled response options

Project title: what is conservation horticulture and what are the skills and resources that horticulturists need to conserve plants?

Interviewees can discuss responses with the interviewer. Responses are confidential.

Question 8: What learning experiences or similar input have been most valuable for developing your conservation work?

Please answer each line with a score from 1 to 5 shown below for your personal experience. If you have not experienced any put 'N/A'.

1. Not valuable at all
2. Somewhat valuable
3. Quite valuable
4. Very valuable
5. Essential

No.	Most useful learning experiences for you	Score 1–5	Comments (optional)
i	Hands-on experience in the nursery or lab (*ex situ*)		
ii	Communication with or observation of collaborators both internal and external		
iii	Hands-on experience in the field		
iv	Written resources		
v	Formal education or training		
vi	Conferences or seminars: attending or presenting at or both?		
viii	Other experience not listed above		

Question 13: Other than funding, what type of resource such as training, publications or another resource do you consider might be useful to you to help improve conservation outcomes in future?

Please answer with a score from 1 to 5 using the scale below.

1. Not useful
2. Somewhat useful
3. Quite useful
4. Very useful
5. Essential

No.	Resources that might be most useful for you in future	Score 1–5	Comments (optional)
i	Training		
ii	Publications		
iii	Mentorship		

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No.	Resources that might be most useful for you in future	Score 1–5	Comments (optional)
iv	Formal community		
v	Information resources		
vi	Other		

Question 18: In your opinion and personal experience how recognised is the value of horticulture for conservation by i) your peers, ii) your organisation leaders and iii) your field of activity, such as professional affiliations?

Please answer with a score from 1 to 4 using the scale below.

1. Never recognised
2. Occasionally recognised
3. Frequently recognised
4. Always recognised

If you do not know please write 'Do not know' in the comments box.

No.	Appropriate recognition by	Score 1–4	Comments
i	Peers		
ii	Organisation leaders		
iii	Wider field of activity		

Feel free to share other thoughts relating to these questions with the interviewer.

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