

A Guide to On-Farm Demonstration Research

How to Plan, Prepare, and Conduct
Your Own On-Farm Trials



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On-farm research allows farmers to improve their knowledge and understanding of their own production systems.

Since 1988, the BC Forage Council (BCFC) has been working to promote the growth and development of a viable forage industry in BC. In 2013, a study by BCFC, "Forage Production and Export Potential in BC's Central Interior", confirmed opportunities to expand the export forage market, identified existing limitations to the forage sector, and provided several recommendations including supporting local, applied production research. In light of anticipated changes in growing conditions and emerging market opportunities, research is required to assess innovative farm practices for adapting to climate change impacts and weather related production risks, and to identify new and adaptive management practices.

In 2014, BCFC began a project to not only support local field trials and increase access to weather data but to create a reference guide that would allow interested producers to start and carry out their own investigations on their individual farm operations. On-farm research allows farmers to improve their knowledge and understanding of their own production systems, which in turn can improve the amount and type of information available for decision making and increase the agricultural community's capacity to adapt to changing markets, technologies, and knowledge.

It is BCFC's hope that this guide will improve individual producers' long term ability to conduct their own on-farm trials to test crops and production methods of interest, refine their forage production and products, and further enhance the production of high quality forage in BC.

We encourage all producers to share their research trials and outcomes on our website. Extra worksheets are also available for downloading from our site: Farmwest.com/bc-forage-council

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Climate Action Initiative
BC AGRICULTURE & FOOD



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Dr. Tarasoff recently moved back to British Columbia and runs her own consulting company, as well as holding an Adjunct Professor position at Thompson Rivers University. Her interests revolve around plant community ecology and principals of plant biology.

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<http://www.farmwest.com/bc-forage-council>

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Demonstration Research Manual in a Nutshell

Chapter 1



IN AN ARMCHAIR!

How demonstration research helps the farmer tease out natural variability from treatment effects..... **PAGES 7 – 10**

Chapter 2



AT THE KITCHEN TABLE!

Through planning and organizing will ensure you are ready to implement your custom demonstration research. **PAGES 11 – 36**

Chapter 3



IN THE FIELD!

All the details of demonstration research – layout, installation, collecting data, as well as what to do if things go wrong..... **PAGES 37 – 44**

Chapter 4



BACK AT THE KITCHEN TABLE

Pull out your calculator and analyze your data to see your treatment effects. **PAGES 45 – 50**

Chapter 5 and 6



IN A CHAIR, AT THE TABLE AND IN THE FIELD!

Double check, check list and things to think about while conducting your demonstration research..... **PAGE 51**

CHAPTER 1

Introduction To Research

1. What is Demonstration Research?
2. Principles of Research

1.1 What Is Demonstration Research?

FARMER DIRECTED AND GOAL SPECIFIC

Before we can discuss 'demonstration research' we must first outline the difference between traditional agricultural demonstration studies and research studies. Typically, demonstration studies are used by Agriculture businesses to demonstrate the benefits of using a new practice or product. The research behind the new practice or product has already been conducted and demonstration studies are installed to show the local producers what could be expected by adopting the new practice or product. Research studies are hypothesis driven experiments that follow somewhat standardized protocols that include *replication* and *randomization*.

What is demonstration research (DR)? Within this document, DR refers to using a combination of demonstration styled studies with research elements to answer a simple question with some confidence. The benefit of DR is that it is farmer directed, it can be carried out independently, and it uses the resources a typical farmer would have on-hand. Demonstration research allows a farmer to use a small portion of their land to test and identify ways to better manage their resources in order to increase productivity, or to achieve any farming goal they may have.

While the results of DR are not intended to be published or to undergo rigorous statistical review, it is important for those wishing to try DR to understand the foundations of research and how variability influences results. An understanding of the foundations of research will enable you to achieve the best results with your demonstration research.



1.2 Principles Of Research

SORTING TREATMENT EFFECTS FROM BACKGROUND NOISE

Research is about predicting future responses. For example, rather than observing that Variety A outperformed Variety B last year; research allows a farmer to state *with confidence* that it is highly likely that Variety A will outperform Variety B *every time* they are planted under the same conditions.

One of the challenges of demonstration research is to sort out the true effects caused directly by the research treatments versus the effects caused by “background noise”.

Within a field, or barn, or soil profile there exists a *population*, or an entire group of similar individuals. The population can be alfalfa plants in a field, cows in a barn, or microbes in the soil. Usually the population is so large that it is not possible to examine every individual; therefore, researchers randomly select a sample of the population and that subset is used to represent the entire population.

How well a population can be represented by a sample depends on the sample size. The larger the sample size, the better it will represent the population.

If you are researching a population of 1,000 individuals, would you trust one person, chosen at random, to provide an accurate, representative measurement of the entire population?

Chances are a single individual would not accurately represent the population. What if your sample contained ten people randomly

chosen from the population? That would be better than the one, but not as good as a sample of 100. As the sample size approaches the size of the population, the sample will more closely represent the population. The only way to get completely accurate results is to measure every individual in a population; however this would be time consuming and expensive. Instead, we sample populations and make the assumption that if we sample enough, we will have a fair representation of the whole population.

The second challenge for researchers is related to naturally occurring variability.

In order to reduce the effects of variability, each treatment you compare in an experiment should be done more than once, or repeated (statistically known as ‘replication’). There are different ways to replicate an experiment. One way would be to replicate the exact same experiment on many farms at the same time. Or, you could replicate across time, performing the experiment on the same farm year after year.



FOR EXAMPLE, if you conducted an experiment just once, you might wonder “did I get those results because it was a wet/dry/hot/cold year?”, or “were those results specific to this field? What would happen if I conducted this research at different locations?”.

Replication across the landscape, or over time, helps you to determine if results are due to your research treatments or due to naturally occurring variation. If one practice is superior to another, it will become evident if you make enough repeated comparisons. In fact, the benefit of one practice compared to another has to be *significant* enough to overcome the effects of natural variability in order to be worth considering. Figure 1 demonstrates one example of natural variability. Within a uniform field, under identical management, there was up to 9 bu/acre difference between strips adjacent to one another, and more than 15 bu/acre across the whole field. In this example, the variability may be due to differences in soil nutrients, soil moisture, or some other factor.

As a farmer, you are likely interested in understanding how your research will perform at your farm specifically. Therefore, the simplest way to replicate your research is to repeat it year after year. By conducting the research multiple times, you can avoid wondering if your results were because 'it was a wet/dry year'.



KEY CONCEPT The more times you repeat your experiment, the greater confidence you will have in your results.

Figure 1

Winter wheat yields in eight side-by-side strips in a "uniform" area of a field; demonstrating natural variability (From Veseth et al., 1999¹).

70 bu/acre
68 bu/acre
66 bu/acre
64 bu/acre
55 bu/acre
59 bu/acre
56 bu/acre
60 bu/acre

As Figure 1 demonstrates, there can be a lot of variability within your field due to factors such as differences in soils, topography, or historical management. It is not practical to try to avoid this variability because some level of variability will always be present; instead you can incorporate natural variability into your DR.

The most effective and practical way to reduce the impact of natural variability is to have a long strip for each treatment area. Generally, the larger, in particular longer, the treatment area is, the better the results are likely to be.

IF possible, 500 ft or longer is recommended for each treatment area.

Within this document, we will outline simple research designs intended to test one treatment against another, or A versus B. Farmers wanting to design complex demonstration research or incorporate replication within their field are advised to consult a government agent, university researcher, or a consulting scientist for guidance with experimental design and statistical analysis of data collected.

¹ On Farm Testing – A Scientific Approach To Grower Evaluation Of New Technologies. Veseth, Wuest, Karrow, Guy, and Wysocki.

CHAPTER 2

Planning Your Research

A STITCH IN TIME SAVES NINE

1. Exploring Your Farming Goals
2. Developing Your Objectives
3. Formulating Your Research Question
4. Deciding What To Measure

Case Study – Testing An Idea Before Betting The Farm On It

5. Scouting For Related Research
6. Assessing Your Resources
7. Visualizing Your Demonstration Research
8. Preparing To Collect Data

A farmer's experience and observations are critical in problem solving and in the development of new procedures and practices. Demonstration research complements experience and observations by incorporating some elements of research design while allowing you to work independently, without relying on a research scientist. When you conduct demonstration research you are in every sense of the word a 'researcher'. Your results may ultimately guide you through a series of changes in how you manage your farm.

While DR can yield important information, it is not without challenges. Conducting research that produces useful information requires discipline and patience. The success of your demonstration research study will depend initially on how well it's planned, and ultimately, on how well you follow your plan. Even a simple research project takes time to plan – don't underestimate this stage of the project.

Within this section of the manual, there are multiple worksheets and project development activities.



KEY CONCEPT The more time you spend in thoughtful preparation the better your results will be!



2.1 Exploring Your Farming Goals

WHY DO YOU FARM?

Before you can ask a research question it is important to sit down and consider what you want to accomplish, not just with the research, but in life, or at least on your farm! The thought process of mapping out your farming goals is not an easy one. It may take some time to conceptualize your goals. Once your goals are established, then you can develop objectives that will help you reach your goals. Often, researchers interchange 'goals' and 'objectives'. While both are very important for successful research, one must clarify goals versus objectives before getting started because goals without objectives can never be accomplished; while objectives without goals won't allow you to reach your long-term vision.



- a. **Goals:** All of us have lifelong goals that guide us through our daily lives. Generally, goals are vague and distant; they encompass a desire or thought.

Q You may have a goal to be a full-time farmer. This goal does not incorporate any concrete, or tangible tasks about how you are going to become full-time farmer – that's where Objectives come in!

- b. **Objectives:** In order to achieve one's goals it is important to put objectives in place.

KEY CONCEPT Objectives are S.M.A.R.T: Specific, Measurable, Achievable, Realistic and Time sensitive! In this way, the overarching goal can be divided into small, individual objectives that come together to support the larger goal. Objectives will be covered more thoroughly in the next section – Developing Objectives.

When developing your goals you'll need to consider all aspects of your financial/ personal life as well as those involved in the decision making process.

USE ACTIVITY #1 AND WORKSHEET #1

Before moving forward, spend some time developing your farming goals

Do you want to increase your herd size without buying/leasing more land? Do you want to generate enough revenue from your operation that you can farm full-time? Do you want to pass your farm on to your kids? Goals will change over time. Ideally, you will create new goals as you attain your current goal. As you move through the process of developing your demonstration research, ask yourself – “how will this information help me reach my goals?” You may find that your research needs to be adjusted in order to support your farming goals.

ACTIVITY #1

GOAL SETTING

Goal setting requires creative thinking; goals reflect your values and beliefs, the resources you have and the opportunities/limitations that you face.

Adapted from: <http://agebb.missouri.edu/mgt/settingfandfgoals.htm>

Step 1. To determine where to go in the future, assess your past.

Review some recent decisions, and ask yourself:

- Why did I do that?
- Did the decision move my business in the right direction?
- If so, did I plan it that way, or did it just work out in my favour?

This step will get you thinking about your decision-making process.

Step 2. List your goal(s)... it is important to write them down (Worksheet #1)!

This is the 'big picture'. Where would you like to see your farm in 1 year, 5 years, 10 years, and in the next generation? Your goals for your farm should fit in with your lifestyle and take into account your resources and limitations. If your goals are too hard, time consuming, or too expensive you may quit before you reach them.

Step 3. Prioritize your short-term (1-10 years) and long-term (10+ years) goals.

Priorities can provide clear guidelines for management decisions, similar to a business plan. To help prioritize goals, ask yourself these questions:

- Which goals are most important for family success? For farm success?
- Which short-term goals, if achieved, would help meet long-term goals?
- Which short-term goals do not support any long-term goals?

Step 4. Assess farm resources and limitations (Worksheet #2).

A quick scan of your resources will help you determine which goals are attainable with the resources you have. This step helps you decide what you have to work with in your planning. A list of farm resources could include:

- The land inventory (acres, quality)
- The farm labour supply
- Tangible working assets (machinery, equipment)
- Money and management (disposable funds, the amount of land you can risk)

It is important to balance the potential payback or benefit of your DR with the likely costs of conducting DR. Having a rough inventory of your farm resources will allow you to ensure that your goals are achievable given your resources.

Step 5. Make plans for action... demonstration research design!



KEY CONCEPT Action without planning is fatal; planning without action is futile.

Given your goal, how do you intend to get there from here? Demonstration research can be a valuable tool to assist you in reaching your farming goals. Keep your goal in mind as you move to the next stage: developing objectives.

Notes

Notes

ASSESSING YOUR RESOURCES

LAND

How much do you have?

How much can you risk?

Best candidate field(s)?

Places to avoid?



LABOUR

How much do you have?

Will you need to hire help?

When is your busiest time?



EQUIPMENT

What do you have available?

Size of largest piece of equipment?

Is equipment in good repair?



MONEY AND MANAGEMENT

Will you need help and when?

Do you have the funds to risk?

Purchase/borrow equipment?



Notes

2.2 Developing Your Objectives

GREAT RESEARCH BEGINS WITH A GREAT IDEA

After assessing your short- and long-term goals as well as your available resources, you are ready to start developing objectives that support your farming goal(s). Remember that objectives are S.M.A.R.T. When developing objectives it is important to keep it simple, simple, simple. You will not be able to achieve your farming goals with one complicated objective.



Focus on just one clear and achievable objective per demonstration research study.

Recall the example to become a full-time farmer (Goal). An objective to reach this goal could be to produce greater yields without purchasing more land. The 'measurement' is *yield*. Recall that objectives are *measurable* while goals are not.

The measurement associated with each objective need to be thoughtfully developed.

2.3 Formulating Your Research Question

KEEP IT SIMPLE, SIMPLE, SIMPLE

Demonstration research requires time, energy and money. Complex studies involve more of each. The simplest questions involve a yes/no answer.

Examples might include:

- Did herbicide 'A' control weeds better than herbicide 'B'?
- Did variety 'A' have higher yields than variety 'B'?
- Are my yields affected with by a low versus a high seeding rate?

When developing your research question, it is important to revisit your farming goals and objective(s).



The example goal is to become a full time farmer. The objective is to produce greater yields without purchasing more land.

You may want to know "would I get greater yields with Fertilizer A or Fertilizer B"? This simple question is the foundation of your demonstration research. This question may lead to future questions such as, "do the yields associated with Fertilizer A outweigh the additional costs of purchasing Fertilizer A?". After reading the case study, you will be directed to the objectives and research question worksheets.

2.4 Deciding What To Measure?

EVERY MEASUREMENT TAKES TIME

The measurements you make must answer your research question. You don't need to measure everything; in fact, a well designed project might seem too simple at first. When deciding on the measurements to take, ask yourself:

- Will these measurements provide data to answer my research question?
- Do I have the resources (time, labour, money) to make these measurements?
- Do I need to gather more resources in order to make these measurements?

Some examples of measurements that could be made to address a forage related research question are outlined in Table 1; many other possibilities exist.

Table 1

Examples of research questions and measurements that could be made to address each question.

Foundation of Research Question	Measurements that Could be Made
Establishment	Plants/hoop ¹ and then extrapolate up to plants/acre
Survivorship	Plants/acre from establishment to harvest
Assessment of various treatments (seeding rate, fertilizer, herbicide, variety) on plant yields	Animal weight gain, forage yields, grazing days, green feed days
Quality of forage	Forage quality analysis
Changes in forage quality	Forage quality analysis at various stages of plant development; or, over time with stored feed
Rotational grazing intensity	Animal weight gain, changes in weed population
Efficiency of bale grazing/swath grazing	Wasted hay, subsequent forage yields
Changes in soil quality	Soil nutrient analysis

Note – The BC Forage Council can provide tools and resources to help you achieve your demonstration research objectives.

¹ A simple hula-hoop can be used. See Helpful Conversions for how to convert hoop area to acres.

CASE STUDY

Testing an Idea Before Betting the Farm On It

Vanderhoof, BC cattle producer Butch Rüter has always had a short-term goal to grow his feedlot operations but knew that he'd need to increase days on pasture in the fall. Keeping his cattle on pasture later would allow him to have more empty pens in his feedlot that could be filled. In order to increase pasture days, Butch first needed to research alternative, high quality, feed options.



"If I can extend my grazing season and improve the quality of the feed, that's worth looking into."

– Butch Rüter

While at a forage conference a few years ago, Butch heard a speaker talk about the benefits of adding late-maturing kale to a forage field to improve feed quality. Having swath-grazed cattle on forage oats for a handful of years, he was intrigued.

Since he had no experience growing kale, he decided to try a small-scale on-farm study so he'd have real data to shape his future seeding decisions.

"Change brings new challenges but it might also bring new opportunities."

In mid-June of 2015, Rüter fenced off a small section of his field and seeded 2 lbs/ac of the kale variety 'Winfred' with 70 lbs/ac of forage oats. Following the first frost that fall, he randomly selected and sent four to six kale plants to a lab for feed quality analysis every two weeks.

He was surprised by the results: not only did the kale stay dark, vibrant green despite the cold weather, it also maintained its protein levels, total digestible nutrients and relative feed value right through mid-December.

"Overall, I was really impressed. It's an expensive seed but it seems to grow well here. Right up until the deer found the plot and ate it all up in late December, those protein levels barely changed at all. Now, I want to expand the project to a bigger size, add a second kale variety, and swath it so I can see if the kale will hold its protein value in the swath."

CASE STUDY, *continued*

TESTING AN IDEA BEFORE BETTING THE FARM ON IT

This project was Ruiters' first try at on-farm research.

"We've tried different things here and there but never to the level of analyzing feed value."

"It was definitely worth the effort," he says.

"It's really up to producers now to do a lot of the work of figuring out what works on their farms. Try things out, even things that might have already been tried in the past. Winters used to be a lot colder here. So things that were tried and didn't work thirty or forty years ago might work now."

Harvest Date	Protein (%)	Total Digestible Nutrients	Relative Feed Value ¹
November 5	19.8	78.4	489
November 12	19.2	76.1	382
November 19	18.3	78.3	472
November 24	19.9	79.4	551
December 14	19.5	76.0	381
December 17	19.0	76.9	425

The MEASUREMENTS made to answer his research questions were:

- Forage analysis of samples collected every 2 weeks from November 1 – December 15

The RESOURCES needed to answer his research questions included:

- Money to purchase forage kale seed and laboratory services for forage quality analysis
- Seed drill suitable for small seed
- Time for seeding
- 2 hours, twice a month throughout the fall and winter to collect and ship samples
- Shipping materials and cost of shipping samples

Complete **Worksheets #3 and 4** to develop objectives, research questions, and measurements needed; as well as a detailed list of the resources you'll need.

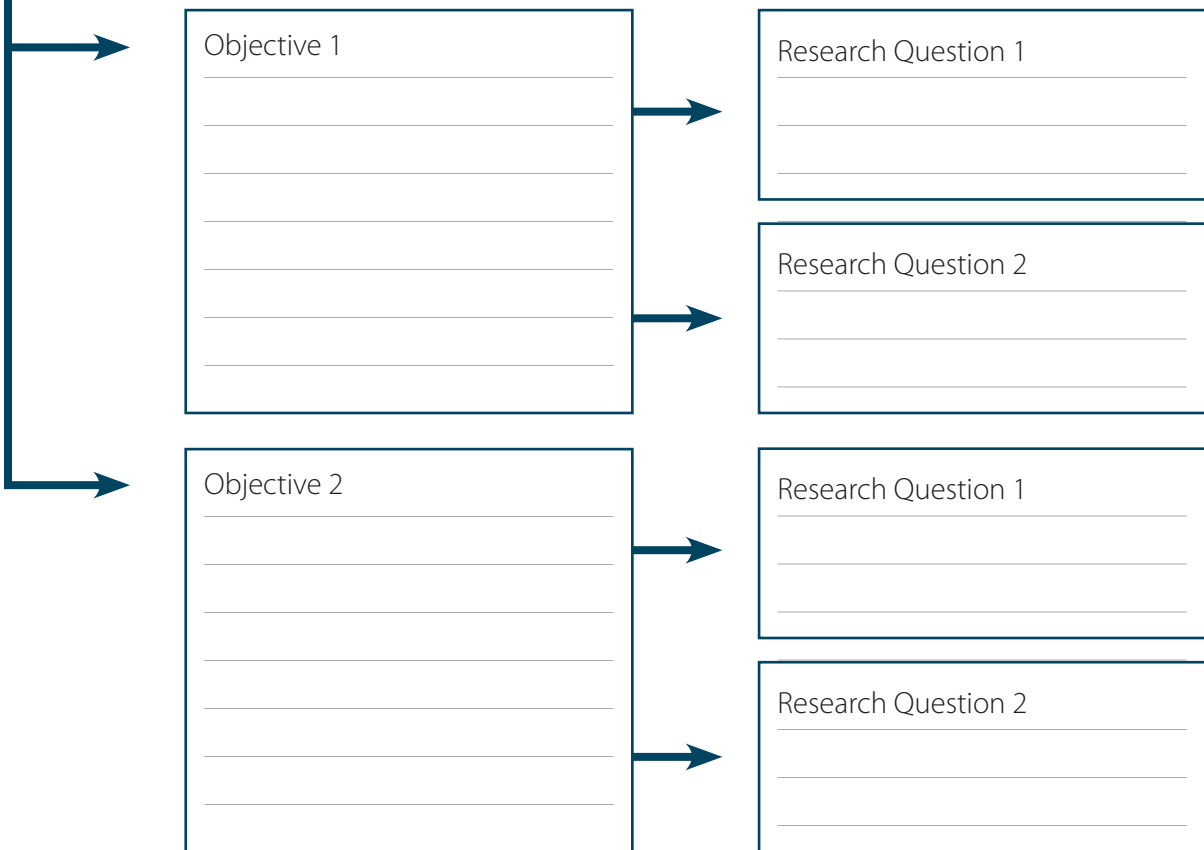
¹ RFV continues to be used as an index to assess forage quality. However, differences in the digestibility of the fiber fraction can result in a difference in animal performance when forages with a similar RFV index are fed.

PRIORITIZING OBJECTIVES AND DEVELOPING RESEARCH QUESTIONS

PRIORITY GOAL FOR DEMONSTRATION RESEARCH

What measurable changes will help me reach my goal?
THESE ARE OBJECTIVES

What specifically do I need to test to answer my objective?
THESE ARE RESEARCH QUESTIONS



Using your **PRIORITY GOAL**, prioritize your objectives and identify your specific research questions.
Start planning now to gather the resources you will need!

Notes

WORKSHEET #4 MEASUREMENTS

**MY RESEARCH
QUESTION**

**MEASUREMENT(S)
TO TAKE?**



<hr/> <hr/> <hr/> <hr/> <hr/>

RESOURCES NEEDED?



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Consider your question, choose your measurements, identify resources needed.
Start planning now to gather the resources you will need.

Notes

2.5 Scouting For Related Research

WHY REINVENT THE WHEEL?

Before diving in to a demonstration research project, spend some time determining if your research question has already been answered. Ask your local agronomist/agrologist, research scientists, university faculty, and other information sources. You may find that there is enough information currently available to answer your research question satisfactorily.

2.6 Assessing Your Resources

WHAT DO I HAVE TO WORK WITH?

Before you can begin designing your research, you need to critically assess your capacity. What do you have at your disposal? How much time do you have? Will you need to purchase any equipment? Can you complete all aspects of your research using existing equipment? How much land can you allocate towards your research? These are just some of the questions that should be sketched out on paper at the kitchen table ahead of time – being certain to incorporate the following factors.



KEY CONCEPT Before you design your project, critically assess your capacity – equipment, time, funds, etc.

i. Accounting for equipment dimensions

As you design your demonstration research, keep in mind the dimensions of the equipment you plan to use. You can sketch out your treatment areas based on your existing equipment to minimize any errors.



FOR EXAMPLE, you have a 20 ft seeder, a 10 ft harvester and a 40 ft fertilizer spreader. You will need to ensure that your treatment areas are designed based on the largest piece of equipment you are planning on using. In this example, each treatment area should be in multiples of 40 ft.

ii. Accounting for equipment variability

All equipment has some level of variability based on its design and condition. For example, the nozzles on a fertilizer sprayer will not spray an equal volume across their whole range and this error will be compounded as nozzles become worn and damaged (See Figure 2). As a result, sprayers are designed for overlap at the outer spray zone of each nozzle. As well, the nozzles on either end of the sprayer will have reduced output on their outer edge.

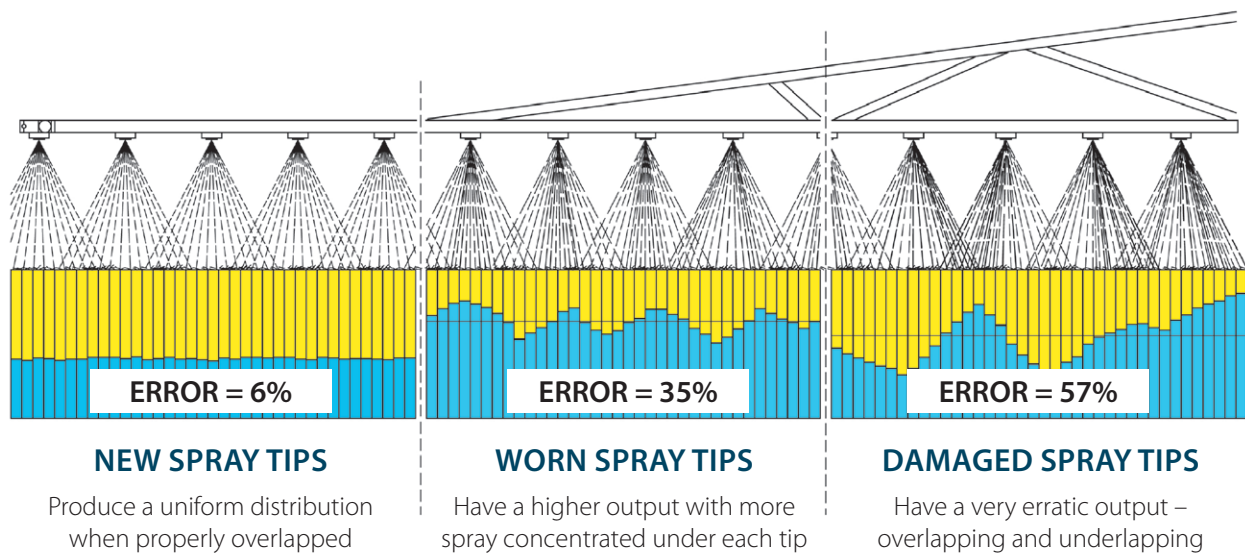


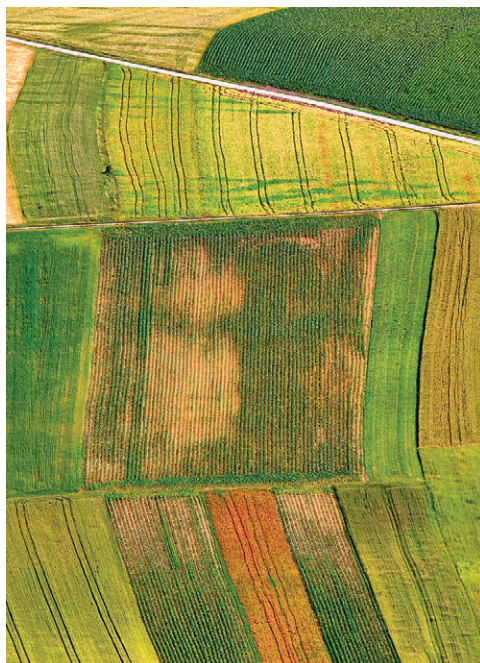
Figure 2

Example of the error associated with worn or damaged nozzles that could affect your demonstration research results (reproduced with kind permission from TeeJet Inc.)

You should accommodate not only equipment dimensions but also multiple passes.



KEY CONCEPT As a rule of thumb, you want the treatment area to be wide enough to allow for at least two passes of your widest piece of equipment, this will ensure that any inconsistencies at the end of the equipment are taken into account. If you cannot incorporate two passes of a given piece of equipment, then be sure to sample from the middle of the strip to avoid the variable edges.



iii. Accounting for field variability

Variability is inherent in any natural landscape.

Even within a small area of your field, you will find natural variability that will affect your DR results. Variability can be a function of soil characteristics, topography, or past management. Therefore, the area being used needs to be large enough to account for, and incorporate, the variability within your fields. In Figure 3, we see that percent moisture content ranges from 13.5 to 17.0% across a flat, uniform field. Whatever the factor, non-uniformity will translate into variability within and between your treatments. This variability is 'background noise' that has nothing to do with your treatments but could lead to incorrect results if not accounted for.

Large scale variability is evident on the landscape.

Figure 3

Example of soil moisture measurements (% soil moisture) taken from a uniform agricultural field in North Dakota (slopes of 2-3% and sandy loam soils). Modified from: Jabro et al. USDA ¹

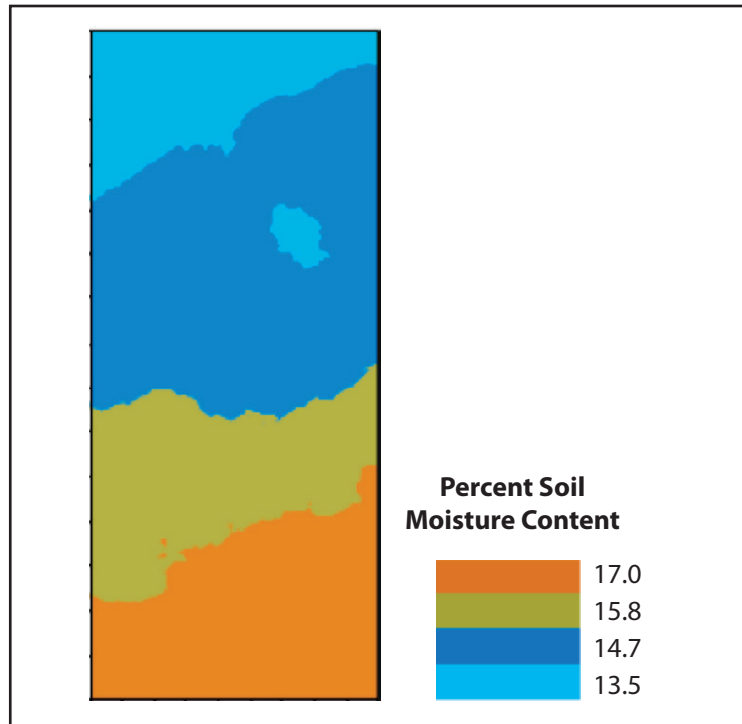


Figure 4

The photo on the top shows a saline patch that would be wise to avoid; while the photo on the bottom illustrates a situation where incorporating field variability makes sense.

iv. Ensuring treatment areas and fields are representative

While it is tempting to pick the flattest, most uniform section of the flattest field, it is important to ensure your results will be transferrable to other parts of your farm; or at least somewhat representative of your farm. If 90% of your land is sloping, then it would be wise to incorporate slope into your design so that you have an idea of what results to expect across the landscape (Figure 4). Variability does not need to be avoided in your demonstration research design; but it does need to be incorporated *consistently* across all treatment areas. To revisit our fertilizer example, if Fertilizer A is spread in an area with a south facing slope, Fertilizer B should also be spread in an area with a south facing slope and not on a flat area.

It is also wise to ensure your treatment areas do not include bizarre or unique landscape features. You can even intentionally skip a saline patch or avoid a hummock (Figure 4).



KEY CONCEPT It is critical that you place your treatments in areas that are truly representative of the majority of your farm.

¹ Spatial Variability of Physical Properties in Lihen Sandy Loam Soil. Jabro, Stevens, and Evans.

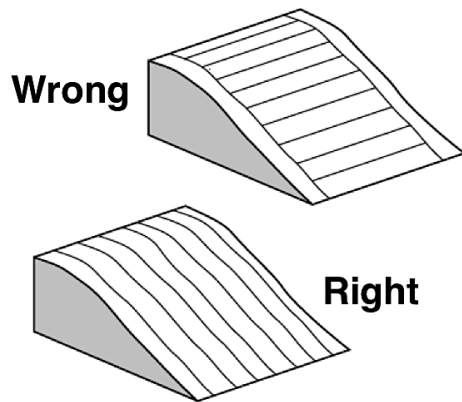


Figure 5

An example of a correct and incorrect treatment area lay-out on sloping land, the goal is to equally incorporate the slope in each treatment strip.

v. Ensuring field variability is consistent across all treatments

We know the importance of considering variability when choosing where to locate treatment areas. If you know that your field is variable in terms of slope, soil type, or any other factor then try to incorporate the variability into all the treatment areas equally. Figure 5 outlines the correct (bottom image) and incorrect (top image) way to lay-out a treatment area on sloping land. The 'wrong' lay-out will ensure that the top treatments are consistently drier than the bottom treatments. Whereas the 'right' lay-out incorporates the slope and its associated variability into each treatment. Although it is not appropriate to till up and down steep slopes, demonstration research strips should be laid out up and down slope and not across them in order to make the effect of slope as uniform across all treatments as possible.

2.7 Visualizing Your Demonstration Research

'DOING THE MATH' WILL SAVE TIME AND MONEY

i. Treatment area size (an example)

After working through sections 2.1-2.4, you decide that to test your research question of Fertilizer A versus Fertilizer B:

- Four passes with fertilizer will result in a more uniform application than just one pass (recall Figure 2).
- In order to have 4 passes, each treatment area will have a width of 160 ft because your spreader is 40 ft wide.
- Each treatment area should be 500 ft long to capture the variability (slope) within the field.
- You also decide that incorporating slope into your DR is important because most of your fields are sloped.
- Therefore, you will need a total area of 160,000 ft², or 3.7 acres (160 ft wide*500 ft long * 2 treatments).

Now that you know how much space you will need and the natural field variability to be considered, the next step is to plan your layout.

ii. Treatment area lay-out

You will want to ensure that your treatment area is not close to a forest edge, windbreak, building, or other structure that will affect your research results. Ensure that you (and/or your livestock) will not need to travel through your treatment area in order to access other fields, pipes, gates, or any other resources. Take your time during this stage, make sure that your treatments are in the best location and are easily accessible.

Additionally, ensure that there is enough room around your treatment area, particularly at each end, for your equipment to turn and get up to speed for the next 'pass', do not turn or slow down within your demonstration research area. Be sure that your equipment is running at the same speed within the treatment area or you will add variability to your results through inconsistent seeding, fertilizing, spraying etc. See Figure 6 for a bird's eye view example of how the treatment area might look on the landscape.



KEY CONCEPT Consider your layout in terms of access, nearby features that could affect results, and equipment operation

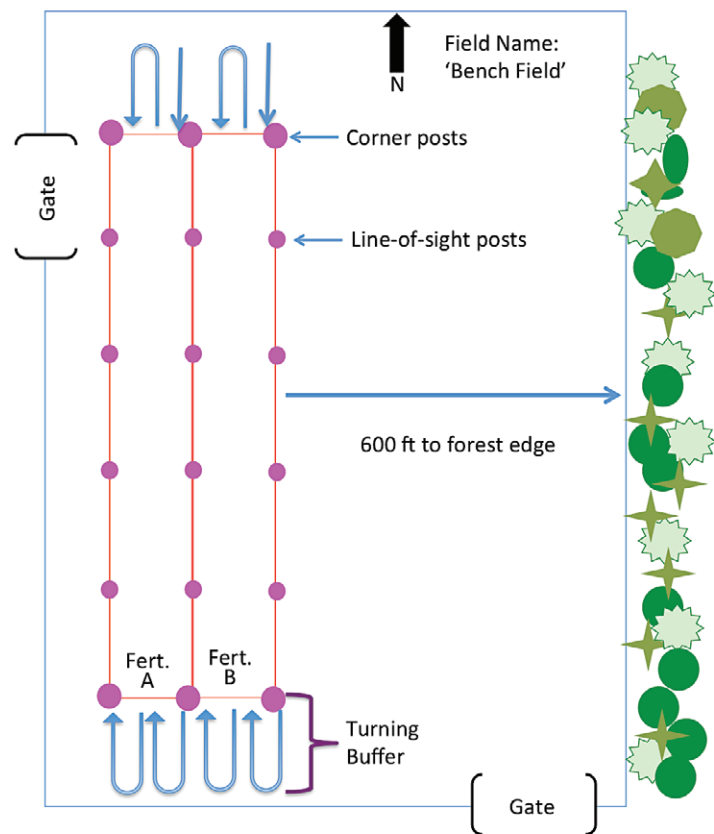


Figure 6

Example of treatment area lay-out within a proposed field.

USE WORKSHEET #5

Take some time and sketch out your demonstration research lay-out

Be sure to include points of reference. Include the field name, location of fences, gates or other landmarks. While the lay-out may eventually change, drawing your DR ahead of time ensures that you spend time considering landscape and land management attributes. Make at least two copies of your layout.

Use Figure 6 as an example.

iii. How to take measurements?

Recall that your Objectives need to be measurable!

Your original Research Question was “would I get greater *yields* with Fertilizer A versus Fertilizer B”? In this case, the measurement is yield. There are different ways to measure yield and the utility of each can vary with the type of crop you are growing.

If you are producing hay, when you harvest your treatment areas, you could simply count the number of bales from each treatment area and multiply that by an assumed bale weight. This would be the least accurate option but it might be within your capacity, given your available resources (which includes time).

A second, and more accurate option would be to weigh each bale and add up the total weights. This would require a bale scale but would give more robust results. However, there will be some error as your approach the edges of your treatment areas; it is hard to avoid the ‘edge effect’ zones of your treatment areas. As well, field variability will not likely be captured in your results.

A third, and most accurate option would be to take many small samples within each treatment area. This third option would result in the greatest accuracy as each sample is weighed independently, you can avoid the edges of your treatments, and you are likely to capture field variability (Table 2).

Because small scale sampling allows you to clearly see variability within your field, you might find that Fertilizer A only produces greater results on the moister, lower slopes of your field! However, small scale sampling is a more time consuming process because it requires manual cutting. As a result, it’s important to determine if you have the labour resources.

Table 2
The pros and cons of each sampling method.

Sampling	Pros	Cons
Count total bales with an assumed bale weight	Fast and Easy	High level of error associated with baler, difficult to avoid edge effect in a small field, and doesn’t show how results are related to field variability
Weigh each bale	Relatively fast, less error and shows obvious field variability results	Difficult to avoid edge effect, doesn’t show subtle variability
Small Scale Sampling	Can avoid edge effect, very accurate results, will show how subtle variability affects results	Time consuming

WORKSHEET #5

SKETCH YOUR FIELD LAYOUT

Remember to draw your Demonstration Research lay-out with a bird's eye view. Try to consider all your operational needs as well as landscape features that could affect your result. Once complete, make at least two copies of this sketch for future use.



Notes

iii. How many measurements to take?

Deciding on the number of measurements to take can be challenging. The more measurements, the more accurate your results will be. However, time is a precious resource and each measurement requires time.

- If you choose to sample the whole treatment area and count or count and weigh your bales then you have sampled the whole population and you have one measurement per treatment area – the total yield of the area.
- If you choose to sample within each treatment area then you need to decide how many samples are required. The number of samples will hinge on the amount of variability within your field.

Revisiting our example research – to compare Fertilizer A versus Fertilizer B, the DR may look similar to Figure 7.

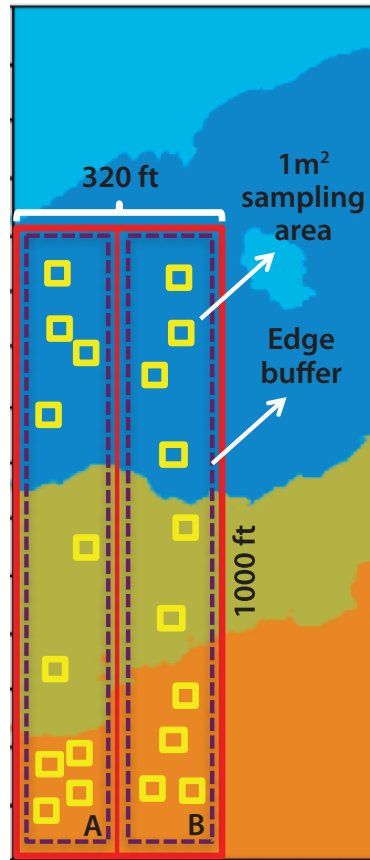
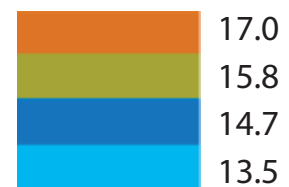


Figure 7

Possible demonstration research design for comparing yields under two fertilizer treatments (A versus B) across moderately variable soil moisture conditions. Note that the very dry upper portion has not been included in the treatment areas and there is no sampling in the edge buffer zone. Figure not to scale.

Percent Soil Moisture Content



KEY CONCEPT If you wish to capture variability, a good rule of thumb is 10 samples within each treatment area.

You have done a large amount of planning, now is the time to critically assess the resources you have available and make changes to your DR design, or spend time gathering the additional resources you will need.

Revisit Worksheet #4 and make any changes to the resources needed. Investigate if equipment can be borrowed from other producers or from the BC Forage Council.



HIGH TECH EQUIPMENT IS NOT REQUIRED TO CONDUCT DEMONSTRATION RESEARCH

Assess the resources you have and design an experiment that can be answered without purchasing specialized equipment.

2.8 Preparing To Collect Data

TIME TO ROLL UP YOUR SLEEVES

In order to know if your treatments are producing real (rather than perceived) differences you need to collect data. Designing your field data record sheets ahead of time will ensure that you are collecting the correct data, that you have a structured and practical method to collect the data, and that you have a notebook or other recording option allocated for data collection. When designing your data collection sheets think of the information that will be collected.



KEY CONCEPT Basic information that should be included in all field data sheets is date, the name of person collecting the data, and an area for general comments at the bottom of the data sheet.

An example is included of a field data record sheet (figure 8) that could be used for the fertilizer comparison research.

Activity	Date									
Seeded Field:	June 1	Sample size:	1 m ²							
Field Sampling:	July 15	Crop:	Alfalfa							
		Harvest:	First							
Field Data Form										
Collected By: Jane Farmer										
Treatment	Weight of each sample (grams)									
	1	2	3	4	5	6	7	8	9	10
Fertilizer A	1160	1180	1090	1100	1240	1240	1480	1650	1580	1600
Fertilizer B	1310	1280	1300	1320	1300	1200	1220	1310	1300	1230
Comments:	Samples 1, 2, 3, and 4 were in drier portion of field. Samples 7, 8, 9, and 10 were in wetter bottom slope of field. Samples 5 and 6 were in between.									

Figure 8

Example of a field data form with hypothetical data that could have been collected in the Fertilizer A versus B scenario outlined in Figure 7. Data presented in this field data form will be revisited in Chapter 4 – Analyzing Your Results

CHAPTER 3

Implementing Your Demonstration Research

READY, SET, GO!

1. Assessing Resources, Again
2. Laying Out Your Treatments
3. Checking Your Equipment
4. Installing Your Demonstration Research
5. Timing Of Data Collection
6. Accuracy In Your Data Collection
7. Multiple Visits To Your Treatments
8. Making Changes ‘On The Fly’
9. Using Your Field Datasheets

Case Study – Using Science To Guide Your Decision-Making



3.1 Assessing Resources, Again

NOT SO FAST!

Before you plant a single seed, go through your list of required resources and make sure you have everything you need to complete your demonstration research. Depending on your project, you may be limited to a short window for planting/harvesting etc. and you need to be sure that your resources are ready when you are!

3.2 Laying Out Your Treatments

BE PREPARED FOR FULL GROWN PLANTS

It is important that you spend time laying out your treatments and marking them with highly visible corner posts. Ideally, you should be able to stand at one end of your treatment, or in a tractor at one end of your treatment, and see the corner post at the opposite end. Each treatment will need four corner posts. Pink flagging

tape is highly visible. Because the treatments are long you may decide to install treatment divider stakes every 50–100 ft to give your eyes a line of sight.



KEY CONCEPT Ensure that the divider stakes and corner posts are taller than your crop will be at harvest.

Treatments should be laid out with two people to ensure that corners are relatively square. Remember, to ensure that your treatments are not close to a forest edge, windbreak, building, or other structure that will affect the research results. If your treatment area is within 100 ft of a structure, now is the time to move the treatment! Double check that you will not need to drive through your treatment area in order to access any other fields, pipes, gates, or other resources. Take your time during this stage, make sure that your treatment area is in the best location and is easily accessible.

If any changes are made, note the changes on your design map.



An example of highly visible stakes along a treatment boundary.

3.3 Checking Your Equipment

CHECK, CHECK, AND DOUBLE CHECK



Invest time in thorough preparation.

Recall Figure 2 (Chapter 2), worn equipment can add a huge amount of variability to your results. Now is a good time to check the mechanics of your equipment and calibrate. Review your demonstration research design and ensure that the equipment you *planned* to use is the same equipment you are using.

3.4 Installing Your Demonstration Research

GO

You are ready to seed, fertilize, spray, etc. Go for it! You've done a lot of planning to get to this stage and you are well prepared.

You will likely take your design map into the field. Have TWO copies of your design map; use one to take in the field, and keep the other in a safe place... you may need it later when your field map is worn and hard to read!

3.5 Timing Of Data Collection

UNDERSTANDING THE BIOLOGY OF YOUR RESEARCH QUESTION

Depending on your research question, you may have multiple sampling dates throughout the growing season, one sample at the end of the season, or some other combination. Be sure that you have not overcommitted your sampling with your farm operations. If you need to sample during your busiest time(s) of the season, then have extra help lined up to ensure that neither your demonstration research, nor your livelihood are compromised.



FOR EXAMPLE If you are interested in rates of maturity across several varieties of alfalfa, you will need to sample plant development on a regular basis during the growing season. However, if your interest is final yield of forage oats then all the sampling is done at the end of the growing season.

3.6 Accuracy In Your Data Collection

THE DEVIL IS IN THE DETAILS

Think of the level of accuracy you need in your results to answer your research question. Use the equipment and method of measurement to capture the level of accuracy you need.



KEY CONCEPT If you are taking 1m² plant samples and weighing each bag individually, you will need a scale with an accuracy of 1 gram rather than a standard bathroom scale!



KEY CONCEPT If you are sampling biomass within a hoop, throw the hoop over your shoulder rather than looking for places to sample that you feel represent the condition of the treatment.

If your hoop lands on a road, rocks or some extreme irregularity then it is appropriate to re-throw the hoop. Also, if you are manually clipping biomass samples, make sure you cut each sample at the same height and with the same level of care.

As you see things in the field, write them down in a pocket notebook or take a photo, then transfer the information to a more permanent record. Your recorded observations can lead to insights day, months, or even years later.



Good field notes, consistent sampling methods and sticking with your plan will ensure your demonstration research results are the best they can be.

3.7 Multiple Visits To Your Treatments

ARE YOU AFFECTING THE RESULTS?

If your question requires you to take measurements multiple times within your treatment area you need to ensure that your sampling method is not affecting your results.



KEY CONCEPT If you revisit your treatments many times during the season, walk the same path each time you access your treatments to ensure that trampling is not affecting your results.

Or, if you harvest a small amount each time you access the treatments, use a random sampling method to ensure that you are not over sampling or biasing your sampling. Recall that random sampling is critical to representative and


unbiased results. An easy method for random sampling is to generate GPS coordinates ahead of time and sample at those locations. Or, throw a hoop over your shoulder and sample inside the hoop – wherever it lands.

However you decide to sample, ensure that your sampling method is random and unbiased.

3.8 Making Changes ‘On The Fly’

THE ONLY CERTAINTY IS UNCERTAINTY

It is entirely possible that your circumstances will change and all the planning that was done ahead of time may need to be modified ‘on the fly’. Making changes along the way is a common research practice, there are just a few cautions to keep in mind. First off, revisit your goal, objective, and research questions. You may need to modify your research questions in order to complete the research. Double check that modifications will still allow you to meet your objective and goal.

 **FOR EXAMPLE**, with the Fertilizer A versus Fertilizer B scenario, what if you realized after applying Fertilizer B that the first two passes were the correct formulation, but then when you mixed a new tank of solution for the second set of passes you added only half the fertilizer concentrate?

Your error resulted in 3 treatments – Fertilizer A, Fertilizer B, and half strength of Fertilizer B. There is no need to remove the experiment. You can modify your research question from:

“Would I get greater yields with Fertilizer A versus Fertilizer B?”

to

“Would I get greater yields with Fertilizer A versus Fertilizer B?”

and

“Is there an effect on yields with half solution of Fertilizer B versus the full solution?”

Because there are now three treatments, you will need to increase your field sampling. But, you are still gathering the measurements you need to answer your objective – “to produce greater yields without purchasing more land” and have salvaged your demonstration research!

It is critical before you modify your demonstration research that you revisit your goal, objective and research question. . . ask yourself if the changes you are proposing will still allow you to meet your objective? Meaning, are you still gathering the measurements you need?

3.9 USING YOUR FIELD DATA SHEETS!

Yes, you!

Revisit the field data sheets you developed during the planning stages. Make sure you use the data sheets and store them somewhere safe for the next stage. Be sure to fill in all sections of your data sheets each time you use them. Taking photos through out the entire research process will help jog your memory and provide valuable insight when analyzing your data.

CASE STUDY

Using Science to Guide Decision-Making

There are dozens of forage varieties available on the market today, each advertised as better than the next. How does one decide what to seed? Longtime Vanderhoof, BC hay producer, Traugott Klein, decided to use science instead of guesswork or popularity to guide his variety decisions.



“I was expecting a difference between varieties but I had no idea what that difference would be”

– Traugott Klein

“Farmers often want to plant what’s hot in the industry but they don’t take into account that the growing conditions on their farms are totally different than they are elsewhere. Bringing in varieties just because everyone else is using them elsewhere just doesn’t work,” says Klein.

In mid-June, 2015, Klein seeded 36 ft wide strips of each of six alfalfa varieties (Stealth, Hybrid 2410, WL 319 HQ, TopHand, Dalton, and Leader) at 18 lbs/ac into an irrigated field.

CASE STUDY, *continued*

USING SCIENCE TO GUIDE DECISION-MAKING

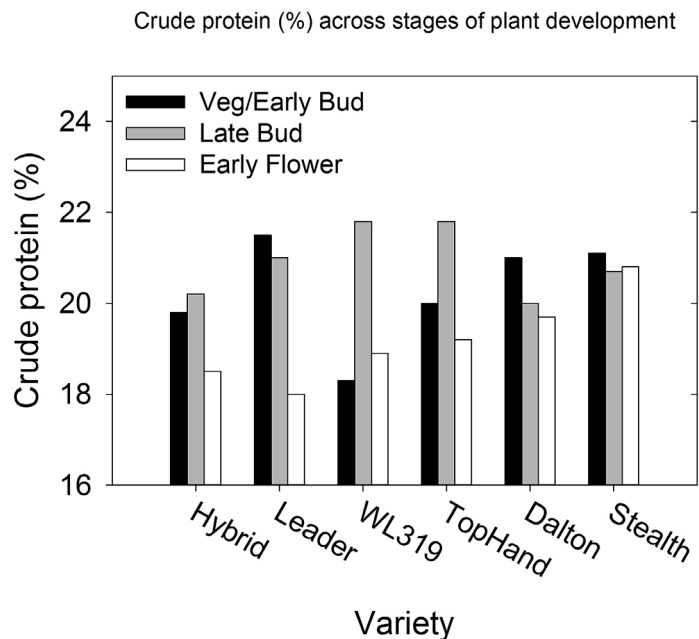
A year later, Klein measured the forage quality of each variety at every stage of maturity as well as their yield at first cut. The results were very different: while WL319HQ, Hybrid, Leader and TopHand all achieved high crude protein early in the season (vegetative through late bud stages), the crude protein values dropped steeply as the season progressed. Only Dalton and Stealth maintained high protein until cutting.

“Each variety has an ideal time when its protein and relative feed value are highest. The problem is, you often can’t harvest at the optimum time because the weather isn’t right. For some varieties, you’d need to be cutting in the middle of June, which you can’t do up here,” he says.

Klein says the results from his studies will make a real difference for his farm business.

“The effort we invested was definitely worthwhile. I was expecting a difference between varieties but I had no idea what that difference would be. Now I know that, for here, Dalton and Stealth are the best fits.

“I’d really encourage other producers to do their own studies since other varieties might better suit their conditions. Harvesting alfalfa with higher protein can make a huge difference – sometimes as much as \$100/ton – in what you can get for the hay. That can make or break your business.”



CHAPTER 4

Analyzing and Interpreting Your Results

A SIMPLE RESEARCH DESIGN ALLOWS YOU TO SEE THE FOREST FROM THE TREES

1. A Single Measurement
 2. The Value Of Sampling At The Correct Resolution
- Case Study** – Detailed Measurements Show What Your Eyes Can't See
3. Assessing Variability
 4. What To Do When It Appears There Are No Differences
 5. Taking Your Research Further

Recall that data collected from your DR are meant to answer a very specific research question. A simple demonstration research design will allow you to tease out the essence of your research question. Typically, the more measurements you can collect, the more insightful and meaningful your results will be. However, the level of detail 'right here, right now' is a reality of research.



4.1 A Single Measurement

THE VALUE INCREASES OVER TIME

If you've decided to collect just one value (total yield) within each treatment area, then it will be impossible to measure variability within your treatment. However, if you conduct the same experiment over and over again, gathering a single yield measurement year after year, then you can start to develop confidence in your results.

4.2 The Value of Sampling At The Correct Resolution

HOW TO INCORPORATE AND ACCOUNT FOR VARIABILITY

A single harvest yield doesn't provide much information about how natural variability within your treatment areas might affect your results. Recall that 10 measurements from each treatment area is a good rule of thumb that will allow you to assess variability within treatments.

Let's revisit our Fertilizer A versus Fertilizer B example.

When assessing hay yields you could weigh each bale within each treatment area and you might find that the total number of bales and corresponding yield (sum of all the bales) is really no different. And you might notice that on the lower, moister areas it appears that Fertilizer A may have produced an extra bale; and in the drier areas Fertilizer B may have produced an extra bale. But, you can't really tell because each bale collects hay from such a large area. If you were to collect several smaller samples within each treatment area, you might be able to determine if there is a difference in yield related to soil moisture. A finer sampling resolution allows you to incorporate and account for variability.

CASE STUDY

Detailed Measurements Show What Your Eyes Can't See

The changing climate means weather is predictably unpredictable on Fort Fraser beef producer Wayne Ray's farm.



“When I looked at my fields, I thought they all looked about the same. But when I threw out my test hoops and actually measured what was inside, I saw there were huge differences”

– Wayne Ray

In spring and summer, it's no longer raining at the same time of year or in the same gentle, frequent way it used to. In 2015, Ray decided to test whether a mixed (five-way) alfalfa blend might fare better than a single variety in these challenging conditions. And, since he'd heard countless different opinions on optimal seeding rate, he also decided to test whether a heavier seeding rate would prove beneficial or a waste of hard-earned money.

“Our climate has changed quite a bit over the years. It's harder to establish crops and harder to get good production,” says Ray. “I thought a blend might help. When you plant a blend, the varieties all have different characteristics so they don't compete with each other as much. And, a blend means you've got a better chance that one or two of the varieties will excel in whatever conditions get thrown at you.”

CASE STUDY, *continued*

DETAILED MEASUREMENTS SHOW WHAT YOUR EYES CAN'T SEE

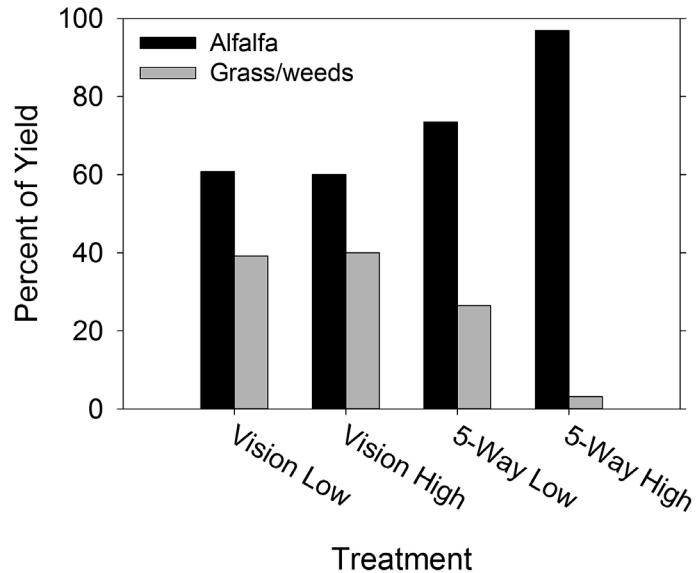
In late June of 2015, Ray divided a 50 acre field into wide strips. He seeded two strips to a five variety blend and two strips to the variety 'Vision', each at 12 lbs/ac and 25 lbs/ac.

In late July one year after seeding, Ray measured the yield from all four strips. The blend outperformed Vision in yield and boasted lower proportions of grass/weeds.

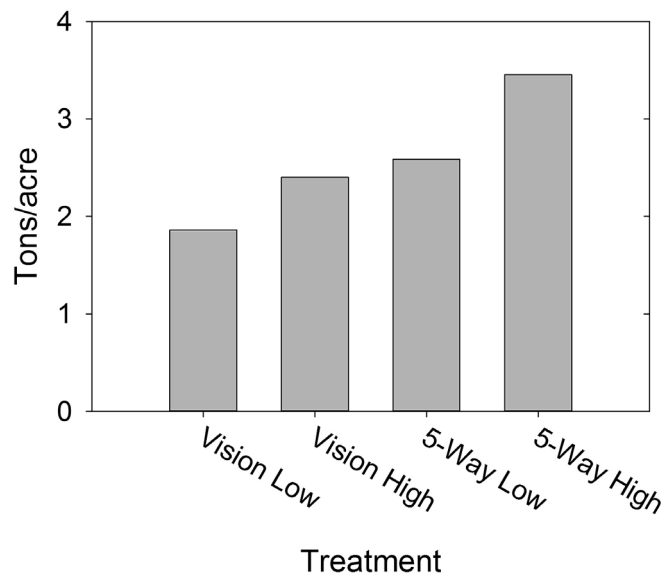
The strip seeded with the high rate of the blend produced an extra ton/acre than either the blend at the low rate or Vision at the high rate; and 1.5 tons/acre more than the low rate of Vision. Assuming hay is worth \$200/ton and the cost of seed is \$4.00/lb, seeding at the higher rate offered an additional value of \$150 – \$225/ac, in 2016.

"You need to look at your results with a researcher's mindset," says Ray. "When I looked at my fields, I thought they all looked about the same. But when I threw out my test hoops and actually measured what was inside, I saw there were huge differences. Do it right: take soil samples, track results, keep monitoring over multiple years. The results are worth the effort."

Percent of wet yield of alfalfa versus grass/weeds of single variety versus a 5-way blend at two seeding rates



Yields of single variety of alfalfa versus a 5-way blend at two seeding rates



4.3 Assessing Variability

LOOKING FOR CONNECTIONS

One of the most exciting aspects of demonstration research is when the light goes on and you have a Eureka! moment. Sometimes connections between treatments and results happen easily, other times, the researcher needs to look very closely at the results again, and again, and again.

Let's revisit the Fertilizer A versus Fertilizer B example.

Table 3 – Yields (grams/m²) from a comparison of Fertilizer A versus Fertilizer B

Treatment	Weight of each of the 10 samples (grams)									
	1	2	3	4	5	6	7	8	9	10
Fertilizer A	1160	1180	1090	1100	1240	1240	1480	1650	1580	1600
Fertilizer B	1310	1280	1300	1320	1300	1200	1220	1310	1300	1230
Comments:	Samples 1, 2, 3, and 4 were in drier portion of field. Samples 7, 8, 9, and 10 were in wetter bottom slope of field. Samples 5 and 6 were in between.									

If we look across all 20 samples we see there is really no difference between fertilizer A and B (Table 3). The averages are very close and the ranges (the highest and lowest values) overlap. Interestingly, Fertilizer A has a much wider range, indicating inconsistent results; whereas, Fertilizer B has a narrow range, indicating more consistent results.

Table 4 – Average yield and range from Fertilizer A versus Fertilizer B comparison

Treatment	Average weight g/m ²	Range
Fertilizer A	1332	1160-1650
Fertilizer B	1277	1200-1320

The comments section provides some very useful information. Recall Figure 7 that outlined the subtle differences in soil moisture in our example field. The farmer has listed which samples fell in moist areas versus dry areas. If we separate the data based on soil moisture (wet vs dry) we see a very different picture (Table 5 and Table 6).

Table 5 – Average yield and range from a comparison of Fertilizer A versus Fertilizer B on DRY sites

Treatment	1	2	3	4	Average	Range
Fertilizer A	1160	1180	1090	1100	1133	1090-1180
Fertilizer B	1310	1280	1300	1320	1303	1280-1320

Table 6 – Average yield and range from a comparison of Fertilizer A versus Fertilizer B on WET sites

Treatment	7	8	9	10	Average	Range
Fertilizer A	1480	1650	1580	1600	1578	1480-1650
Fertilizer B	1220	1310	1300	1230	1283	1220-1310

We find that taking the smaller yield samples within each treatment area gave us much more useful and insightful information. We can clearly see that on drier sites Fertilizer B outperforms Fertilizer A (Table 5), but on wetter sites the opposite occurs (Table 6).

Results from this study could lead the farmer towards implementing a fertilizer program that is specific to soil moisture conditions – thus meeting their GOAL of increasing yields without purchasing more land.

4.4 What To Do When It Appears There Are No Differences

DON'T THROW THE BABY OUT WITH THE BATHWATER

Too often researchers assume that there needs to be a difference between treatments for the answer to be of value. However, no differences between treatments can be just as valuable a result as large differences.

What if the cost of purchasing Fertilizer A was not worth the increase yield gained on wetter sites? Then, a farmer might decide that Fertilizer B, the less expensive option is suitable for all soil moisture conditions. The critical link when interpreting no differences between treatments is to revisit your goals and objectives.

4.5 Taking Your Research Further

If you are interested in more complex experimental design, some excellent design suggestions and statistical analysis can be found through The Practical Farmers of Iowa. A publication entitled “The Paired-Comparison: A good design for farmer managed trials (Exner and Thompson, 1998) is particularly useful.

CHAPTER 5

Conclusion

“YOU CAN’T BUY THE ANSWERS IN A BAG”

– Dick Thompson, *Practical Farmers of Iowa*.

The culture of curiosity is yours to explore; don’t take someone else’s word for it – figure it out for yourself. Little by little, using the resources at hand, you can make a tremendous difference in how you farm, the knowledge you pass on to those around you, and the science/art of farming.

As we saw from our example, using demonstration research, our producers were able to customize their fertilizer program to meet their farming objective of producing more forage without purchasing more land; supporting their priority goal of being full-time farmers.

We encourage all producers to share their research trials and outcomes on our website.
Extra worksheets are also available for downloading from our site: Farmwest.com/bc-forage-council



CHAPTER 6

Summary / Checklist

REVIEW THE FOLLOWING TIPS ONE MORE TIME!

- Keep it simple, especially at first. Limit your project to a comparison of two treatments. As you gain confidence, try something more challenging.
- Assess your resources and keep your demonstration research in-line with what you have available.
- Plan, plan and plan. Spend time listing your goals, objectives, and research questions. Then, spend time sketching out your experimental design and preparing your field datasheets.
- Avoid pitfalls. Test/inspect your equipment ahead of time, have help lined up for when you will need it, stick to your research plan and be willing to make changes 'on the fly'.
- Don't lose sight of your goals and objectives. Unexpected events happen in research, try to salvage your work and still answer your objectives.
- Stay consistent. Treat all experiments the same - avoid personal bias.
- Remain objective. The results may not turn out exactly as you'd hoped. Be prepared to learn from negative results.
- Take lots of field notes. Observations in the field will provide insight into your results.
- Don't ignore unexpected results. Sometimes an experiment will yield useful, yet unexpected, information. Unintended findings may prove to guide you towards new research or help explain the current results.
- Repeat, repeat, repeat. Repeat your experiment until you are comfortable with the results under varying conditions. You can repeat the experiment within one field, across many fields, and/or over many years. The more times you conduct the experiment, the more confidence you will have in your results.
- Connect your results to your business plan.

Glossary of Terms

AVERAGE – basically, the average is the sum of all the numbers divided by the number of numbers. The average number is the value that represents all the others if you could take just one number from the group.

BACKGROUND NOISE – the normal, or expected, natural variability within your farming system that will have an affect on your demonstration research results. Variability in soil moisture across a field is an example of background noise that will affect your yields.

BIAS – when a sample is collected in such a way that some individuals are more or less likely to be collected than others.

DATA – a collection of facts, numbers, or observations (a dataset). In demonstration research, we typically use quantitative data, a collection of numbers (crop yield, protein levels, weight gain etc) that is used to determine if one treatment is different from another.

EDGE EFFECT – in this manual, edge effect refers to the margins of the treatment area where the treatment is influenced by neighboring conditions (untreated or other treatment). Results along the edges of treatments are not reliable.

EFFECT – in demonstration research, the term effect is related to the treatments, and is the difference in the data results (more yield, higher protein levels, more weight gain etc) from your treatments.

GOAL – general intention that is not specific enough to be measured.

MEASUREMENT – in demonstration research a measurement forms the foundation of your dataset. A measurement could be the weight of one bale of hay, the protein level of a sample of alfalfa, or the weight gain over the season for a single cow. You need many measurements from a single treatment to form a dataset related to the treatment.

OBJECTIVE – outlines the strategy or steps to reach a goal. Unlike goals, objectives are specific, measurable, and have a defined completion date. They are more specific and outline the “who, what, when, where, and how” of reaching the goal.

POPULATION – in demonstration research, the population is made up of all the individuals we are interested in studying. For example, if you are interested in how well alfalfa responds to low versus high fertilizer regimes within a given field, then you have two populations in the field: alfalfa with low fertilizer, and alfalfa with high fertilizer.

RANDOM – in demonstration research, the notion of randomness means that each member, or individual (e.g. a single plant), from the population has an equal chance of being selected. It is critical that the individuals chosen are selected without bias because they will make up the dataset that is used to represent the population. If individuals are selected with bias then we can't be certain that they are a fair representation of the whole population.

RANGE – is the difference between the lowest and the highest values in your dataset. Range is a simple measurement of variability and therefore you want your range to be as small as possible.

SAMPLE – very often it is not possible to study the entire population – it may turn out to be very expensive and also time consuming. Therefore, we measure just a portion of the individuals within the population. Those individuals, chosen randomly, are the samples that represent the population.

TREATMENT – within demonstration research, the treatment is typically A versus B, or Yes versus No. The treatment is what ever the researcher wishes to investigate; for example: Fertilizer A versus Fertilizer B, or Tilling versus No-Till.

TREATMENT AREA – the treatment area is the area within a field that receives a single treatment. For example, a field is divided in half, one side is treated with Fertilizer A and the other side is treated with Fertilizer B. Each half of the field is a treatment area.

UNBIASED – when we sample randomly we are unbiased in our sampling method and we ensure the samples are a random representation of the population.

VARIABILITY – within a dataset, variability is a measurement of how far spread out the data is. Variability of 0 would indicate that all the values in the dataset are identical. The greater the variability, the harder it is to have confidence in the treatment effects. See Range.

Helpful Conversions & Units

Length		
1 cm	10 mm	0.4 in
1 m	3.3 ft	1.09 yd
1 km	3281 ft	0.62 mi
1 ft	12 in	30.48 cm

Area		
1 cm ²	100 mm ²	0.16 in ²
1 m ²	10 000 cm ²	1.2 yd ²
1 ha	2.47 ac	43,560 ft ²
1 in ²	0.0007 ft ²	6.45 cm ²
1 yd ²	9 ft ²	0.8 m ²
1 mi ²	640 ac	2.59 km ²

Capacity and Volumes		
1 cm ³		0.06 in ³
1 m ³		1.3 yd ³
1 l		0.22 gal
1 pt	20 fl oz	0.5 l
1 gal	8 pt	4.5 l


Diameter of hoop	Multiplier	Example
21"	18,150	5 plants/hoop*18,150 = 90,750 plants/acre
13.5"	145,000	5 plants/hoop*145,000 = 726,000 plants/acre

Multiplier to convert g/hoop to g/acre: Area of hoop (in²) = πr^2 Multiplier = $\frac{6,273,000}{\text{area of hoop}}$

EXTRA WORKSHEET #4 MEASUREMENTS

**MY RESEARCH
QUESTION**

**MEASUREMENT(S)
TO TAKE?**



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RESOURCES NEEDED?



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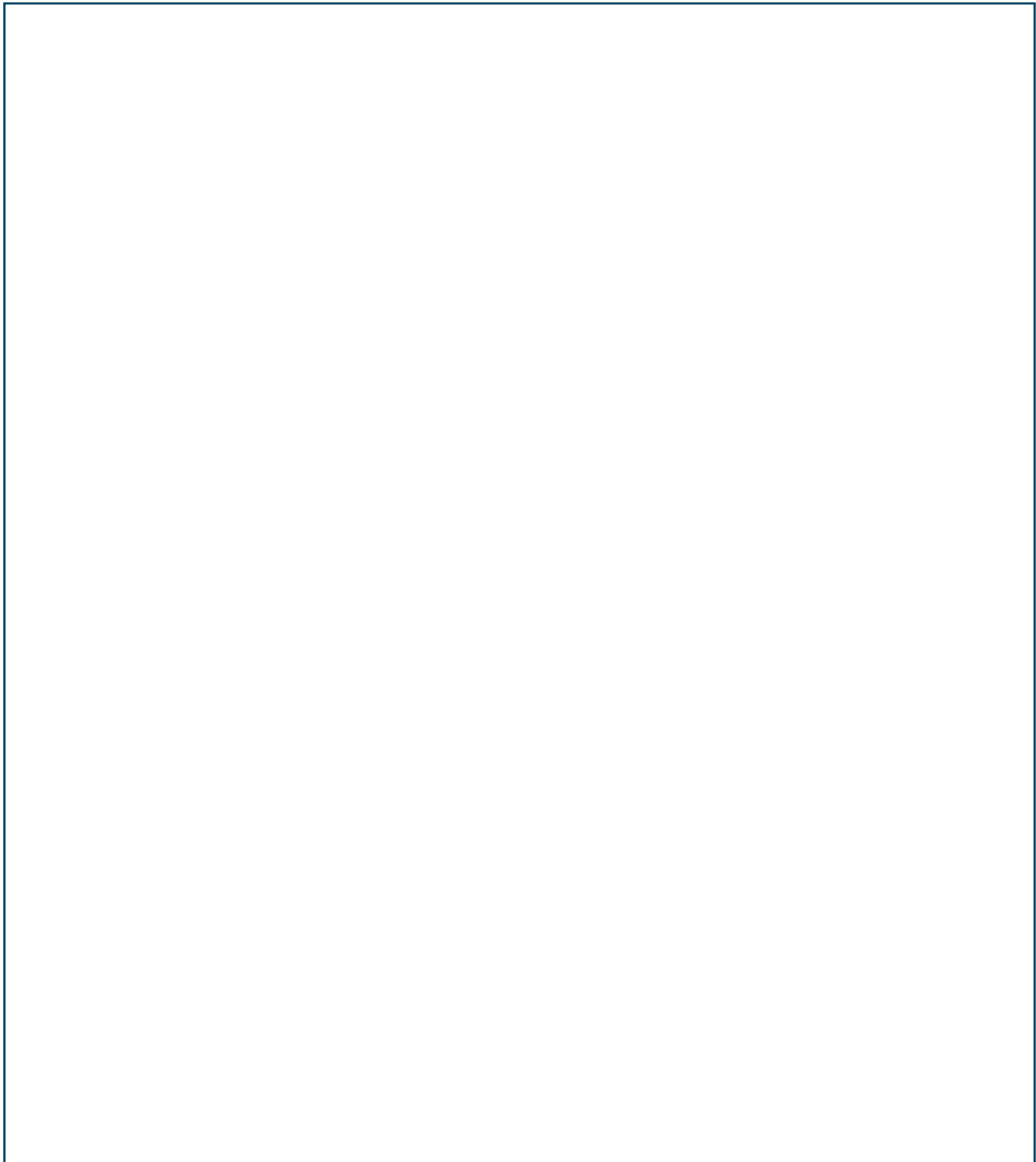
Consider your question, choose your measurements, identify resources needed.
Start planning now to gather the resources you will need.

Notes

EXTRA WORKSHEET #5

SKETCH YOUR FIELD LAYOUT

Remember to draw your Demonstration Research lay-out with a bird's eye view. Try to consider all your operational needs as well as landscape features that could affect your result. Once complete, make at least two copies of this sketch for future use.



Notes



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