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Introduction

This manual provides simple guidance to help you perform safe and successful fieldwork as part of your research. The "field" can be urban, rural, or wild. You may work alone or in a team. The experiment may be structured or survey-based in design. You may operate adjacent to your research center or in remote locations. Regardless, there are principles and considerations that can be universally applied that will allow you to implement a robust and meaningful research project and collect quality data. While this manual can help anyone involved in outdoor research, it is particularly aimed toward graduate and undergraduate students, and early-career researchers who are honing their skills and gaining experience. Everyone makes mistakes in their early development, and fieldwork often involves a steep learning curve, potentially hazardous or challenging conditions, and considerable time and financial commitments. Naturally, your unique field of study will determine some of the technical skills that you will build and depend on, but elements of planning, site description, logistics, and teamwork are universal. Experience is the best teacher, but hopefully this manual will help you to make a good start.

What is "Fieldwork?"

Fieldwork is any research or data gathering conducted outdoors, outside of the laboratory, library, or office settings. As researchers, our individual fields can be almost anywhere (Figs. 1.1 and 1.2). For a sociologist, it might be a school, a shopping mall, or wherever there are people. For a marine biologist, it may be on or even deep within the ocean. This particular guide is generally intended for students and researchers in the broad disciplines of soil, crop, and environmental sciences. However, many of the principles discussed throughout this book will be helpful for any researcher venturing outside of the laboratory setting.

For simplicity, I will refer to all outdoor research as "fieldwork" and all indoor research (be it laboratory, desk, or workshop) as "labwork."

The challenge faced by researchers in the field is to apply scientific methodologies into environments which are by their very nature, heterogeneous and subject to limited human control. As field researchers, we cannot control the weather, the movements of wildlife, heterogeneity of soils, rock, or vegetation, and innumerable other factors which may influence the results of our

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Fig. 1.1 Researchers investigating a soil pit in Ireland. *Source:* Sara Vero.

Fig. 1.2 Field research can take you to some breathtaking scenery. *Source:* Bo Collins.

investigations. This may seem contrary to the scientific method, which typically controls variables and factors so that one or a few factors of particular interest may be examined independently. In reality, outside of the laboratory, these conditions rarely, if ever, exist (Fig. 1.3). Fieldwork is therefore critical to examine how the theories, devices, and processes developed under controlled conditions perform in reality.

Research can be considered to take place within a "hierarchy of complexity" (Read, 2003). Studies that are reductionist in approach, dealing with only one of the many variables which simultaneously influence biological, physical, and chemical functioning in reality, can provide insight into the underlying mechanisms of behavior. However, these effects might be difficult to discern or become less influential at the field scale. These studies offer a high level of "precision," but perhaps, a lower level of "relevance." Conversely, field studies allow a broader understanding of patterns and effects within a "real-world" context. In other words, they have a lower level of "precision," but a high level of "relevance" (Read, 2003). Of course, there is no strict rule regarding this; rather, it is a spectrum along which various experimental approaches are positioned. For this reason, coupled field and lab studies can be used to develop a more integrated understanding. This is common, especially when developing a thesis at graduate level. Let us take an example.

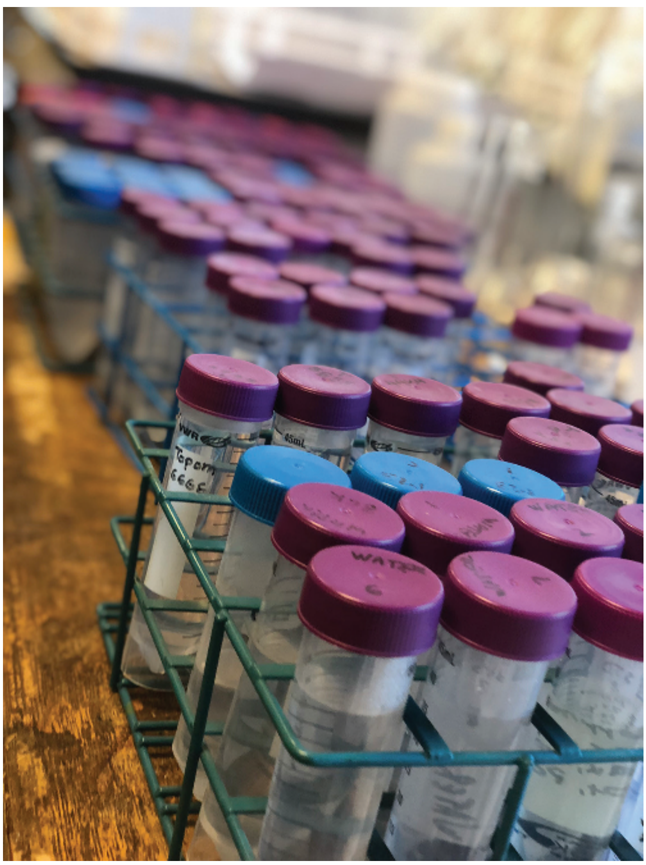

Fig. 1.3 The field is rarely as tidy and organised as the laboratory. *Source:* Bo Collins.

A student investigating potassium (K) requirements of mixed species grassland might conduct three structured experiments.

1) A soil incubation study in the laboratory to indicate the release and adsorption potential. This would indicate fundamental chemical behavior of the soil, without any confounding factors.
2) A pot study in a glasshouse or growth chamber to examine the response to various K levels in different species mixtures (Fig. 1.4). This would give an indicator of the potential implications of K availability.
3) A plot study at field scale over three years (Fig. 1.5). This would reveal the impacts of the behaviors observed in detail in the first two experiments, but at an applied spatial and temporal scale. Results from this approach can be used to develop recommendations for farm management.

While the conclusions from experiment one could be extrapolated to the field scale, without the bridging provided by experiment two, and the real-world implications observed in the field during experiment three, any recommendations derived thus would be vulnerable to overemphasis or misinterpretation. Conversely, while field experiments might reveal the implications or applications of (for example) farm management practices, they may struggle to differentiate the underlying causative factors. A joint approach incorporating both laboratory and field elements can often yield a more comprehensive understanding, and justified conclusions than either can in isolation.

Fig. 1.4 A pot study in a glasshouse can be highly controlled. *Source:* Bo Collins.

Fig. 1.5 A plot study like this grass trial can be used to examine effects of fertilizer, drought, crop species etc. under 'real world' conditions, and can be integrated with laboratory approaches such as pot trials or incubations. *Source:* Sara Vero.

Who Does Fieldwork?

Researchers at almost any stage of their career may undertake in fieldwork, although frequently, the amount of time an individual spends in the field will probably decrease as they move toward a more senior or supervisory position (Fig. 1.6). Fieldwork is an excellent teaching tool for bringing

Fig. 1.6 Fieldwork is an opportunity to learn practical skills and apply lessons learned in the lecture theatre or classroom and to be mentored and trained. *Source:* Jaclyn Fiola.

relevance and "real-world" meaning to processes taught in classroom or laboratory setting, both in the secondary and high school setting, and at the undergraduate and graduate levels. In these cases, fieldwork often consists of tours, expeditions, demonstrations, or very structured experiments under the supervision of an experienced tutor or guide. Maskall and Stokes (2008) reported that although there is little empirical evidence that fieldwork quantitatively improves learning, it is generally viewed with enthusiasm by both students and their teachers. Why is this the case? Perhaps it reflects genuine interest held by those individuals either teaching or seeking to learn about the outdoors, for whom classroom activities, while vital, are not complete on their own. Perhaps it is that the tactile and tangible experiences in a "real-world" setting enhance conceptual knowledge and demonstrate its application. Fieldwork teaches students practical and communication skills, contextual understanding, critical and "big-picture" thinking, and the capacity to manage sometimes challenging tasks. These qualities are immensely valuable, both to the individual and to prospective employers, but may not be truly reflected in standard assessment. Sadly, it seems that fieldwork for pre-university students is declining due to a number of factors, including funding and associated costs, implicit hazards and risks, and the move toward computational research in the environmental sciences. This is also true in postgraduate research and throughout industry and academia, as more powerful computational models are widely and cheaply available (Kirkby, 2004). It should be remembered however, that field research is still an indispensable component of modeling. Direct measurements provide the data by which models are built, calibrated, and tested, thus ensuring accuracy and realism. Field and model approaches should not be considered as completely separate approaches to agricultural and environmental research. Rather, they are tools which can be used in conjunction with one another, to build conceptual understandings and examine hypotheses. I hope that educators reading this guide will consider the great advantages and opportunities offered by fieldwork and will resist the trend to remove it from their curriculums.

Thankfully, many undergraduate students still take courses that are either wholly or in part field based and may conduct individual or group fieldwork projects. At this stage of an individual's education, they are likely to be specializing and honing in on their area of interest. Fieldwork at this stage not only teaches the student but better enables them to learn in the future, by exposing them to challenges, forcing them to apply their existing knowledge, adapt to new situations, and work with other people. At the undergraduate level, field research advances students' knowledge, provides realistic, hands-on learning opportunities, develops critical thinking and problem solving, and communication skills and teamwork (Fig. 1.7). In short, fieldwork helps you *learn to learn*. This is the best lesson of all.

As a masters or doctoral student in any environmental field, you are more than likely to have at least a component of field research. Of course, the type, duration, and goal of fieldwork varies depending on the specific project. As a post-graduate student, *you are a researcher*. While you are under the supervision of an advisor, it is your responsibility to design, conduct, and analyze your own experiment. This will likely change your approach to fieldwork. It is no longer prestructured and prepared by a lecturer or assistant as it is for undergraduate students. You are out there to answer a question. Anticipate that fieldwork may be challenging, both physically and mentally, but if we already knew the answer, there would be no need for your research! Although there are many unknowns, a sound approach to your field research can help you to find that answer (Fig. 1.8).

When we look beyond education, researchers of all ages, career stages, and areas of interest may take to the outdoors to examine hypotheses, develop/test new technologies, monitor responses to change and ground-truth models. Burt and McDonnell (2015) proposed that lateral, novel thinking and constructive debate is constrained by a dearth of fieldwork and the assumption-challenging

Fig. 1.7 In addition to technical skills, fieldwork teaches communication, teamwork, problem solving and planning. These are valuable abilities both for researchers and student who pursue other careers. *Source:* Krista Keels.

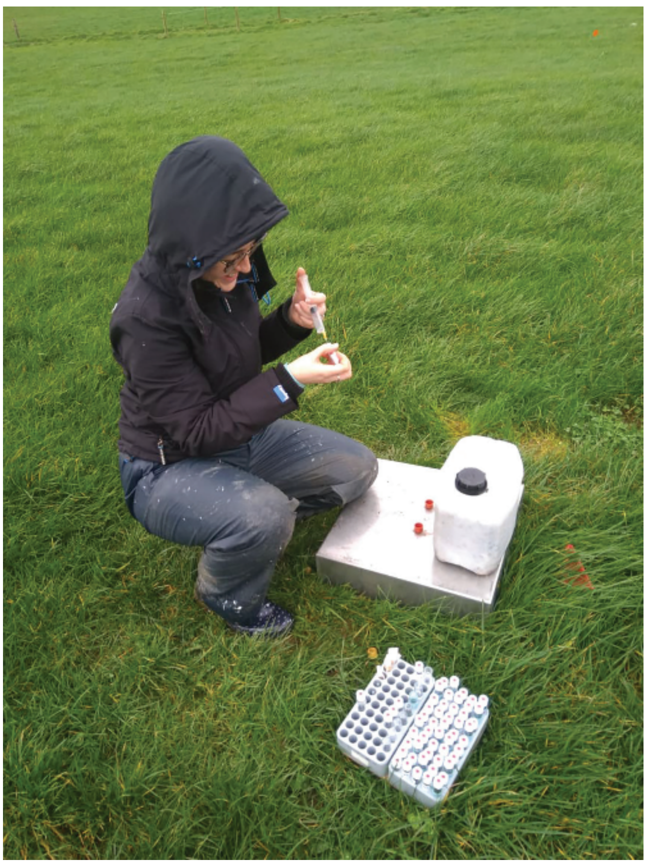

Fig. 1.8 A well designed field experiment allows effective data collection and in turn, helps you to examine your hypothesis. Knowing why you are doing this is the first crucial step. *Source:* Rachael Murphy.

experiences that only the field can bring. It seems very likely that this limitation occurs beyond the field of hydrology that they described, and perhaps infects many fields of environmental investigation. Consider this scenario, without the monitoring and examination of diverse or dynamic environments, our understanding of their behaviors is grounded in assumptions made a priori, from potentially very different situations. We may be in error then not because our calculations are intrinsically incorrect or inaccurate, but rather, because they simply do not "fit" the areas we are concerned with.

Why Am I Doing this?

People often question why they are doing fieldwork (sometimes loudly and with profanity) too late. This is often midway through their experiment, with the weather closing in, as they are struggling to collect samples! It is actually the most important question you can ask yourself and is the driver for all of the decisions you will make during the planning process. Asking "**Why?**" will help you identify the appropriate design of your experiment. It is important to remember that the experiment should be designed to test your specific hypothesis (possibly excepting case studies – discussed later). You should not choose to perform any fieldwork without examining whether it can provide *appropriate*, *sufficient*, and *timely* data relating to your hypothesis.

Let us briefly unpack these three qualities. Is the data you intend to collect *appropriate* to your hypothesis? For example, if you are examining nitrogen use efficiency in soybeans, you will probably need to account for nutrient inputs, crop uptake, leaching, and gaseous losses. You will also need meteorological and soil data for context. All of this data is relevant to your hypothesis. Other data may not be appropriate. For example, the traits of your soybean species relating to disease resistance might be relevant to soybean research in general, but if it is not a factor in nitrogen use efficiency, then examination of these traits (which are important themselves) are not appropriate to your study.

Sufficient data means that you have enough measurements to satisfactorily answer your research question. That means enough sites, variables, blocks and/or plots, and replicates. In crop studies, it may mean having multiple growing seasons. There is no real rule of thumb for this. Let the literature guide you and if possible, consult a statistician *before* beginning your experiment. It is not pleasant to realize that more replications are needed once a study has started, and even worse to discover once the field trial is "finished"!

Finally, you need *timely* data. That means that both the collection and analysis of the data is physically achievable for you and your coinvestigators, and ultimately, possible within your project timeframe. This is closely related to having sufficient data, and a balance must be achieved between gathering enough samples and completing your research in good time. If you have embarked on a two-year MS program, there is little point in designing a field experiment involving three years of monitoring! This might seem obvious, but it is very common for fieldwork to overrun projected timescales.

Particularly in the early weeks of a project, it is common for individuals to rush into fieldwork due to enthusiasm and eagerness to collect data – any data! However, if the data is not relevant, the methods or site are inappropriate or the experimental design is weak, the fieldwork often results in much wasted time and resources and flaws that are revealed during the peer-review process. There may be lessons learned in this process, but that time would be better spent in scrutinizing "why do this?" and in planning, so that your work can succeed from the beginning. As an example, I once was asked to give advice to a PhD student in relation to a sampling campaign he had embarked on. When I asked why he had chosen to collect samples from a certain location near his campus, he responded "Well it was convenient, and I needed to get started." However, in his rush for data, he had chosen a site that was completely unsuitable to the method of analysis he was developing, and so had wasted months of valuable time.

Some whys:

- To obtain data that will allow you to examine a hypothesis or question
- To provide contextual information
- To examine "real-world" case studies
- To gain skills and experience
- To test the performance of devices, processes, or tools

For graduate students there are two main concurrent goals. First, to explore and hopefully fill a knowledge gap in their particular discipline, by conducting a series of related experiments culminating in a thesis. The other goal is to develop skills that they can apply to other research projects or to industry. This goal is by no means less important than the scientific objective. Fieldwork is a fantastic opportunity to develop practical skills, problem solving, logistical skills, and teamwork. It is often relatively simple to get a sensor working in the lab when you have tools at hand, good lighting, and someone to ask for help. Can you do it on a rainy day, far from your office when you can't find your screwdriver? From an employer's perspective, the exact detail of your (no doubt important and complex) past research may or may not be interesting or applicable to the role you are interviewing for, but your ability to learn and apply practical skills will help you to be useful and effective in any situation.

Before embarking on a campaign of fieldwork, ask yourself these questions:

1) What am I trying to examine?
   This is the first and most important question to ask yourself. It must be related to your hypothesis or question. Your fieldwork must do one (or both) of the following:
   A) Provide information that either proves or disproves your hypothesis. For example, your hypothesis might be "Soil compaction reduces the yield of perennial ryegrass over three years." Your fieldwork must then measure differences in the yield of perennial ryegrass under both compacted and non-compacted conditions. Critically, it must be measured over three years. A two-year study won't answer your hypothesis!
   B) Provide contextual information that helps explain your results or their implications. For example, let's say you conduct an incubation study in the laboratory to measure denitrification in soil at various temperatures. In that scenario, you can impose whatever temperatures you like. What temperatures are actually encountered in a real soil, outdoors and exposed to the weather? So, you might conduct fieldwork in which you install sensors to measure temperature over time. This provides context for your laboratory study and helps you to examine its relevance in the discussion section of your paper or thesis.
2) What treatments do I need to examine my hypothesis?
   A **treatment** is the condition, practice, or manipulation that you apply to your field site. This will depend entirely on your hypothesis, and in many field studies, multiple treatments may be applied either in isolation or in combination with one another. In surveys or case studies, there may not be any treatments at all, since you are measuring the state of a person, place, animal, or thing, or are documenting a particular event or situation. When a treatment is applied, there should always be a control that is not modified, against which you can compare your results.

3) What do I need to measure?
   Again, this comes down to your hypothesis. You need to measure the variables that you expect might be altered by your treatment. If you are examining the effects of light pollution in urban areas on the behavior of a certain bird species, then you might want to measure how frequently the birds eat, sleep, mate, or sing. However, you must also quantify the treatment. In this case, how many hours of light are the birds subject to, relative to a non-polluted situation?

   Collecting supplementary information during your fieldwork is also useful because it either helps explain what you observed or it may help your reader to evaluate how applicable or transferable your results are to their own situation (Fig. 1.9). Some examples are location (latitude, longitude, elevation, country) or weather variables (precipitation, temperature, humidity). There are, of course, many other details that are relevant in different fields of study, so think carefully before launching your field campaign. It is usually far easier to collect data at the time rather than returning for further data collection when a reviewer has asked for it! Look at the literature on related studies as a guide. For example, if everyone conducting a river survey typically describes whether their study area is a first, second, or third order stream, this is a good indicator to you that this is highly relevant information. As you become more familiar with your field of study identifying what contextual measurements you should take will become more obvious.
4) How should I take measurements?
   There are often several methods or tools available for measuring a certain parameter. For example, soil hydraulic conductivity can be measured using a double-ring infiltrometer, a transducer infiltrometer, an Amoozemeter, a falling head test, a constant head test, and others. The differences between these devices might seem subtle or minor until you become familiar with them, but might be vital when it comes to interpreting your results. There is often an element of availability that needs to be considered here. What tools and facilities can you access? Can your

Fig. 1.9 Weather information is one category of supplementary data that can be helpful in interpreting or contextualising the results of your field experiment, although it can be useful in it's own right also. *Source:* Sara Vero.

university or research institute provide training, or can you buy or rent equipment? Can you outsource analysis for specific tests? How time-consuming and how expensive are the various options?

Most importantly, be thorough in your literature review. Consider what methods are used in related research and why. Don't be afraid to contact the authors of the papers which you are referencing. They will often be able to explain exactly why they used particular methodologies and to offer advice.

5) What characteristics should my site have?
This is a multifaceted question so let us break it down into manageable parts:
   A) **Does the site have the characteristics which will allow you to test your hypothesis?** In other words, if your hypothesis is that slope aspect influences the rate of snowmelt in alpine mountain ranges then your field sites must (i) be alpine mountains, (ii) have snow-cover for a given period, and (iii) exhibit a range of different slope aspects that you can compare. This might seem obvious, but it is remarkably easy to choose sites based on ease of access, familiarity, or other generally positive traits that are actually poorly suited to the hypothesis in question. When choosing sites that are intended to be representative of a particular environment or situation you must think carefully about what the defining characteristics are and list them. Then, you can review potential sites objectively.
   B) **Does the site have any characteristics that might unduly influence or confound the examination of your hypothesis?** So, in your alpine snowmelt study, is one of your potential sites heavily forested while the others are relatively bare? If so, then this site is probably not suitable for inclusion in your study as there are other factors that might overly influence your results.
   C) **Can you access the site?** Even if you identify a site that is ideal on paper (it has all the characteristics of the scenario you want to study and it is suitable for application of your treatments), there are also logistical concerns. How far away is it? How long will it take you to get there and back? Is there electricity, water, or other facilities you might need? Is the landowner willing to grant you access? How close can a road get you to the site and are you capable of transporting your equipment across fields, rivers or hills? Is it safe? Are there any potentially dangerous animals? Be realistic in evaluating these issues.
6) How long will fieldwork take?
Fieldwork can be more time-consuming than expected on paper and as you are subject to the environment and the unexpected (loss of tools, breakdowns, bad traffic, poor conditions, etc.), it is vital that you schedule extra time for these possibilities. Your planning might look something like this:

Travel time + Setup + Treatments + Measurements + Rest + 'The Unexpected'

Travel time can be estimated with reasonable accuracy from route planning tools such as Google maps; however, you should allow extra time for traffic. If you are bringing heavy equipment such as a trailer, you may also be slower than otherwise expected. You can't really attach a precise number of hours to the unexpected events that can occur during fieldwork. Rather, schedule some spare time to allow for unplanned circumstances. You can help minimize these by preparing thoroughly, using checklists, and practicing with your equipment in advance. Setup and application of treatments and measurements can be estimated in advance if you conduct a trial run. The more familiar and practiced you are with the tools and techniques you will use, the more efficient you will be. Never try a technique or tool out for the first time in the field. Rest is also critical. Don't expect that you will be able to squeeze in an extra few measurements at the expense of a lunch or coffee break. This may be unavoidable sometimes, but if you are engaged in a prolonged fieldwork campaign, it will wear you down and ultimately make you less effective. If you are driving to your field site, this becomes even more important. Tiredness is sadly a common cause of road accidents. If you feel yourself becoming sleepy while at the wheel (considering sometimes, long distances to field sites and the strenuous nature of the work this is not unusual), pull over where it is safe to do so, take a nap, eat, drink a coffee or energy drink, or if necessary and possible to do so, rest overnight. If you are traveling with someone, you may want to share the driving. Fieldwork is no excuse for being irresponsible in this regard. Unsafe driving puts both yourself and others at risk. This is discussed in detail later on.

You should also consider the importance of seasons or years. Many environmental and agricultural research projects need multiple seasons or years to allow full examination of a treatment. While this might be fine for permanent researchers, if you are a PhD student you typically have a very finite length of time in which you must gather, analyze, and write-up your data. If your PhD program is three years long and allowing time for design and setup prior to the experiment, and time for thesis preparation subsequently, achieving two years of field data may be challenging. However, multiple seasons or years usually add greater reliability to your findings. The fewer seasons of data you report, the greater the likelihood that your data and interpretations will be influenced by factors such as weather specific to that year. It is up to you and your advisors to figure out the optimal approach here. This is something that you should consider prior to starting your field campaign. Remember, you can usually spend as much or as little time in the laboratory as you find necessary. When it comes to field seasons however, we are all at the mercy of time!

7) What statistical structure will I use?
It is good practice to consider your statistical approach or even to seek the advice of a statistician when initially planning your fieldwork. If you are conducting a plot or other replicated study, this will help you to select the optimum number of replicates. If you are conducting a case study, statistical approaches may not be easily implementable as the variables in this type of research are not always strictly controlled. In such cases, a thorough and well-developed discussion of your results is particularly important.

8) How much will this experiment cost?
It is all too easy to design large-scale, comprehensive, and high-tech field studies. In reality, costs must be accounted for as this will constrain your plans. Some general costs you need to consider include:

Staff	Consumables	Licenses/visas/permits
Vehicles/fuel	Accommodation	Hardware/Software
Equipment	Contractors	Analyses

Field studies can incur large costs, and it is important to be realistic in estimating these at the outset. If your intended study includes a field component over many years you should firmly establish funding in advance. Many research institutes will have a financial department that can help you to calculate your budget, but it is up to you to determine the costs of equipment, consumables, and analyses that you will require. Keep in mind that you may not have the skills, equipment, or authority to perform certain tasks and may need to hire contractors. Your research institute may have established relationships with these contractors or else you may need to shop around and obtain quotes for the intended work. Just as additional time is sometimes required, there can also be unexpected costs, such as replacements for equipment, additional samples to be processed, etc. Leave yourself some extra budget, if possible, to cover these eventualities.

9) Do I have the equipment?
Equipment includes tools, safety gear, appropriate clothing, machinery, and sampling or measurement devices that you will need during your field study. Don't assume your research center will have exactly what you need, and be very wary if someone tells you "Oh, we have one of those in the shed…" Stored equipment should always be carefully examined and tested to see that it is functioning correctly and can actually supply the results you need. Sometimes older equipment can be repaired or refurbished if it has only minor damage. Often simply replacing dry and cracked tubing, O-rings, and other rubberized components is all that is required as these parts tend to degrade in storage. Check whether such equipment has been surpassed by more modern devices. These may offer superior measurements, greater ease of use, or will be more understandable to the modern readers of your studies.

If you are purchasing new equipment or if you have several different devices at your disposal that measure the same variable, it is a good idea to speak to an expert who thoroughly understands the various approaches and can advise you as to which would best serve your purpose. It's vital to do your background research also. Typically, newer methods or devices will be tested against the older, more established approaches. Look for peer-reviewed research on your intended methods and consider emailing the corresponding author if you have further questions.

If equipment does become damaged, think carefully before attempting to repair it. Some items can be repaired relatively easily, but don't assume that you have the skills to do so unless you have been appropriately trained. This is particularly true for equipment which has mechanical or electronic components. Equipment is often purchased with warranties and service agreements. Check that you will not invalidate these by tampering with the device! For "simple" repairs or maintenance, such as replacing hoses or cleaning sensors, consult the manuals and use the correct tools. Much hardship and frustration can be saved by reading the instructions before you take things apart!

If your research institute has equipment that is available to many different people, be sure to check with whoever is responsible for its storage or maintenance before you take it. There may be a schedule or roster for its use and taking equipment without following the proper routine can infringe on other people's work. Remember, your project is no more or less important than theirs! Always return used equipment in a timely manner and in good condition.

Clean tools after you have used them and put them in their proper place (Fig. 1.10). Be respectful.

Fig. 1.10 Always clean and store equipment properly after using it. Don't leave it in poor condition for the next person. *Source:* Sara Vero.

10) Do I have the skills?

It will probably be obvious that you will need the scientific skills related to applying your treatment, and correctly collecting, processing, storing, and analyzing your samples. These skills will often be learned at your university, through on-the-job training, by reviewing standard operating procedures (SOPs), or by seeking specific training via workshops, courses, or online. Think about what other skills you might need that are not “scientific” in nature but will be required. For example, can you read a map, mark out plots accurately, drive off-road, pull a trailer, use essential machinery, etc. The list is endless! Some tasks may not only require that you *can* do them, but also that you have training, licenses, and/or approval from your institute or under the law. Driving skills come under this category.

Where you are lacking certain skills, you have three options.

1) **Learn** – The major advantage here is that you can accrue new abilities that will help you in your future research or work and this should always be a priority throughout your career, particularly in the early stages. However, in some instances it may be too time-consuming or inefficient from a cost perspective and it would be better to seek assistance (Fig. 1.11).
2) **Teamwork** – Much of the best research is done in teams and collaboration is one of the most important abilities a researcher must establish (Fig. 1.12). Fieldwork is an excellent way to learn this and allows more ambitious and comprehensive studies than are usually possible by one or two individuals in isolation. We will discuss later how to organize your team.
3) **Contractors** – Some tasks are better outsourced to people or agencies who specialize in this area. This could be because it is a once-off task and it may not be worth your time developing, or it could be that the task is so specialized that it requires an expert. Machinery

Fig. 1.11 Collaboration in the field is a great opportunity to learn new skills from experienced researchers. *Source:* Brandon Forsythe.

Fig. 1.12 Sometimes additional help may be necessary. This team is working together to handle large, awkward equipment. *Source:* Katie O'Reilly.

use also is often best outsourced. Hiring a crane operator, for example, will likely be preferable than learning to use one and then renting the crane itself! Liaising with contractors is essential to ensure that everyone knows their task, is in agreement regarding the price and will be at the right place at the right time.

11) What training do I need?

Methods and equipment – You should be confident that you understand all of the methods and equipment you intend to use both in theory and in practice. While reading the manual is an important starting point, it is not always enough! Remember the six Ps–Proper Planning and Practice Prevent Poor Performance.

Health and safety – Check your institutional policies before commencing either field or labwork. There are often mandatory requirements regarding manual handling training, basic first aid, biosecurity, or other health and safety protocols. You may also consider specific training that might be relevant to your intended research (Fig. 1.13). For example, if you are researching infection rates of toxoplasmosis in urban feral cats you might need training in animal handling, zoonosis, and ethics relating to research with animal subjects. Research institutes typically are very supportive of training, especially on health and safety issues.

Training takes time. This should be accounted for in addition to the fieldwork itself as it should be completed before you venture into the outdoors. Although fieldwork is certainly an opportunity to learn and develop new skills, the first time you try a new technique, tool, or idea should never be during the "live event," when you need everything to run smoothly.

Don't underestimate the value of informal practice. Set aside some time to trial run your equipment and techniques. This will ultimately save time in the field, prevent damage to equipment, allow effective measurements, and prevent a great deal of frustration.

Fig. 1.13 You may need training in safety protocols. For example, the researchers investigating prairie burning in this photo from Konza Prairie, Kansas, have training in fire safety and emergency response. *Source:* Jesse Nippert.

12) What assistance do I need?

Broadly speaking, there are two factors to consider when determining how many people you need on your team and who they should be.

Skills – Often you will require specific skills on your team that include experience, specialist training and equipment, expert knowledge or all of these factors. In these situations, it may be best to recruit someone to your team who has these skills. For example, if you are primarily a hydrochemist studying pesticide transport to groundwater and you need an accurate characterization of the soil profile, you probably should seek the assistance of a pedologist with both training and experience. This is a great opportunity to learn from these individuals.

Labor – Many hands make light work and furthermore, some jobs are simply not safe and/or possible for a single individual. An example from my own research is a series of river surveys during low flow. In that study, I needed approximately 50 water and sediment samples from across entire river and tributary networks, and they needed to be taken in the space of roughly 4 h. Alone, that would have been completely impossible. However, the sampling methodology was relatively simple and needed only brief training. From my research center, five people lent their assistance each day. We met each morning, I assigned everyone a specific stretch of river and the team regrouped once their samples had been collected. The density and tight timing of sampling could never have been achieved with fewer people, no matter how skilled or motivated.

Students and researchers are generally helpful and enthusiastic. Most researchers can probably relate plenty of stories of teamwork generously and freely volunteered between friends. I can list a dozen friends and colleagues who readily contributed their time and effort during my PhD alone. Collaboration is built on reciprocation. Depending on an individual's contribution they may merit inclusion as a co-author, a collaborator, in acknowledgments, or by some other recognition of their input. This can only be determined on a case-by-case basis and should be reviewed in light of your institutional policies. When possible and appropriate, try to contribute your skills and assistance to others in return.

Outside of collaborators, you may need to hire assistance. This is especially true where skills or equipment are outside of your expertise. For example, if you need electricity to feed a river bankside analyzer this should not be considered to be an opportunity to become an electrician! This needs skill, experience and tools both to do the job correctly and to safeguard your health and that of your team. Hire a registered electrician!

13) Do I need permission from landowners, local authorities, managers, etc.?
Some fieldwork may be conducted on study sites that are owned by research institutes or on which the institutes have agreed access to. In this case, you most likely need approval from senior managers or officials within your institute. It is best practice to also communicate with whatever staff are responsible for the day to day management (e.g., the farm manager on an agricultural research station). This will prevent either your interruption of their work, and vice versa. You should inform them of where exactly you will be, for how long, what you intend to do and if there is anything you need them to do or avoid doing. For example, if you are operating a gas flux tower on a research farm you may want the staff to refrain from allowing livestock into that area of the site unless additional fencing has been installed.

When operating outside of a research facility there are some other concerns that you should consider. If you want to conduct research on privately owned land you will need explicit permission from the land owner. It is best practice to obtain this in writing. The same rule applies if you need to cross someone's property to access a site, even if they themselves do not own that site. Remember, your work does not take precedence over a right to property or privacy and is *never* an excuse for trespassing. It is important to be clear about what you intend to do. Are you digging a soil pit? Taking water samples from their stream or well? It will help your work immensely if you maintain good relationships with any property owners that you interact with. This is particularly the case where you will be onsite on many occasions. The best way to do this is by being respectful of their time, property and privacy, and by communicating appropriately.

Privacy is an important consideration. It is very common to obscure the identification of on-farm sites in publication for confidentiality, as landowners may not wish for their home or business location to be disclosed. This is an entirely reasonable request and should always be respected. In Europe, this is the law (General Data Protection Regulation 2016/679). Equally, where farmers, community groups or other stakeholders have contributed to your research (by supplying sites, providing data, completing surveys, etc.) their contributions should be acknowledged in talks or presentations that might arise from your results. Farmers may request to see your results prior to publication, sometimes out of concern for potential repercussions but often to improve their own practices or better understand their land. Local farm discussion groups, fishing and hunting clubs, outdoor enthusiasts, and community associations frequently welcome researchers operating in their areas to give talks and explain their findings. This is helpful, both in disseminating your work and in building positive relationships with the community. It also enables them to enact changes in their practices to improve their environment, or to simply better understand it. Good relationships with your hosts are crucial, and good channels of communication are the foundation of building trust.

Communication is particularly vital if there is any element of hazard or risk involved. As an example, I was once installing a soil sensor array, which involved a >2 m deep pit. The land owner was fully aware and approved of the project. However, at nightfall on the first day we had not finished the installation and the pit was still open. I rang the land owner to inform him and he had no concerns. But your responsibility may go further than that. During the day I had noticed a house nearby the field with three young children playing in the garden. While you or I may quickly recognize the danger of an open pit, a 6-yr old probably would not, and may find it all too interesting! I set up warning signs around the area and then politely introduced myself to the family. I presented identification, explained what I was doing on the nearby farm and explained that the pit would be open overnight but that we would return to complete the installation and backfill it in the morning. As a result, I could rest easily that evening knowing that I had alerted the young family to the potential hazard and taken steps to mitigate the risk.

You may be conducting fieldwork in a public or common area. It is best to consult your local authorities (e.g., county council, park ranger, etc.) if this is the case. Your research institute may have ongoing agreements or relationships that can help you in this, but if you are proposing entirely new research at a site that has not previously been used by you or your colleagues it is best to provide a clear and comprehensive description of what you are planning to do and any related considerations. Again, written permission is important. Don't assume that it is permissible to do whatever you have planned in a public area. You may need to file permits, seek derogation, or to provide advance public notice, particularly if your planned fieldwork is invasive or disruptive to other people, or is perceived as being so.

Maybe you'll be fortunate enough to do research in an exciting or dramatic location; the Antarctic, rainforests, areas of conservation. Or perhaps in areas that are particularly dangerous, such as radioactive or contaminated zones. You may need permission or simply to inform the department or agency responsible for those areas. Similarly, if you are traveling abroad for research make sure you have the appropriate Visa. This will in many cases not be the same as a holiday or work visa that you may be familiar with. If you encounter any difficulties be prepared to contact your embassy.

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