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SYMPOSIUM

Deficits in Accessibility across Field Research Stations for Scientists with Disabilities and/or Chronic Illness, and Proposed Solutions

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Synopsis Equity and inclusivity in STEM research has become a larger topic of discussion in recent years; however, researchers and scientists with disabilities and/or chronic illnesses are often missing from these conversations. Further, while field research is a major research component for some STEM disciplines, it is unclear what accessibility barriers or accommodations exist across the field sciences. Field research can sometimes involve harsh environments, topography, and weather that present challenges to those with disabilities and/or chronic illnesses. A large and coinciding obstacle standing in the way of field research accessibility is the ableism present across science and academia, resulting in and from a lack of prioritization of attention and funding from universities and institutions. Biological field stations have been shown to be valuable not only as infrastructure for field-based research, but also as providing resources toward the scientific education of students and scientific outreach initiatives for the general public. As such, biological field stations are perfectly positioned to reduce barriers in research inclusion and accessibility for students and scientists with disabilities and/or chronic illnesses. The current work presents the results of a survey meant to inventory the presence or absence of accessible infrastructure across field stations, with responses spanning six countries and 24 US states. Our results highlight a number of accessibility deficits in areas such as accessible entrances, kitchens, and bathrooms. Our results suggest that (1) biological field stations have significant variability in accessibility with significant deficits, especially in non-public-facing buildings used primarily by staff and researchers, and (2) field stations would benefit from an increase in federal funding opportunities to expedite their progress toward compliance with Americans with Disabilities Act (ADA) standards. We propose potential solutions to field work infrastructure spanning a range of financial costs, with emphasis on the point that efforts toward accessibility do not require an "all-or-nothing" approach, and that any step toward accessibility will make field stations more inclusive. Additionally, we further suggest that federal funding sources, such as the NSF and NIH, as well as university leadership, should consider broadening diversity initiatives to promote the continuation of, and increased accessibility of, university-affiliated field stations.

Introduction

Equity and inclusivity in field sciences has become a larger topic of discussion in recent years, with an imperative focus on scientists from racial or ethnic backgrounds and gender minorities (Morales et al. 2020; Demery and Pipkin 2021; Lawrence and Dowey 2022; Ramírez-Castañeda et al. 2022). Field research, or scientific investigations conducted in natural environments outside of a laboratory or other controlled settings, is a vital component of many areas of research such as in ecology, conservation, and geosciences. Educational experiences in the field are influential to scientific trainees (Chiarella and Vurro 2020) and important for their retention in STEM (Boyle et al. 2007; Beltran et al. 2020). True inclusivity will require dismantling the many barriers that exclude or deter scientists based on their gender identity, sexual orientation, disability, ethnicity, race, religion, socioeconomic status, native lan-

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guage, relationship status, caretaker status, and the intersections of these identities.

Those with disabilities and chronic illnesses represent a large, minoritized, and disenfranchised group in the United States, with one in every four people living with a disability or chronic illness according to the Centers for Disease Control and Prevention (CDC 2022). The Americans with Disabilities Act (ADA) defines disability as "a physical or mental impairment that substantially limits one or more major life activities" (Americans with Disabilities Act of 1990), and the National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP) defines chronic diseases (often interchangeably called "chronic illness") as "conditions that last 1 year or more and require ongoing medical attention or limit activities of daily living or both" (NCCDPHP 2022).

The harsh environments, topography, and weather that can be experienced during field research present larger obstacles of accessibility than in a classical classroom or research laboratory setting. Unfortunately, an even larger and coinciding challenge to these environmental barriers is the ableism, or discrimination in favor of individuals without disabilities, present in science and society at large (Tucker and Horton 2019). Scientists with disabilities and chronic illnesses are substantially underrepresented (NCSES 2021) and report experiencing hostility, devaluation, and blatant discrimination (Powell 2021a; Hall et al. 2004; 2021b). There have been efforts to improve accessibility and accommodation within the settings of a research lab (Hilliard et al. 2013; Sukhai et al. 2017). However, these efforts have been largely focused on K–12 science labs, with a lack of empirical evidence on the environments of post-secondary education (Jeannis et al. 2018). Thus, it is unclear what barriers or accommodations exist in academic research settings, especially under the conditions of field research. Field research stations, in particular, are invaluable scientific resources and are perfectly positioned to serve a broader need in reducing the barriers to research inclusion and accessibility for students and researchers with disabilities and chronic illnesses.

Scientific field stations serve as meeting places, outdoor laboratories, and resource libraries for researchers, while also providing protected environments for personnel, equipment, instruments, and samples. They range in complexity from a site with one or two primitive buildings lacking treated water or consistent electricity to a large sprawling campus of buildings housing laboratory instruments, lodging for personnel, dedicated staff, bathrooms, showers, and kitchens.

Regardless of complexity, field stations have a specific opportunity to be a central resource toward broadening accessibility in the field sciences for those with disabilities and/or chronic illnesses. The presence of infrastructure opens opportunities to those with physical impairments and chronic illnesses: Electricity can allow for the charging of necessary medical devices, while walls and a roof can provide an extra layer of inclement weather protection for people who suffer from poor circulation or thermoregulatory constraints. Accessible infrastructure at field stations reduces the barriers that scientists with disabilities and/or chronic illnesses face when conducting field research and can make an otherwise inaccessible environment for some individuals (such as a remote field site lacking any nearby field station) accessible.

Finally, a crucial element regarding accessible resources is whether this information is readily available. Websites can represent tools to convey information regarding accommodations to potential patrons, but may vary in the level of detail that they provide regarding accessibility accommodations, raising the concern that individuals would lack this information regarding their ability to visit (Cassner et al. 2011).

The following work served to survey the presence or absence of accessible infrastructure at field stations across a wide geographic range and located in a diversity of environments, and whether these accommodations are readily available for potential field researchers. With these results, we highlight reported obstacles standing in the way of field stations addressing deficits in accessibility. Since the ADA encourages and allows the prioritization of "readily achievable" steps toward barrier removal (Americans with Disabilities Act: Title III Technical Assistance Manual), we also suggest methods of improvement that span the range of financial costs, which may be important for field stations looking to balance increasing accessibility with the challenge of acquiring funding for full renovation or complete ADA compliance.

Methodology

Survey dissemination

To survey aspects of accessibility at field research stations, we created a survey in Qualtrics and disseminated this survey on a weekly basis to the OBFS (Organization of Biological Field Stations) email listserver (OBFS listserver), as well as on Twitter with the help of faculty, students, and staff from both our university and other universities. OBFS is a professional organization and coordinated membership network of field stations located across 20 countries (McNulty et al. 2017), and as of April 2023, there are 215 member field stations (OBFS 2023). OBFS is not a comprehensive or evenly distributed geographic representation of worldwide biological field sta-

tions, and does have a clear dominance of North American members; however, its membership comprises almost 17% of the total biological field stations worldwide (Tydecks et al. 2016). The membership size of OBFS, and both the promptness and willingness of its participants, creates an invaluable resource for survey dissemination, and thus we chose to utilize OBFS as the primary sampling frame for the convenience sampling technique (Taherdoost 2016). The survey was open until additional disseminations across Twitter and the OBFS listserver failed to yield responses for more than two novel field stations and closed after approximately 3 weeks. Respondents were able to fill out surveys for as many field stations as they were familiar with. The authors have no manner from which to determine if a specific respondent filled out more than one survey, as no personally identifiable information was collected.

Survey scope

The survey was composed of 11 questions and was written with references to the ADA. The ADA (both the original publication from 1990 and the update in 2010) sets the accessibility standards for infrastructure in the United States (2010 ADA Standards for Accessible Design; Americans with Disabilities Act of 1990). We decided to utilize these guidelines as the United States was the first country in the world to pass a set of comprehensive protections for the basic civil rights of individuals with disabilities with the original passage of the ADA in 1990. Since then, many countries have also utilized the ADA as a framework or reference to create their own protections for citizens with disabilities (Jimenez 2000; Gostin 2015). Since our distribution methods would also bias our respondents to English-speaking individuals and North America, especially the United States, our main audience was likely most familiar with the ADA. Accessibility as defined by the ADA was described for each circumstance in the survey (see Supplement Part A). International respondents were told to answer based on the ADA accessibility definitions, but (optional) could let us know in Q8 to what extent that station complies with any existing disability access laws in that country, or other information they felt would be helpful.

The ADA covers a wide scope of basic civil rights for individuals with disabilities, ranging from employment, public transit, telecommunications, to infrastructure (Introduction to the Americans with Disabilities Act 2023). Our survey focuses on parts of the infrastructure guidelines for accessible buildings. We tried to approach accessibility in a broad manner while still keeping the survey short to encourage complete response rates. We broke accessibility down into five primary categories: general building and campus accessibility (navigating the outdoors and entrances/exits of buildings), and then the four main amenities (bathrooms, showers, lodging, and kitchens) associated with field stations that enable activities of daily living (ADLs): feeding, hygiene, toileting, sleeping, etc. (Katz 1983; Edemekong et al. 2022).

For the clarity of this publication, we will use "field station" to describe areas of infrastructure and "field site" to describe a field location that lacks infrastructure, from which researchers collect field samples. The authors experienced an inconsistent and sometimes interchangeable usage of the nomenclature "field stations" and "field sites" during prior conversations with field researchers (Kuebbing et al. 2021). To avoid discouraging submissions due to unclear terminology, we used the nomenclature of "field stations" and "field sites" interchangeably ("field stations/sites") in the survey but also asked questions (Q4) that would allow us to categorize the responses to post-hoc remove "field sites" responses, if necessary.

Section One: Basic Station Information

Q1: Field Station/Site Information—Requested the following information:

(1) Name of Station/Site
(2) State/Province
(3) Country

Q2: "What is the affiliation of the person filling out this survey? (Field station director, visiting researcher, etc.)." Open-ended answer.
Q3: "When have you most recently visited this site?." Multiple choice answer, allowed to pick just one option:

(1) I am actively working at the site
(2) Within the last year
(3) 1–2 years ago
(4) 3+ years ago

Q4: "Does the site have any of the following:." Multiple choice answer, choose all that apply:

(1) Bathroom(s)
(2) Shower(s)
(3) Lodging
(4) Kitchen

Q5: "Does the kitchen have any of the following:." Multiple choice answer, choose all that apply (but answer 3 is exclusive):

(1) Stove and/or oven
(2) Microwave
(3) None of the above

Section Two: Surveying Accessible Features

Q6: "At your station/site, which of the following exist for your buildings?." Respondents are asked to pick "None," "Some Buildings," or "All Buildings" for each of the following:

(1) Automated exterior doors
(2) Ramps into buildings that do not have a flush ground-level entrance
(3) Railings on stairs and ramps
(4) Electricity
(5) Treated water
(6) Accessible parking
(7) Accessible path connecting to parking or other buildings

Q7: "Does your field station/site have:." Respondents are asked to select all that apply.

(1) At least one ADA-accessible bathroom
(2) A roll-in shower
(3) A shower seat either in the ADA-accessible bathroom, or a portable shower seat available upon request
(4) At least one ADA-accessible lodge room
(5) A mini fridge that can be available upon request
(6) If a kitchen is available, is it fully ADA compliant?
(7) If there is a stove/oven, are the controls on the front of the appliance? Select this if so.
(8) If there is a microwave, is it at a height accessible for a wheelchair user? Select this if so.
(9) A fridge or other climate controlled device in an accessible building, within which medication can be stored
(10) An ADA accessible entrance for all buildings with non-portable equipment and research instruments

Q8: "OPTIONAL: Is there anything you wish to clarify or add?" Open-ended answer.
Q9: "What current obstacles stand in the way of addressing deficits in accessibility at your field site?" Open-ended answer.
Q10: "Does your field station/site have a website?" Multiple choice answer, allowed to pick just one option:

(1) Yes
(2) No

Q11: "Does your website list any accessibility information such as:" Respondents are asked to pick "Listed on Website", or "Not Listed" for the following:

Availability of:

(1) Electricity
(2) Treated water
(3) Bathrooms or showers

Accessibility of:

(4) Bathrooms
(5) Showers
(6) Lodging
(7) Kitchen
(8) Entrances into buildings (ramps, stairs, railings, etc.)

Presence or Absence of:

(9) Automated exterior doors
(10) Railings on ramps and/or stairs
(11) Parking for buildings
(12) Accessible paths between buildings
(13) Accessible fridge or climate controlled equipment that can be utilized for medication storage
(14) Elevators in buildings with more than one floor

Not all questions or options were shown to each respondent as some were dependent on responses to previous question(s) (see Supplement Part B for a detailed description of the survey logic).

Data analysis

An initial set of 67 unique responses was collected by the end of the survey period. Of those responses, 9 were $\leq$58% complete and were removed from the dataset. Three responses were 92% complete, wherein the respondent answered "yes" for website (Q10) but did not provide website listing details in Q11. These three responses were kept, for a final result of 58 unique survey responses. There were no responses that fell under this publication's definition of a "field site," and thus from this point forward, we will use "field station" when presenting or discussing the results of this survey. All survey results were exported from Qualtrics as Excel files (see Supplementary Excel File).

Some field stations had multiple surveys submitted (Supplementary Table S1). The responses for these field stations with multiple surveys were only counted once for each question. Specifics as to how responses were condensed and/or summarized can be found in Supplement Part C.

As the question of respondent affiliation (Q2) was an open answer, we manually grouped responses by similarity for the purpose of reporting demographics. For example, a co-director and a director are both counted under the sub-category "Director." The 57 retained survey responses were then placed into four main groups: "Admin" ($n = 33$), "Staff" ($n = 6$), "Visiting" ($n = 17$), and "Other" ($n = 1$).

Wilson score intervals for all proportions were calculated at the 95% confidence interval, and then converted and expressed as percentages for clarity. All Wilson score intervals are reported inside brackets.

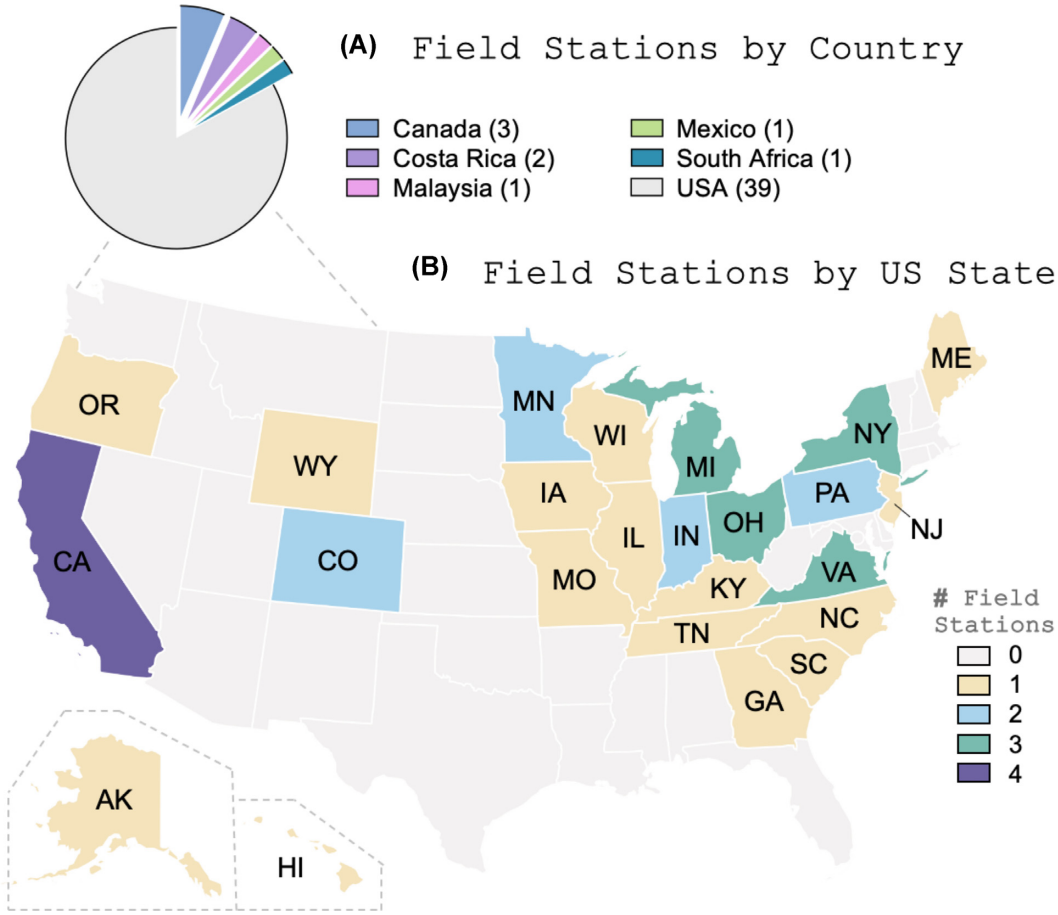

Fig. 1 Field station geographic distribution: Submitted surveys included field stations ($n = 47$) from six countries (A) and across 24 US states (B). (A) Surveys were submitted for field stations in Canada ($n = 3$), Costa Rica ($n = 2$), Malaysia ($n = 1$), Mexico ($n = 1$), South Africa ($n = 1$), and the United States ($n = 39$). The 39 US field stations were located across 24 US states: Alaska ($n = 1$), California ($n = 4$), Colorado ($n = 2$), Georgia ($n = 1$), Hawaii ($n = 1$), Iowa ($n = 1$), Illinois ($n = 1$), Indiana ($n = 2$), Kentucky ($n = 1$), Maine ($n = 1$), Michigan ($n = 3$), Missouri (n = 1), Minnesota ($n = 2$), New Jersey ($n = 1$), New York ($n = 3$), North Carolina ($n = 1$), Ohio ($n = 3$), Oregon ($n = 1$), Pennsylvania ($n = 2$), South Carolina ($n = 1$), Tennessee ($n = 1$), Virginia ($n = 3$), Wisconsin ($n = 1$), and Wyoming ($n = 1$).

Excel (v16.70 (23,021,201), Microsoft®), PowerPoint (v16.70 (23,021,201), Microsoft®), Prism 9 (v9.1.2 (225), and GraphPad Software, LLC) were utilized to analyze the results and create graphics. The United States Map infographic was created using MapChart (mapchart.net) and modified in Affinity Photo (v1.10.6, Serif (Europe) Ltd). Wilson score intervals were calculated using the Proportion Confidence Interval Calculator by Statistics Kingdom (www.statskingdom.com/proportion-confidence-interval-calculator.html).

IRB oversight

The University of Pittsburgh Institutional Review Board (IRB) reviewed this study and deemed IRB oversight and exemption to be unnecessary, given that field stations represented the study subject of interest.

Results and discussion

Geographics and demographics

The final tally of survey responses ($n = 57$) covered 47 unique field stations across 6 countries (Fig. 1A), with the majority of stations ($n = 39$ or 83% [80.5 ± 10.6]) located within the United States of America (Fig. 1B). This geographic distribution of field stations is very similar to that of OBFS members (McNulty et al. 2017), which was the primary dissemination channel for this survey. Some field stations had surveys submitted by multiple respondents, and those results were summarized as described in the supplement (Part C).

Comparisons of field stations from the United States geographic regions of the West, Midwest, South, and Northeast, as defined by the U.S. Census (Regions and divisions 2022), were conducted as described in Supplement Part E, and no significant differences were found

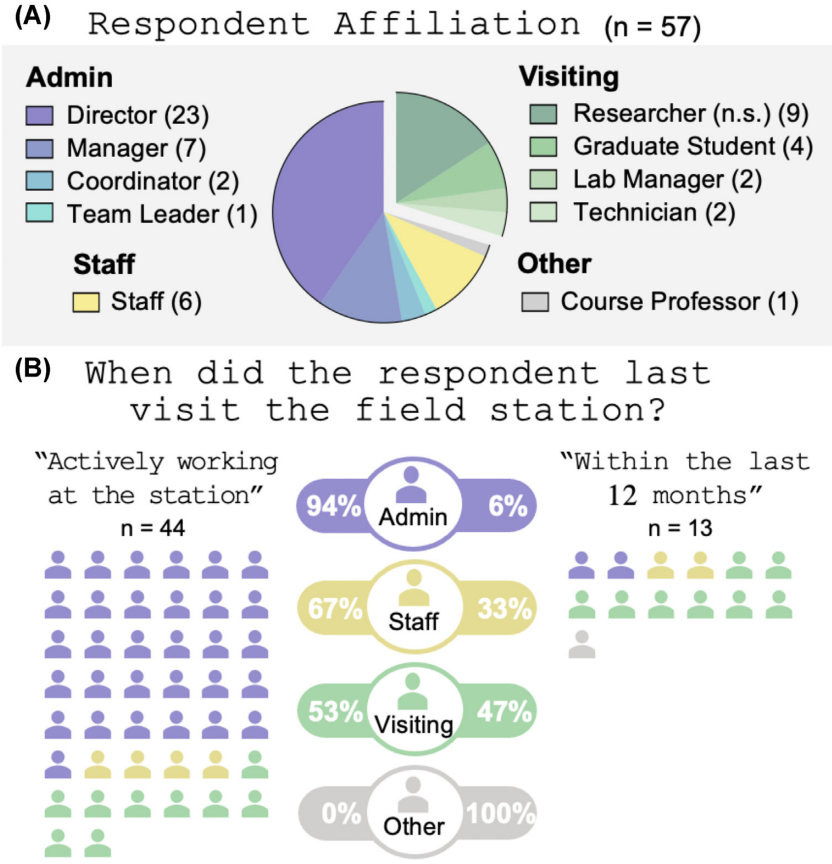

Fig. 2 Respondent demographics: (A) Respondents were asked about their affiliation to the field station they are submitting a survey for. The 57 retained survey responses were comprised of respondents from the affiliation groupings: "Admin" ($n = 33$), "Staff" (n = 6), "Visiting" ($n = 17$), and "Other" ($n = 1$). (B) Respondents were queried on how recently they visited the field station and were provided with 4 answers to pick from: "Actively working at the station," "Within the last year," "1–2 years ago," and "3+ years ago." All respondents were either actively working at their field station ($n = 44$) or had visited within the last 12 months ($n = 13$). The majority of admin respondents (94%) were actively working at the field station, with two admin respondents (6%) having visited in the last 12 months being respondents that held director positions but were no longer the current director at that station.

(not shown). The scores for these United States regions also did not significantly differ from the scores of the field stations located outside of the United States of America. We also utilized the EPSCoR ("Established Program to Stimulate Competitive Research", National Science Foundation 2023) designation to investigate the impact of the uneven distribution of federal research and development grants on the accessibility of field stations in those jurisdictions. Comparisons between field stations located in EPSCoR-eligible states and non-EPSCoR states were conducted as described in Supplement Part E, and no significant differences were found (not shown). However, institutional funding does not necessarily mean those funds make their way to the field stations, or that increasing aspects of accessibility are prioritized.

The majority of respondents (57.9% [57.4 ± 12.4]) hold or recently held an administrative position at their field station (Fig. 2A). Nine respondents listed their affiliation as "Researcher" and were thus categorized under "Visiting" with the other more specific affiliations of graduate student (researcher), lab manager, and technician. Visiting scientists comprised 29.8% ([31.1 ± 11.6]) of the survey responses. Field station staff submitted 10.5% ([13.0 ± 8.1]) of the total surveys, and one respondent listed their affiliation as a "course professor." Respondents were asked how recently they visited the field station, and 77.2% ([75.5 ± 10.7]) answered as actively working at that specific field station, while the other 22.8% ([24.5 ± 10.7]) had visited the field station "within the last 12 months" (Fig. 2B).

General accessibility of the field station buildings and campus

To characterize factors that can impact whether someone with chronic illness and/or disabilities can safely access the field station campus and buildings on that cam-

pus, respondents were asked to answer for each factor whether it was available at all buildings, some buildings, or none of the buildings at their respective station (Fig. 3). All surveyed field stations had electricity at some or all of their buildings (17.0% [19.5 ± 10.6] and 83.0% [80.5 ± 10.6], respectively), and most field stations had access to treated water in some or all of their buildings (23.4% [25.4 ± 11.8] and 63.8% [62.8 ± 13.3], respectively). Six field stations (12.8% [15.6 ± 9.6]) had no access to treated water. Access to uncontaminated (treated) water can be incredibly important to individuals with compromised immune systems (CDC 2021; 2022b) and/or skin conditions (Wang et al. 2021). The majority of field stations had "accessible paths connecting to parking or other buildings" for some or all of their buildings (53.2% [53.0 ± 13.7] and 34.0% [35.3 ± 13.1], respectively), and many had accessible parking present for some or all buildings as well (42.6% [43.1 ± 13.6] and 46.8% [47.1 ± 13.7], respectively). For buildings with stairs and/or ramps, only 40.4% ([41.2 ± 13.5]) of field stations answered to having railings on all of those structures. Almost a third of all field stations (27.7% [29.4 ± 12.4]) lacked "ramps into buildings that do not have a flush ground-level entrance," and automated exterior doors were absent at 32 of the 47 field stations (68.1% [66.7 ± 12.9]) with only 2 field stations (4.25% [7.7 ± 6.5]) having automated exterior doors on all of their buildings. In all of these cases, it is possible that the "some buildings" answers could refer to stations where these factors were implemented for public-facing buildings and not for buildings used mainly by researchers. In fact, that very scenario was mentioned across four of the field stations in the later open-answer sections from respondents and is further supported by the responses to Q7.10 asking whether buildings with non-portable equipment research instruments had ADA accessible entrances, wherein only 13 field stations (29.8% [29.4 ± 12.4]) answered affirmatively (not shown).

One potential explanation for variation in accessibility across field stations could be the erroneous "all or nothing" perception that facilities are, or can ever be, completely accessible or completely inaccessible with regards to ADA standards. Understandably, the cost associated with suddenly making an older building compliant with all current ADA standards can be prohibitive. However, the mindset of needing to fit this "all or nothing" approach can be counterproductive if it causes managers to forgo any progress toward accessibility. Rather, improvements should be thought of and approached as a series of small steps, not halted at an incorrectly perceived "all-or-nothing" mountain (Mol and Atchison 2019).

This departure from the "all or nothing" perception is further reinforced by the ADA. The ADA is a civil rights law (Americans with Disabilities Act of 1990) that also dictates a set of standards for accessibility that entities should work toward (2010 ADA Standards for Accessible Design). The Department of Justice allows entities to prioritize barrier removal that is easily accomplished without much difficulty or expense, otherwise phrased as "readily achievable" (Americans with Disabilities Act: Title III Technical Assistance Manual). There are suggestions and protocols for making progress toward accessibility even if the result after that step is not fully compliant to current ADA standards. Each step toward complete compliance opens doors of access for some individuals with disabilities. Here, cost-friendly solutions exist, such as hardware to retrofit old doors to have power-assisted opening.

Related to the "all or nothing" approach to accessibility, one may ask what the purpose is of powering doors that perhaps are too narrow by ADA standards for wheelchairs. It is important to note that disabilities do not exist on a binary, but with variation in the need for accommodation (Stokes et al. 2019). Some individuals that utilize wheelchairs are still able to ambulate with other assistive devices for certain lengths of time or distances and may be able to enter certain buildings if the door itself is power assisted. People with mobility impairments of any type can benefit from assisted doors, as many exterior-rated doors are prohibitively heavy for individuals with balance or strength issues. If the cost of power-assisted retrofit kits is still prohibitive for field station, consideration of the weight and hardware on the door can help to improve accessibility. In the absence of power assist, picking an accessible hardware type (such as lever-style handles instead of knobs) and/or replacing or purchasing new doors with lighter-weight material are still alterations that increase access. Even slowing the speed at which a door closes can provide a benefit, allowing someone more time to maneuver through the door without also holding back its weight.

Accommodation availability and ADA accessibility

This survey also queried the presence of, and accessibility of, bathrooms, showers, lodging, and kitchens across field stations. Relevant 2010 ADA accessibility standard (2010 ADA Standards for Accessible Design) descriptions were provided to the respondents and can be found in the supplement (Part A).

Field stations exhibited variability in the presence of accessible bathroom and shower amenities. While all surveyed field stations had at least one bathroom, 16 of the stations (34% [35.3 ± 13.1]) lacked a fully

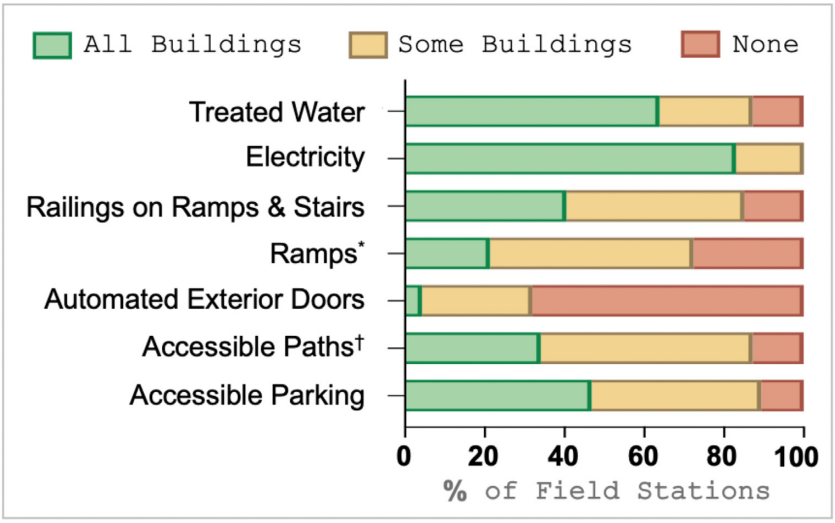

Fig. 3 Presence of utilities and accessibility of building entrances and surrounding campus: Respondents were asked to answer whether "all buildings" (green, first bar in each stack), "some buildings" (yellow, second bar in each stack), or no buildings ("none," red, last bar in each stack) had the listed utilities or accessibility features. The number of field stations ($n = 47$) with each respective answer will be listed in the following format, ("all," "some," and "none"), for each utility or accessibility feature. Treated water (30, 11, and 6), electricity (39, 8, and 0), railings on ramps & stairs (19, 21, and 7), ramps* (10, 24, and 13), automated exterior doors (2, 13, and 32), accessible paths (16, 25, and 6), and accessible parking (22, 20, and 5). The percentage of field stations with each respective answer is as follows: Treated water (63.8, 23.4, and 12.8%), electricity (83.0, 17.0, and 0.0%), railings on ramps & stairs (40.4, 44.7, and 14.9%), ramps* (21.3, 51.0, and 27.7%), automated exterior doors (4.25, 27.6, and 68.1%), accessible paths (34.0, 53.2, and 12.8%), and accessible parking (46.8, 42.6, and 10.6%). Some feature names/descriptions are shortened due to space constraints on this figure: * "Ramps" was presented to respondents as "ramps into buildings that do not have a flush ground-level entrance." † "Accessible paths" was presented to respondents as "accessible path connecting to parking or other buildings."

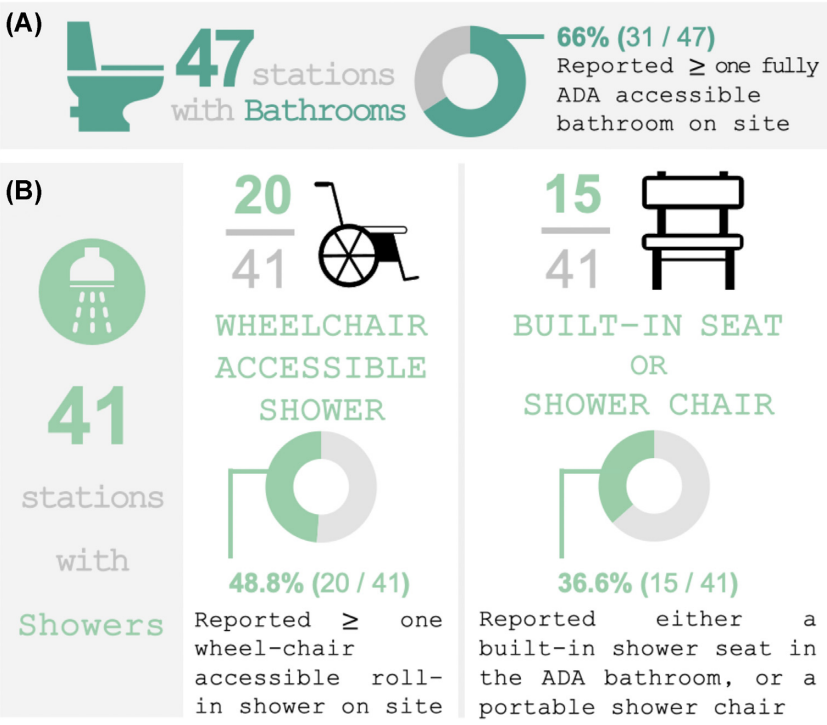

Fig. 4 Bathroom and Shower Availability and Accessibility: (A) All surveyed field stations ($n = 47$) had at least one bathroom available. 31 of those field stations (66%) reported at least one bathroom that conformed to the 2010 ADA standards. (B) For showers, 87.2% of field stations ($n = 41$) had at least one shower available. 48.8% ($n = 20$) of those stations with showers reported having at least one wheelchair-accessible "roll-in" shower, and 36.6% ($n = 15$) of those stations with showers reported having either a built-in shower seat in the ADA bathroom, or a portable shower chair.

ADA-accessible bathroom (Fig. 4A). Forty-one surveyed field stations (87.2%) offered shower accommodations, but only 20 stations (48.8% [48.9 ± 14.6]) reported having a wheelchair-accessible shower (Fig. 4B). Given the potentially prohibitive costs and space requirements that may be associated with updating a shower to be wheelchair accessible, we also surveyed whether field stations had mobility-assistance features present in non-roll-in showers. Only 15 field stations (48.8% [37.7 ± 14.1]) had either a shower with a built-in seat in their "ADA-accessible bathroom" or a portable shower chair available upon request (Fig. 4B). Reputable shower chairs with adjustable heights, back, and armrests can be purchased within the range of 50–80 USD and can provide much needed mobility support and safety in a slick wet environment. Similar to the range of accommodations discussed above regarding exterior doors, even if a shower is not fully wheelchair accessible, some individuals that use wheelchairs may still be able to ambulate into a shower provided a seat is available for them to transfer onto, and so providing any amount of accommodation will increase accessibility.

Changing faucet hardware to lever-style handles and rehanging a door to open outward from the bathroom, and not into the bathroom are additional considerations that can greatly improve the accessibility of that bath facility without costing a prohibitive amount, especially in the context of necessary repairs. Thus, being familiar with ADA standards is not only important for planned renovations but should also be prioritized when making decisions of repairs at field stations.

The majority of surveyed field stations (78.7% [76.6 ± 11.5]) offered lodging for researchers; however, only 16 of those field stations (43.2% [35.3 ± 13.1]) reported having at least one ADA-accessible lodge room on (Fig. 5A). There are many factors involved in "fully ADA-accessible" lodging (see Supplement Part A), and some may not be possible to easily accomplish due to financial or spatial/structural constraints. However, simple steps such can improve the accessibility of a lodge room, such as removing unnecessary furniture to clear larger walking paths or providing an ADA-height bed frame by cutting down a bed frames that are too tall or adding plastic bed raisers to frames that are too short. Additionally, if there is a room that is feasible for a wheelchair to access the entrance of, light switch extenders (∼10 USD) can be installed on existing switches to make them an accessible height for wheelchair users.

Very few field stations reported having an ADA-accessible kitchen. Only 4 of the 41 stations (9.8% [13.2 ± 9.3]) reported ADA-compliant kitchens (Fig. 5B), perhaps due to space constraints and budget requirements for kitchen renovations. However, we also asked respondents about the accessibility of two common cooking appliances in their kitchens. While most of the kitchens had a stove and/or oven, only 27.5% ([29.5 ± 13.4]) of those kitchens reported having a stove/oven with front controls that do not require the user to reach over the top of the appliance to operate (Fig. 5C). Additionally, 37 of the kitchens had a microwave available, but 22 of those kitchens (59.5% [58.6 ± 15.1]) had their microwaves located at a height that was not wheelchair accessible (Fig. 5D). Field stations should prioritize stoves/ovens with front controls when replacing an old appliance, as these controls are more accessible to, and safer for people with mobility, balance, coordination, and vision impairments. A microwave at a wheelchair-accessible height can, in the absence of other factors, provide the ability for an individual to conduct life-necessary functions such as sterilizing their own drinking water or making their own meals safely, especially for immune-compromised individuals (Obayashi 2012) or those with certain gastrointestinal disorders/diseases (Brown et al. 2011) that prohibit the ingestion of many uncooked foods.

While our survey focuses primarily on factors that many would erroneously consider to be important only to individuals with physical disabilities, we wish to mention that all of these accessibility factors can have an impact for a wide variety of people. Individuals with chronic illness, pain disorders, hearing impairments, and pregnant individuals, to name a few, can also benefit from many of the accessibility factors characterized in this survey. Some non-exhaustive examples include: access to a fridge or other climate-controlled device can be vital for the storage of certain medications for individuals with chronic illness, or for the storage of milk from nursing mothers, electricity can be necessary for the charging of medical devices or FM hearing assistive devices, and automated or power-assisted doors can help avoid symptom exacerbation for individuals with pain disorders. Further, individuals with physical disabilities may also have other secondary health conditions, and the persistence of physical barriers and lack of ADA compliance, as well as the resulting isolation, can exacerbate secondary conditions such as depression (McClain et al. 2000).

Availability of accessibility-related information

Availability of accessibility-related information is imperative for a scientist with disabilities and/or chronic illness to make an informed decision on conducting research at a field station. The majority of surveyed field stations (87.2% [84.4 ± 9.6]) had public websites (Fig. 6A), but the websites only mentioned an average of 3 of the 14 (21.4% [27.6 ± 20.0]) surveyed accessibility (Fig. 6B) or prevalence-related topics (Fig. 6C)

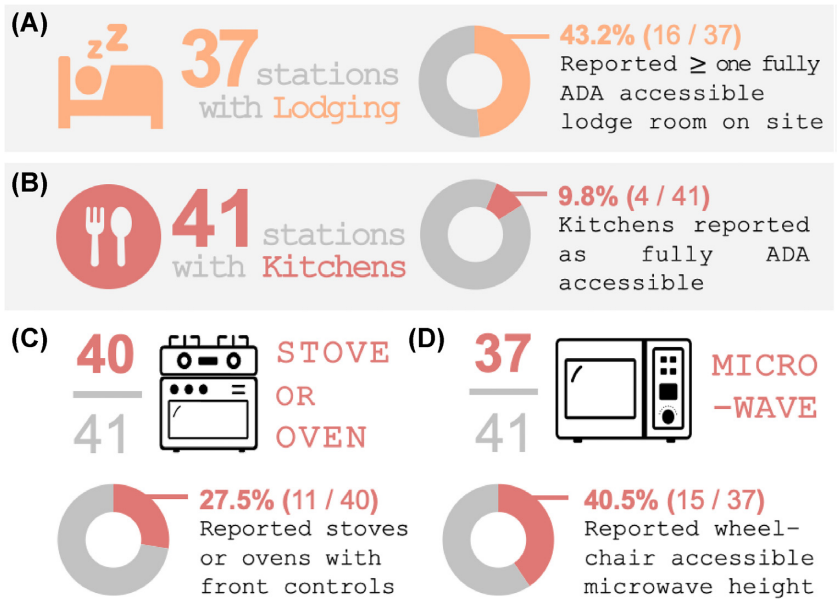

Fig. 5 Lodging and kitchen availability and accessibility: (A) Most surveyed field stations have lodging accommodations (37 of the 47 surveyed field stations, or 78.7%). Sixteen (43.2%) of those field stations with lodging reported having at least one lodge room conforming to 2010 ADA standards. (B) Of the 47 surveyed field stations, 41 (87.2%) had at least one kitchen available. Of those 41 stations with kitchens, only 4 (9.8%) reported their kitchen as conforming to 2010 ADA standards. When surveying appliance accessibility in kitchens, (C) 40 of the 41 stations with kitchens (97.6%) had a stove and/or oven, but only 11 (27.5%) reported their stove and/or oven as having accessible front controls, and (D) 37 of the 41 stations with kitchens (78.7%) had a microwave, but only 15 (40.5%) reported their microwave as being at a wheelchair-accessible height.

in some capacity. Upon visiting a subset of the websites ourselves, we found that a large amount of those mentions were framed to address visits from the general public in topics like general parking availability, maps of the campus (from which accessible parking could perhaps be deciphered), the presence of a bathroom, and the availability of electricity in at least one building either directly mentioned or implied indirectly through the presence of other mentioned features (such as air conditioning in a public-use building). Very few of the websites discussed these topics regarding buildings utilized only by research staff and visiting researchers, suggesting a substantial lack of available information resources for scientists looking to visit these stations.

Websites represent tools to convey information, resources, and accommodations to potential patrons. A similar survey of websites for public libraries found variable details of accessibility accommodations across buildings, raising the concern that individuals would lack this information regarding their ability to visit (Cassner et al. 2011). Our survey demonstrates that similar variability exists for field stations. Supplying this information freely is important so as to not place the burden on individuals with disabilities to reach out for clarification on what accommodations are available.

That is to say, if an effect of reading this paper is for a field station to purchase a shower chair, but the website neither acknowledges scientists and researchers with disabilities or chronic illnesses, nor lists disability accommodations that exist at the station, nor mentions the existence of the shower chair, then the resulting impact may be questionable. This lack of available information also runs the risk of a spurious result and the conclusion of "*no one has used the shower chair in the last 10 years, hence there is no need for it.*" People will utilize what they know is available for them, and we as a field have not yet shown our receptiveness toward, and acceptance for, researchers with disabilities and/or chronic illnesses. Providing accurate information regarding available accommodations is an important and necessary step in reducing the barriers of accessibility in field research.

Future suggestions

While this survey has highlighted the existence of accessibility deficits, future work will be needed to better understand the extent of this deficit both within the United States and internationally. Future surveys could consider utilizing direct contact of field stations to try and accomplish a more even geographic distribution, multimedia approaches to increase response rates, and multiple language options. However, we strongly suggest that

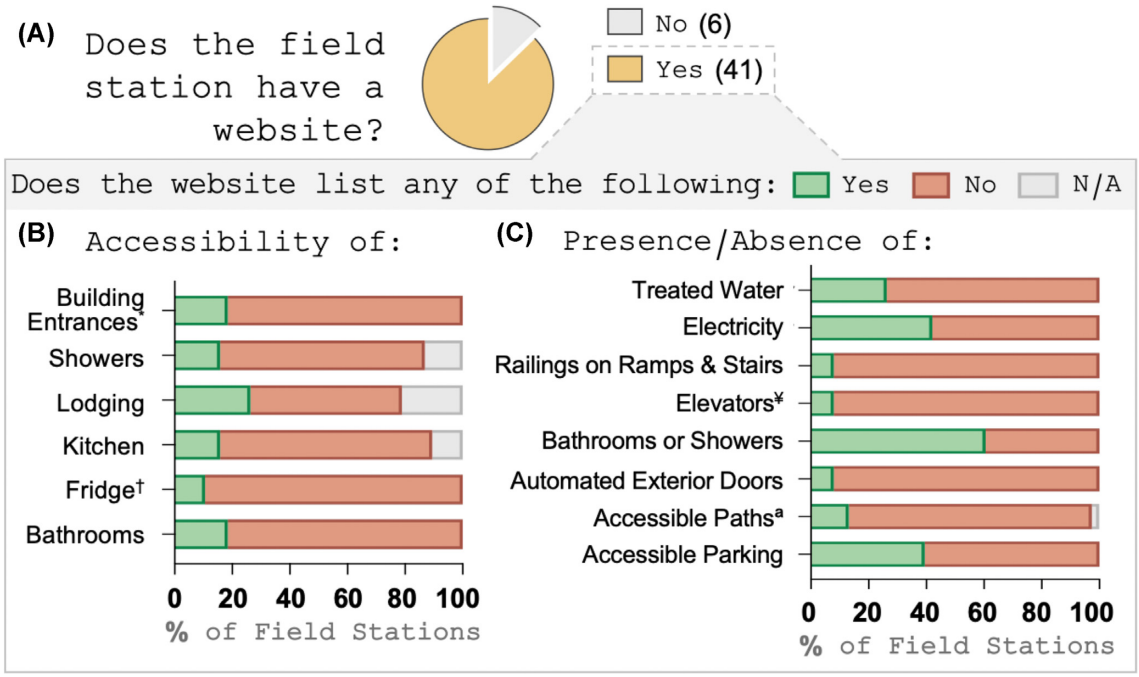

Fig. 6 Availability of accessibility-related information: (A) Of the 47 surveyed field stations, 41 (87.2%) reported having a website, while 6 (12.8%) reported lacking a website. For the 41 stations with a website, respondents were asked to answer with either "Yes" (green, first bar in stack) or "No" (red, second bar in stack) regarding whether their field station website lists (B) the accessibility of certain factors or (C) the presence/absence of certain factors. Some respondents chose to leave certain topics void of an answer, and these are represented as "N/A" (light gray, third bar in stack if present). As specified in the methods, 3 field stations with websites did not fill out this question of this survey. Thus, for B and C, the sample size is 38 field stations. The number of field stations ($n = 38$) with each respective answer will be listed in the following format, ("Yes," "No," and "N/A"), for each feature: accessibility of (B) Building Entrances* (7, 31, and 0), Showers (6, 27, and 5), Lodging (10, 20, and 8), Kitchen (6, 28, and 4), Fridge† (4, 34, and 0), Bathrooms (7, 31, and 0), and presence or absence of (C) Treated Water (10, 28, and 0), Electricity (16, 22, and 0), Railings on Ramps & Stairs (3, 35, and 0), Elevators¥ (3, 35, and 0), Bathrooms or Showers (23, 15, 0), Automated Exterior Doors (3, 35, and 0), Accessible Paths[a] (5, 32, and 1), and Accessible Parking (15, 23, 0). By percentage, accessibility of (B) Building Entrances* (18.4, 81.6, and 0%), Showers (15.8, 71.0, and 13.2%), Lodging (26.3%, 52.6%, 21.1%), Kitchen (15.8, 73.7, and 10.5%), Fridge† (10.5, 89.5, and 0%), Bathrooms (18.4%, 81.6%, 0%), and presence or absence of (C) Treated Water (26.3, 73.7, and 0%), Electricity (42.1%, 57.9%, 0%), Railings on Ramps & Stairs (7.90, 92.1, and 0%), Elevators¥ (7.90, 92.1, and 0%), Bathrooms or Showers (60.5%, 39.5%, 0%), Automated Exterior Doors (7.90, 92.1, and 0%), Accessible Paths[a] (13.2, 84.2, and 2.60%), and Accessible Parking (39.5, 60.5, and 0%). Some feature names/descriptions are shortened due to space constraints on this figure: * "Building Entrances" was presented to respondents as "Entrances into buildings: ramps, stairs, railings, etc.". † "Fridge" was presented to respondents as "Accessible fridge or climate controlled equipment that can be utilized for medication storage." ¥ "Elevators" was presented to respondents as "Elevators in buildings with more than one floor." [a] "Accessible Paths" was presented to respondents as "Paths between buildings."

visiting field stations directly may be required for the most comprehensive inventory of field station accessibility, not only to remove the reliance on shorter surveys to try and encourage response rates, but also to remove the reliance on respondent comprehension of the relevant laws or guidelines. A previous study by Sanchez et al. that conducted site visits found that healthcare clinics often perceived themselves as more accessible and ADA compliant than they actually were (Sanchez et al. 2000). Performing site visits would also feasibly enable a broadened scope to include more accessibility factors that primarily impact those with chronic illness, visual impairments, hearing impairments, mental health considerations, or sensory processing disorders.

Final notes

The productive discussions promoting inclusivity and equity within field work must start involving issues of accessibility as well. Those with disabilities and/or chronic illnesses represent a large and disenfranchised group, and this identity often intersects with aspects of race, ethnicity, gender identity, sexual orientation, and age. Yet, it is no new surprise that STEM fields continually struggle to retain students with disabilities, especially in postsecondary and doctoral levels of education (NCSES 2017; 2021). STEM career fields and academia have perpetuated a long and pervasive history of ableism (Brown and Leigh 2020; Dolmage 2017; Brown and Ramlackhan

2022) and institutional otherism (Reutlinger 2015) that is ingrained in the rigidity of both physical infrastructure and conceptual attitudes surrounding education and research (Powell 2021a; Hall et al. 2004; 2021b).

The limitations in discussions regarding accessibility cause the default assumption to also become the correct assumption: that people with disabilities are not accommodated. Until we can challenge this way of thinking, initiate steps toward change, and provide ample evidence and consistent progress such that this assumption is wrong, it will persist in both thought and reality. Initiating these changes will require that people who hold privilege be vocal advocates—not just on behalf of those less privileged than them, but in a way in which they listen to the needs of and be vocal with those who are less privileged (Stokes et al. 2019).

Universities and institutions need to start prioritizing accessibility at affiliated field stations. Field stations are not just an outreach station for the general public, but also valuable classroom and research settings for students and trainees, and a workplace that is just as deserving of an accessible environment for employees. Additionally, federal funding agencies such as the NSF and the NIH have been voicing the importance of access, inclusion, and recruitment in research and STEM for people with disabilities (Bernard 2020; 2021; Butterfield 2021). Increasing the recruitment and retention of scientists with disabilities and chronic illnesses in the field sciences will require correction in the large deficits in infrastructure accessibility. While we presented cost-friendly areas of improvement, the results from this survey have highlighted a substantial need for an increase in federal funding and funding opportunities to assist field stations with expediting progress toward ADA compliance. Additionally, federal funding agencies could broaden their diversity initiatives to promote both the continuation of and accessibility of university-affiliated field stations. However, one might question the true limitation of university funding given that major universities continue to undergo rapid growth and development in physical infrastructure in the face of increasing student enrollment (SCUP 2021). Thus, like many issues associated with accessibility, the future of accommodations at field research stations may be a question of priority.

Author contributions

The survey was created by E.N.R. with advisement from K.D.K, and disseminated to OBFS by E.N.R. and Twitter by E.N.R. and K.D.K. Data were collected and analyzed by E.N.R., and manuscript written by both E.N.R. and K.D.K.

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Supplementary data

Supplementary data available at *ICB* online.

Conflict of Interest

The authors have no conflicts of interest to declare.

Data accessibility

Survey data are provided in the Supplementary Excel File with some alterations or omissions (as detailed in Part D of the main Supplementary file) to ensure response anonymity.

References

2010 ADA Standards for Accessible Design. In: USDo Justice, editor. Washington, DC: Dept. of Justice.

Americans with Disabilities Act of 1990. United States of America: 101st Congress, 2nd Session, 1990. p. 327–78.

Americans with Disabilities Act: Title III Technical Assistance Manual. III-4.4000 Removal of barriers, Washington, DC: Department of Justice.

Beltran RS, Marnocha E, Race A, Croll DA, Dayton GH, Zavaleta ES. 2020. Field courses narrow demographic achievement gaps in ecology and evolutionary biology. Ecol Evol 10:5184–96.

Bernard M. 2020. [Electronic]. Barriers to inclusion of individuals with disabilities in the scientific workforce. Blog. [last accessed Feb 27 2023].

Bernard M. 2021. [Electronic]. Advancing disability inclusion in the scientific workforce. Blog. [last accessed Feb 27 2023].

Boyle A, Maguire S, Martin A, Milsom C, Nash R, Rawlinson S, Turner A, Wurthmann S, Conchie S. 2007. Fieldwork is good: the student perception and the affective domain. J Geogr High Educ 31:299–317.

Brown AC, Rampertab SD, Mullin GE. 2011. Existing dietary guidelines for crohn's disease and ulcerative colitis. Expert Rev Gastroenterol Hepatol 5:411–25.

Brown N, Leigh J (editors). 2020. Ableism in academia: theorizing experiences of disabilities and chronic illnesses in higher education. London: UCL Press.

Brown N, Ramlackhan K. 2022. Exploring experiences of ableism in academia: a constructivist inquiry. High Educ 83:1225–39.

Butterfield S. 2021. Dear colleague letter: Persons with Disabilities—STEM Engagement and Access (PWD-SEA). Alexandria (VA): National Science Foundation.
Cassner M, Maxey-Harris C, Anaya T. 2011. Differently able: a review of academic library websites for people with disabilities. Behav Soc Sc Librar 30:33–51.
CDC. 2021. Prevention & control—immunocompromised persons. Atlanta (GA): Centers for Disease Control and Prevention.
CDC. 2022. Disability and Health Data System (DHDS). Atlanta (GA): Internet: Centers for Disease Control and Prevention.
CDC. 2022b. Drinking water: water contamination and diseases. Atlanta (GA): Centers for Disease Control and Prevention.
Chiarella D, Vurro G. 2020. Fieldwork and disability: an overview for an inclusive experience. Geol Mag 157: 1933–8.
Demery A-JC, Pipkin MA. 2021. Safe fieldwork strategies for at-risk individuals, their supervisors and institutions. Nat Ecol Evol 5: 5–9.
Dolmage J. 2017. Academic ableism: disability and higher education. In: Mitchell D, Snyder S, editors. Corporealities: discourses of disability. Ann Arbor (MI): University of Michigan Press.
Edemekong P, Bomgaars D, Sukumaran S, Schoo C. 2022. Activities of daily living. In: StatPearls [Internet]. https://www.ncbi.nlm.nih.gov/books/NBK470404/. [last accessed Apr 18 2023].
Gostin LO. 2015. The Americans with Disabilities Act at 25: the highest expression of American values. JAMA 313:2231–5.
Hall T, Healey M, Harrison M. 2004. Fieldwork and disabled students: discourses of exclusion and inclusion. J Geogr High Educ 28(2):255–80.
Hilliard L, Dunston P, McGlothlin J, Duerstock BS. 2013. Designing beyond the ADA—creating an accessible research laboratory for students and scientists with physical disabilities. Paper Presented at: RESNA Conference.
Introduction to the Americans with Disabilities Act. 2023. Washington, D.C: U.S. Department of Justice Civil Rights Division: Disability Rights Section.
Jeannis H, Joseph J, Goldberg M, Seelman K, Schmeler M, Cooper RA. 2018. Full-participation of students with physical disabilities in science and engineering laboratories. Disabil Rehabil Assist Technol 13: 186–93.
Jimenez R. 2000. The Americans with Disabilities Act and its impact on international and Latin-American law symposium: the Americans with disabilities act: a ten-year retrospective. Ala Law Rev 52: 419–24.
Katz S. 1983. Assessing self-maintenance: activities of daily living, mobility, and instrumental activities of daily living. J Am Geriatr Soc 31: 721–7.
Kuebbing S, Clark D, Gharaibeh B, Janecka M, Kohl K, Kramp R, Ohmer M, Olmsted C, Peralta Martinez K, Rudzki EN et al. 2021. Field safety manual. Pittsburgh (PA): Biological Sciences Department, Dietrich School of Arts and Sciences, University of Pittsburgh. https://www.ple.pitt.edu/sites/default/files/Documents/pitt_biological_sciences_field_safety_manual.pdf
Lawrence A, Dowey N. 2022. Six simple steps towards making gees fieldwork more accessible and inclusive. Area 54: 52–9.
McClain L, Medrano D, Marcum M, Schukar J. 2000. A qualitative assessment of wheelchair users' experience with ada compliance, physical barriers, and secondary health conditions. Top Spinal Cord Inj Rehabil 6: 99–118.
McNulty SA, White D, Hufty M, Foster P. 2017. The organization of biological field stations at fifty. Bull Ecol Soc Am 98: 359–73.
Mol L, Atchison C. 2019. Image is everything: educator awareness of perceived barriers for students with physical disabilities in geoscience degree programs. J Geogr High Educ 43: 544–67.
Morales N, Bisbee O'Connell K, McNulty S, Berkowitz A, Bowser G, Giamellaro M, Miriti MN. 2020. Promoting inclusion in ecological field experiences: examining and overcoming barriers to a professional rite of passage. The Bull Ecol Soc Am 101: e01742.
National Science Foundation. 2023. Established Program to Stimulate Competitive Research (EPSCoR) Alexandria (VA): National Science Foundation. [last accessed 2023].
NCCDPHP. 2022. About chronic diseases. National Center for Chronic Disease Prevention and Health Promotion ''https://www.cdc.gov/chronicdisease/about/index.htm''. [last accessed Apr 18 2023].
NCSES. 2017. Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017 Alexandria (VA): National Center for Science and Engineering Statistics, National Science Foundation.
NCSES. 2021. Women, Minorities, and Persons with Disabilities in Science and Engineering: 2021 Alexandria (VA): National Center for Science and Engineering Statistics, National Science Foundation.
Obayashi PAC. 2012. Food safety for the solid organ transplant patient. Nutr Clin Pract 27: 758–66.
OBFS listserver. Charlottesville, VA: Organization of Biological Field Stations; [last accessed Feb 26 2023]. https://www.obfs.org/obfs-listserver.
OBFS. 2023. Station directory. Charlottesville (VA): Organization of Biological Field Stations. " https://www.obfs.org/directories#!/''. [last accessed Feb 11 2023].
Powell K. 2021a. Academia's ableist culture laid bare. Career Feature 598: 221–3.
Powell K. 2021b. Academia's ableist mindset needs to change. Career Feature 598: 693–5.
Ramírez-Castañeda V, Westeen EP, Frederick J, Amini S, Wait DR, Achmadi AS, Andayani N, Arida E, Arifin U, Bernal MA et al. 2022. A set of principles and practical suggestions for equitable fieldwork in biology. Proc Natl Acad Sci USA 119: e2122667119.
Regions and divisions. 2022. U.S. Census Bureau; [last accessed 2023]. https://www.census.gov/history/www/programs/geography/regions_and_divisions.html.
Reutlinger C. 2015. The ableist othering of Disability in the Classroom: An Experiential Investigation of Academic Adjustments in Higher Education. Manhattan (KS): Kansas State University.
Sanchez J, Byfield G, Brown TT, LaFavor K, Murphy D, Laud P. 2000. Perceived accessibility versus actual physical accessibility of healthcare facilities. Rehabil Nurs 25: 6–9.
SCUP. 2021. 2021 Campus Facilities Inventory (CFI) Report. Ann Arbor (MI): Society for College and University Planning.
Stokes A, Feig AD, Atchison CL, Gilley B. 2019. Making geoscience fieldwork inclusive and accessible for students with disabilities. Geosphere 15: 1809–25.
Sukhai MA, Mohler CE, Doyle T, Carson E, Nieder C, Levy-Pinto D, Duffett E, Smith F. 2017. Creating an accessible science laboratory environment for students with disabilities.. Ontario's Universities Accessible Campus,Toronto, ON, Council of Ontario Universities.

Taherdoost H. 2016. Sampling methods in research methodology; how to choose a sampling technique for research. Int J Acad Res Manag (IJARM) 5: 18–27.

Tucker F, Horton J. 2019. "The show must go on!" fieldwork, mental health and wellbeing in geography, earth and environmental sciences. Area 51: 84–93.

Tydecks L, Bremerich V, Jentschke I, Likens GE, Tockner K. 2016. Biological field stations: a global infrastructure for research, education, and public engagement. Bioscience 66: 164–71.

Wang V, Boguniewicz J, Boguniewicz M, Ong PY. 2021. The infectious complications of atopic dermatitis. Ann Allergy Asthma Immunol 126: 3–12.