SARA E. VERO

FIELDWORK READY

AN INTRODUCTORY GUIDE TO FIELD RESEARCH FOR AGRICULTURE, ENVIRONMENT, AND SOIL SCIENTISTS

American Society of Agronomy
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Fieldwork Ready:
An Introductory Guide to Field Research for Agriculture, Environment, and Soil Scientists

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With gratitude to all those friends who have dug through the earth, marched across grasslands or waded upstream with me. What a wonderful adventure.

To the reader; my grandfather Paddy Vero said that "An ounce of help is worth a ton of pity." I have been the happy beneficiary of many kind helpers. I hope this book will give you at least that ounce of help when you need it.

"Whatsoever your hand finds to do, do it with all your might"

Ecclesiastes 9.10

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Preface

Field-based research is a cornerstone of agronomic and environmental science, yielding information that helps us produce crops efficiently, manage resources, and steward the environment. For students and researchers, it allows insights into the real world, which cannot be achieved in the classroom or library alone. Fieldwork is, for many, an exciting and engaging part of their work and studies. However, it brings unique challenges pertaining to experimental design, planning, safety, and team management, in addition to the scientific techniques being employed. The field researcher needs to be well-rounded and adaptable; able to deal with the unexpected and to improvise in response to challenges arising outside of the clean, controlled environment of the laboratory.

Fieldwork Ready is intended to help you to become an effective researcher, whether you are involved in agronomy, soil science, hydrology, geography, or any other field-based study. This book includes advice on design, planning, and logistics, which are essential for all field researchers, and then discusses basic techniques related to environmental monitoring, and soil, water, plant, and wildlife research that any investigator should be familiar with. These are intended as a guide upon which you can and should build further skills. For those of you who are already experienced in the field, this book should help you think more deeply about how and why you do field research, and hopefully, to improve upon your skills and knowledge.

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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.

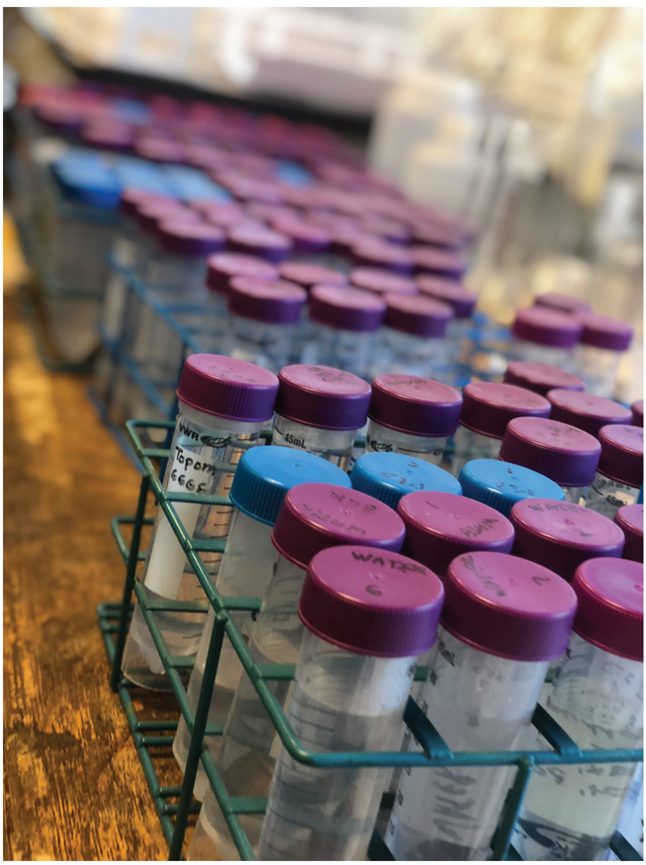

Fig. 1.3 The field is rarely as tidy and organised as the laboratory. *Source:* Bo Collins.

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.

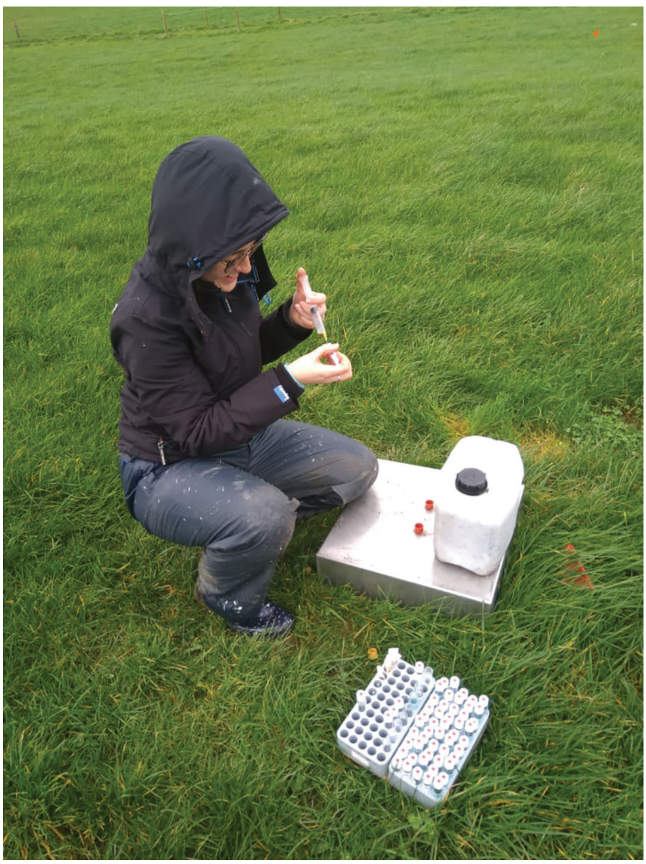

Fig. 1.8 A well designed field experiment allows effective data collection and in turn, helps you to examine your hypothesis. Knowing why you are doing this is the first crucial step. *Source:* Rachael Murphy.

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