Translating scientific knowledge for farmer adoption: A green manure model

Joanna L. MacKenzie &
Andrew H. Hammermeister

September 19, 2016

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Linking Organic Knowledge
OACC
Organic Agriculture Centre of Canada

The Importance of Knowledge Dissemination

"Agricultural extension and knowledge transfer programs are crucial to the adoption of research outputs on Canadian farms. However, structural changes and the diminishing role of provincial & federal governments have resulted in the need for a new participatory research and extension model that is based on knowledge sharing and co-learning. This will benefit both the research and farming communities."

AIC·2016

Disseminating Agricultural Research
Bridging the Gap Between Idea and Adoption

Conference Report

Available at www.aic.ca

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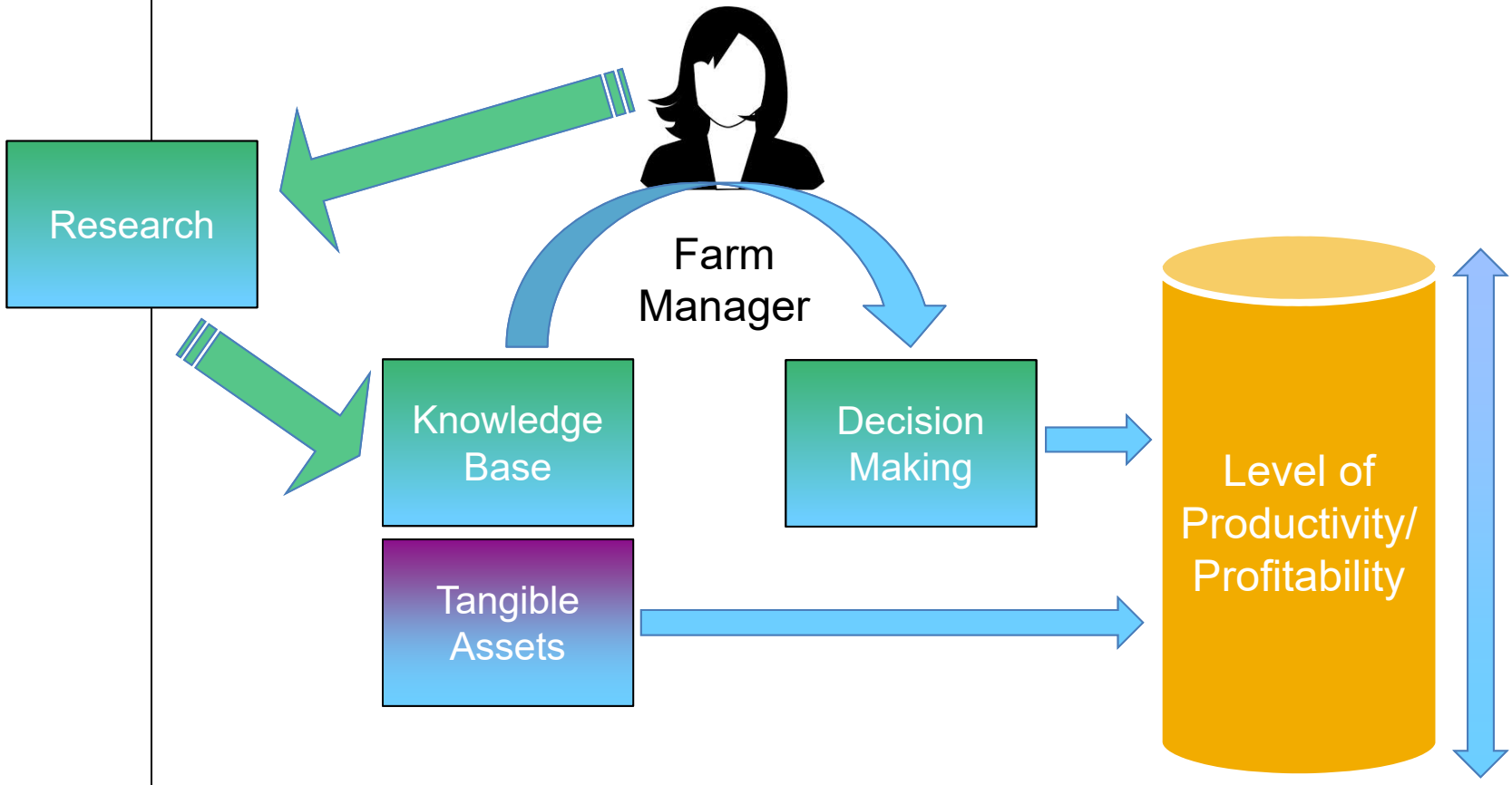
Organic is Knowledge Intensive



"While scientific research is vital, knowledge transfer is the action that allows it to have impact within the sector."

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Adapted from Savard et al., 2014

Knowledge Dissemination: A Green Manure Case Study

What is a green manure?

A crop that is planted to improve soil fertility, without intent to harvest a product

Legumes

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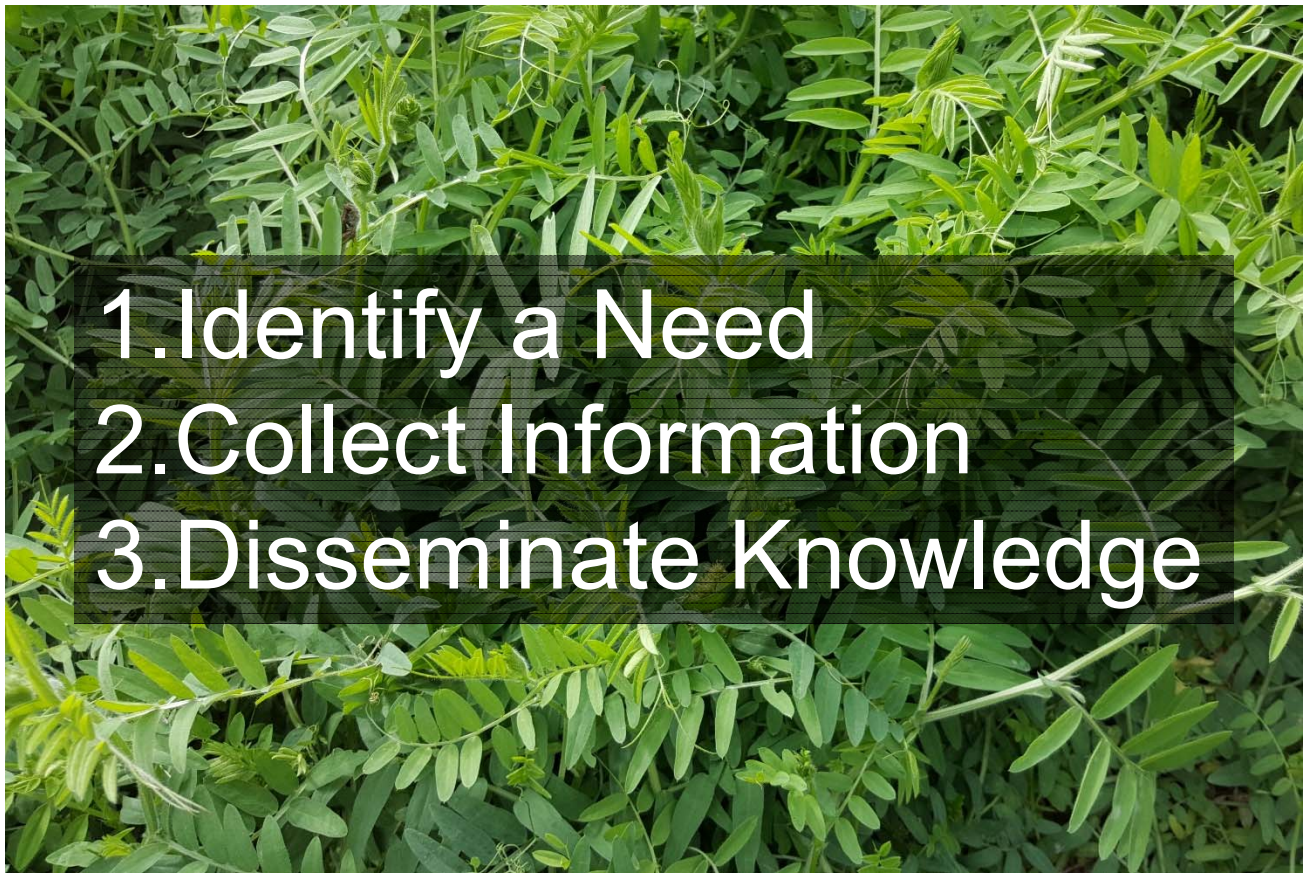
Knowledge Dissemination: A Green Manure Case Study



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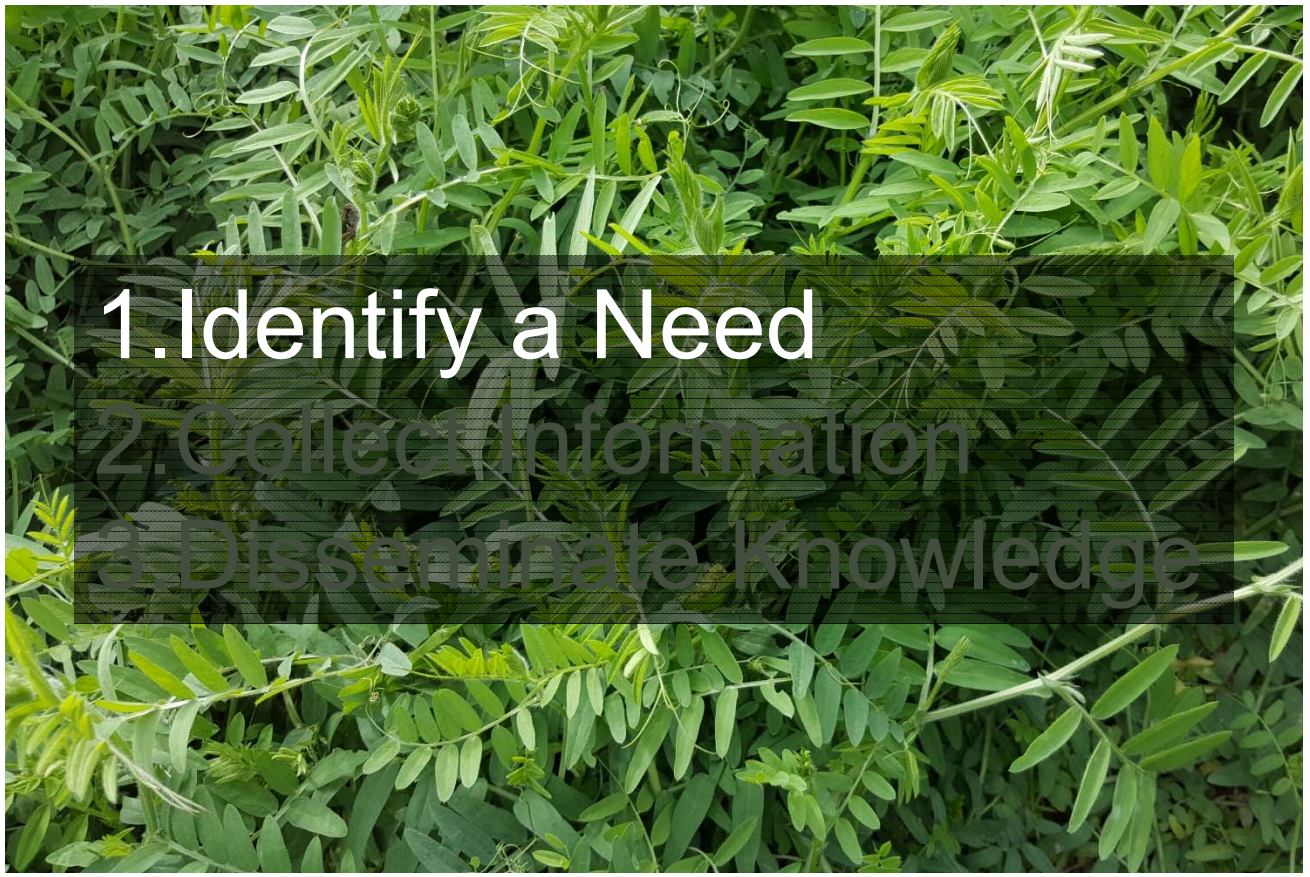
Knowledge Dissemination: A Green Manure Case Study



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Prairie Organic Grain Initiative

prairie organic grain initiative

To achieve resiliency and stability while growing the organic sector in the Prairies by focusing on both quantity and quality of organic grains and developing relationships across the value chain.

New Grower Stream

Objective:
Increased number of new organic producers

With high organic prices for organic grains, there is a strong incentive for growers to convert to organics. But the pathway to becoming organic often seems daunting, and the transition period is seen as a significant risk that will take considerable effort. Through targeted marketing, a suite of resources and supports for transitioning producers, and a series of training events, this stream will increase the number of organic growers.

Optimization Stream

Objective:
Improved management increases quantity and quality

Organic grain production remains underdeveloped. While there has been some research and investment in organic infrastructure in the Prairies, there are still significant gaps. Through compiling the latest research on organics, creating resources, training producers on how to implement these practices, mobilizing the industry and helping to build organic infrastructure, this stream will improve organic field crop quantity and quality.

Market Development Stream

Objective:
Increased markets for prairie organic grains

A major barrier to profitable organic production is whole-farm business planning and marketing of organic products. The Prairie organic brand needs to be promoted in new as well as existing markets. Information sharing across the whole value-chain is also crucial for market development. Through data integration, networking and buyer missions abroad, this stream will ensure profitability for producers and processors while providing improved market access.

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Update on the Optimization Stream

The Optimization Advisory Team has been meeting regularly over the last several months and have determined eight priority areas to focus resources and activities. The team is now developing an implementation plan for each area.

1 Improving Soil Fertility

Understanding the role of Green Manures in Soil Fertility: Green Manures are crops grown primarily to add nutrients such as nitrogen to the soil for a subsequent crop. Understanding how to maximize soil fertility through green manures is crucial to improving crop quality and yields.

Application of Off-Farm Nutrients: Green manures may supply most but not all nutrients for organic crops, so producers often need to add nutrients from off-farm at some point. However, what to use, where to source it, how to apply it and what is most economical in terms of nutrient use is still poorly understood by many organic producers.

2 Improving Weed Management

Tillage Equipment and Practices: Tillage is typically the primary weed management technique used by organic producers, but there are many variations in terms of timing, depth, adjustments etc. that can greatly effect weed management and crop quality. There are also new technologies being developed to mitigate weed pressure without impacting the crop, however they have not been thoroughly tested under prairie organic conditions, and their cost-effectiveness needs to be explored.
Cultural Management Practices to Reduce ***Weed Pressure:*** Organic producers use multiple cultural techniques to reduce weed pressure, such as increasing seeding density, seeding in two directions, increasing or decreasing row spacing and intercropping. Producers often try different things each year without really knowing what will be effective. More examples of effective techniques in different crops are required.

3 Improving Crop Quality

Post-Harvest Sanitation and Economics: Organic harvests can contain more weed seeds and more immature grain than conventional, so cleaning and storage of organic grain is crucial for ensuring crop quality is maximized. Easy to use technologies like the Quick-Clean greatly improve sanitation and economics, but there is poor uptake among producers. Bin cleanliness is another factor that impacts crop quality.
Cultural Management Practices to Improve ***Crop Quality:*** Organic management relies heavily on cultural control practices for nutrient and weed management. However, these are often regionally-specific, and practices vary widely from producer to producer. Systematizing cultural management practices by crop and region could go a long way to improving organic crop quality.

4 Improving Whole Farm Management

Understanding Crop Rotation for Nutrient Budgeting and Weed Control: Crop rotations are integral to organic production, both for nutrient and weed management, however Prairie organic producers vary widely on how they use rotations. Through monitoring nutrient budgets in the rotation, adjustments can be made to maximize crop quantity and quality.
Cost of Production and Rotation Design: Before producers know what changes to make to their system, they have to understand how their bottom line will be impacted. This requires having a good understanding of their cost of production and how to calculate it. Many organic producers are not making management decisions from a cost of production perspective, which can negatively impact their profitability.

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Why Green Manures?

- Critical fertility source for Prairie organic grain production
- Many organic farmers are still seeking resources to inform management decisions
- Key in supporting transition, and optimizing yield and quality

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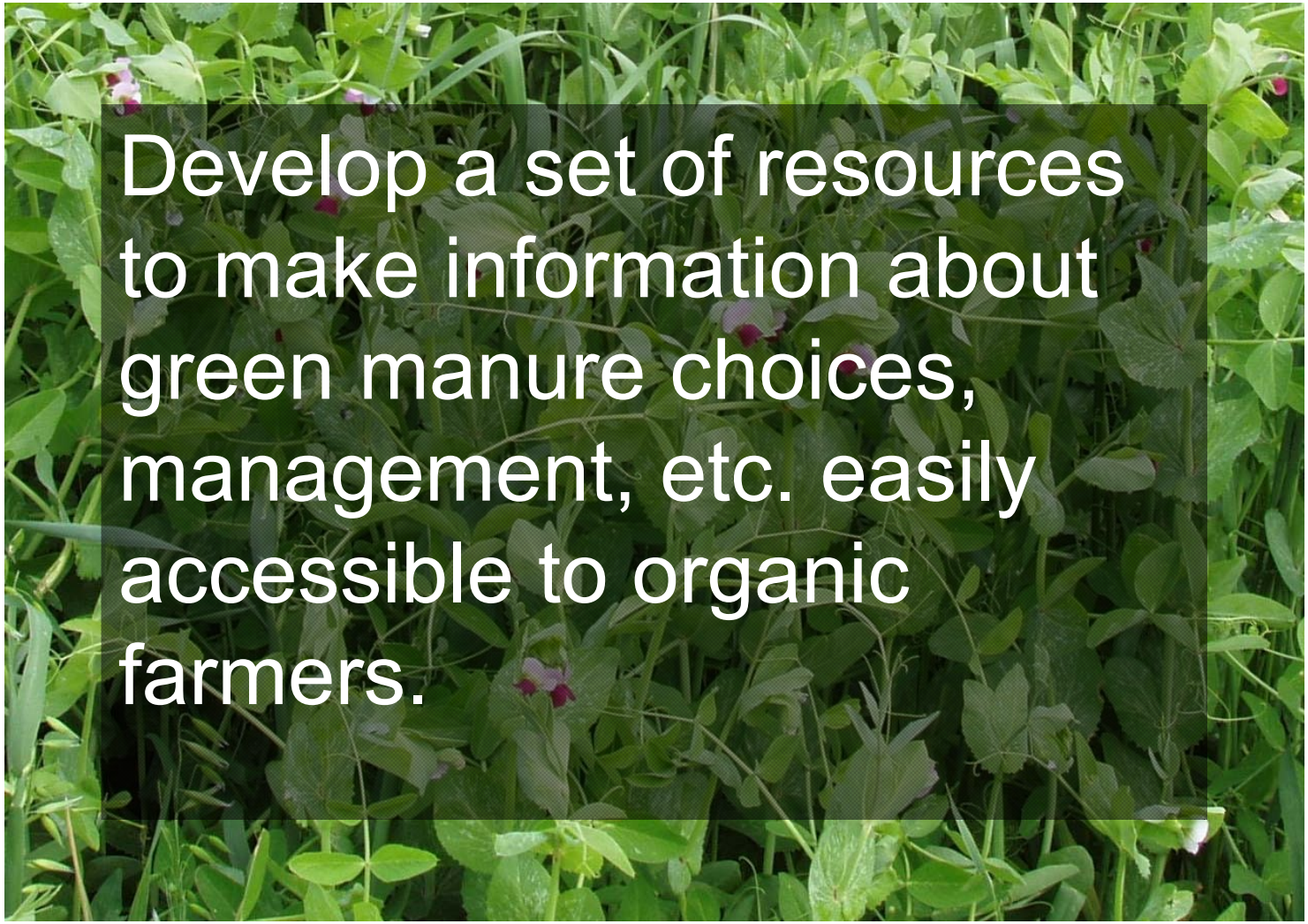
The Goal



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Knowledge Dissemination: A Green Manure Case Study

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Step 2: Collect Information

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Collecting Information: Consultations

1. Consult with farmers to identify gaps in green manure knowledge & resources

- 14 one-on-one interviews with Prairie organic grain producers
    - 27 farmers participated in a field day event
- Surveyed on information needs and format preferences

Overview of the organic grain producers surveyed, including their location, soil zone, cropping system, farm size and organic status

Province	Soil Zone	Cropping System	Acreage	Organic Status
Alberta: 8	Br/Dk Br: 27	Crops only: 5	> 1000 acres: 9	Organic: 10
Manitoba: 6	Black: 9	Forage in rotation: 9	< 1000 acres: 5	Transitional: 2
Sask.: 27	Dark Gray: 3			Split: 4
	Gray: 1			

Collecting Information: Consultations

2. Consult with researchers and extension specialists for guidance on content and format of green manure resources

- Subject-matter experts (research & extension)
    - 13 one-on-one interviews or email conversations

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Collecting Information: Consultations

Overarching informational needs:

- Use of green manures varied widely, by farming system & soil zone
  - This is an important consideration for resource development
- Economic cost of green manures must be justified or offset

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Collecting Information: Consultations

- Detailed informational needs:
  - Overarching + specific information
  - Economic value of green manures
  - Soil fertility & moisture impacts
  - Best species choices
  - Availability of seed & inoculants
  - Green manure mixes
  - Multi-functionality
  - Green manures as a weed management tool
  - How to integrate into the rotation
  - Management techniques
  - How to adapt plans

Collecting Information: Consultations

Format preferences:

- Varied, and included:
  - Concise information with option for more in-depth materials
  - Printed factsheets, manuals
  - Videos
  - Need for on-the-ground knowledge
    - In-person consultations
    - Field days and workshops
  - Split preference for online/print

Step 2: Collect Information

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Collecting Information: Enviro-Scan

- Identified, classified and analyzed currently available research and extension resources
    - Scientific & extension information from the last 35 years from Canadian Prairies & adjacent US states

The Enviro-Scan report & database of studies is available on the Organic Alberta website, http://organicalberta.org/

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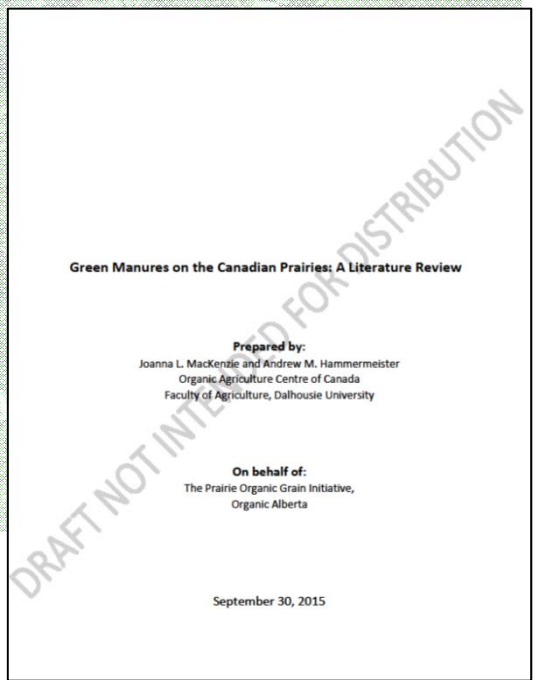
Collecting Information: Enviro-Scan

Collecting Information: Lit Review

- Looked at research studies conducted over the last 35 years on the Canadian prairies and adjacent US Northern Great Plains.
- Total of 56 studies.
- Summarized the research results relevant to green manure use for Prairie organic grain production.
- Literature also emphasized regional differences.


Green Manures on the Canadian Prairies: A Literature Review

Prepared by:
Joanna L. MacKenzie and Andrew M. Hammermeister
Organic Agriculture Centre of Canada
Faculty of Agriculture, Dalhousie University

On behalf of:
The Prairie Organic Grain Initiative,
Organic Alberta

September 30, 2015

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Collecting Information: Lit Review

- Need for information on:
  - ❑ Overarching + specific information
  - ❑ Economic value of green manures
  - ❑ Soil fertility & moisture impacts
  - ❑ Best species choices
  - ❑ Availability of seed & inoculants
  - ❑ Green manure mixes
  - ❑ Multi-functionality
  - ❑ Green manures as a weed management tool
  - ❑ How to integrate into the rotation
  - ❑ Management techniques
  - ❑ How to adapt plans

Collecting Information: Lit Review

- Information available on:
  - ☑ Overarching + specific information
  - ☑ Economic value of green manures
  - ☑ Soil fertility & moisture impacts
  - ☑ Best species choices
  - ❑ Availability of seed & inoculants
  - ☑ Green manure mixes
  - ☑ Multi-functionality
  - ☑ Green manures as a weed management tool
  - ☑ How to integrate into the rotation
  - ☑ Management techniques
  - ❑ How to adapt plans

Step 2: Collect Information

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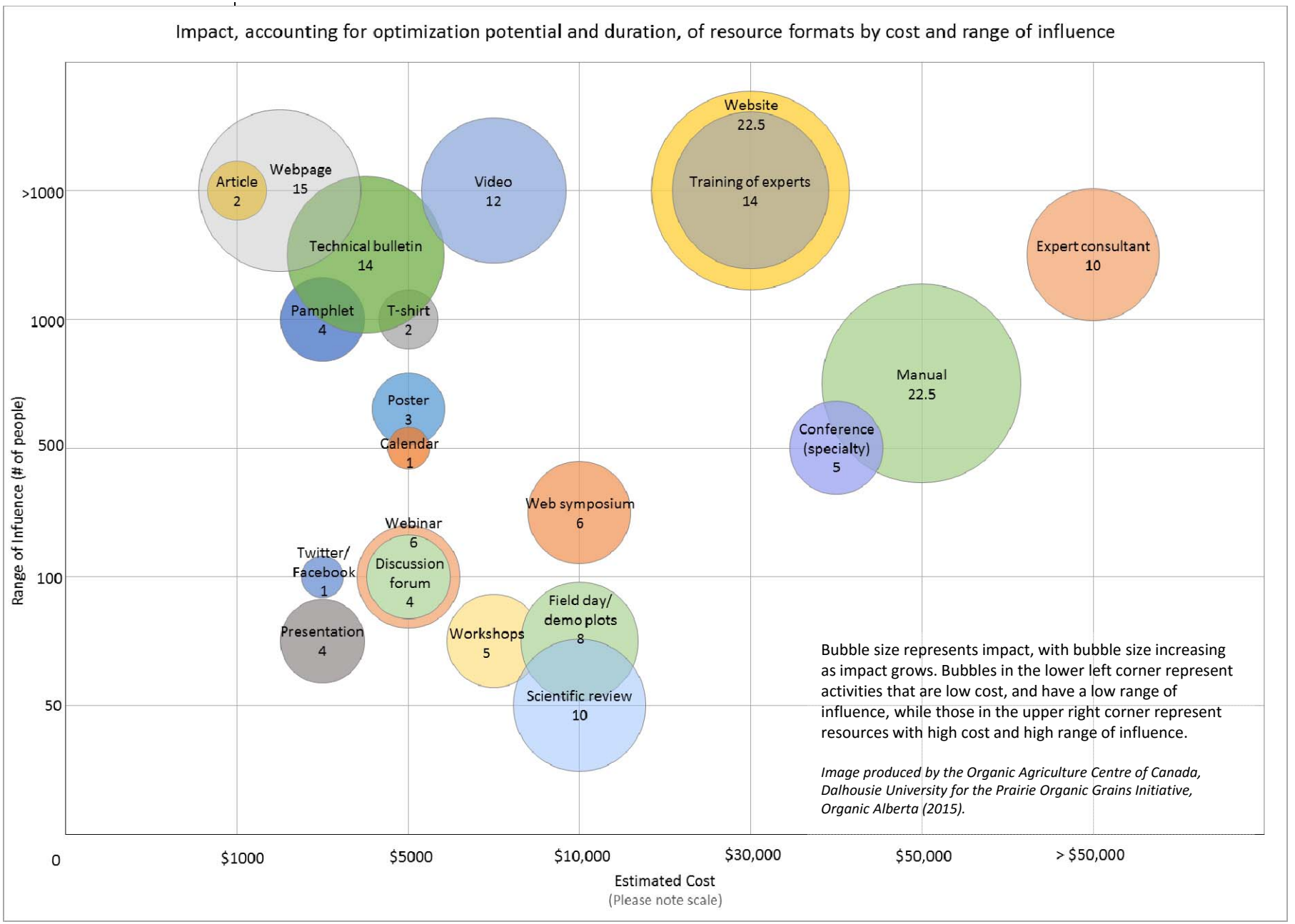
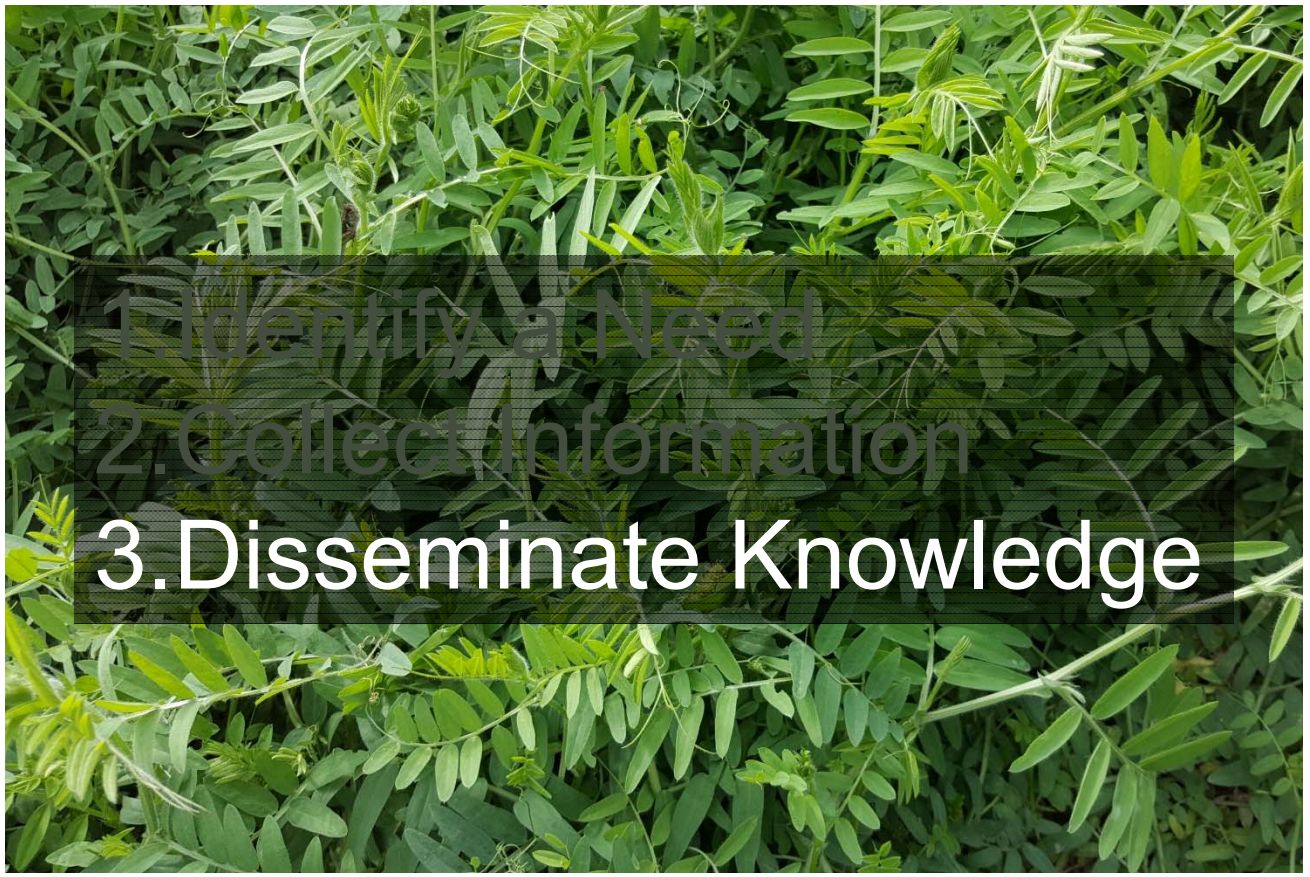

Impact, accounting for optimization potential and duration, of resource formats by cost and range of influence
Range of Influence (# of people)
>1000
1000
500
100
50
0
$1000
$5000
$10,000
$30,000
$50,000
> $50,000
Estimated Cost
(Please note scale)
Article 2
Webpage 15
Video 12
Website 22.5
Training of experts 14
Expert consultant 10
Technical bulletin 14
Pamphlet 4
T-shirt 2
Manual 22.5
Conference (specialty) 5
Poster 3
Calendar 1
Web symposium 6
Webinar 6
Discussion forum 4
Twitter/ Facebook 1
Presentation 4
Workshops 5
Field day/ demo plots 8
Scientific review 10
Bubble size represents impact, with bubble size increasing as impact grows. Bubbles in the lower left corner represent activities that are low cost, and have a low range of influence, while those in the upper right corner represent resources with high cost and high range of influence.
Image produced by the Organic Agriculture Centre of Canada, Dalhousie University for the Prairie Organic Grains Initiative, Organic Alberta (2015).

Knowledge Dissemination: A Green Manure Case Study



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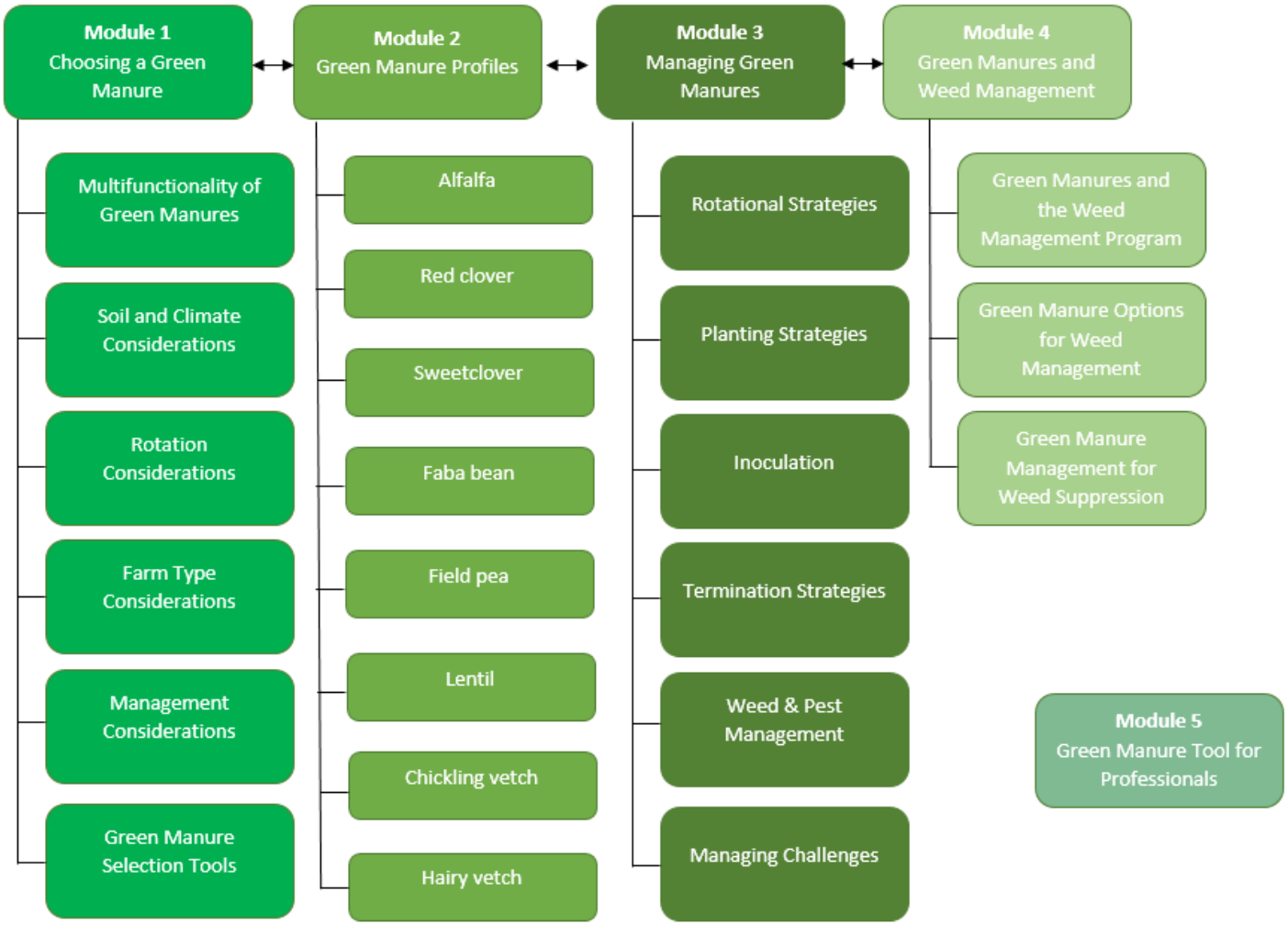
Online Green Manure Toolkit



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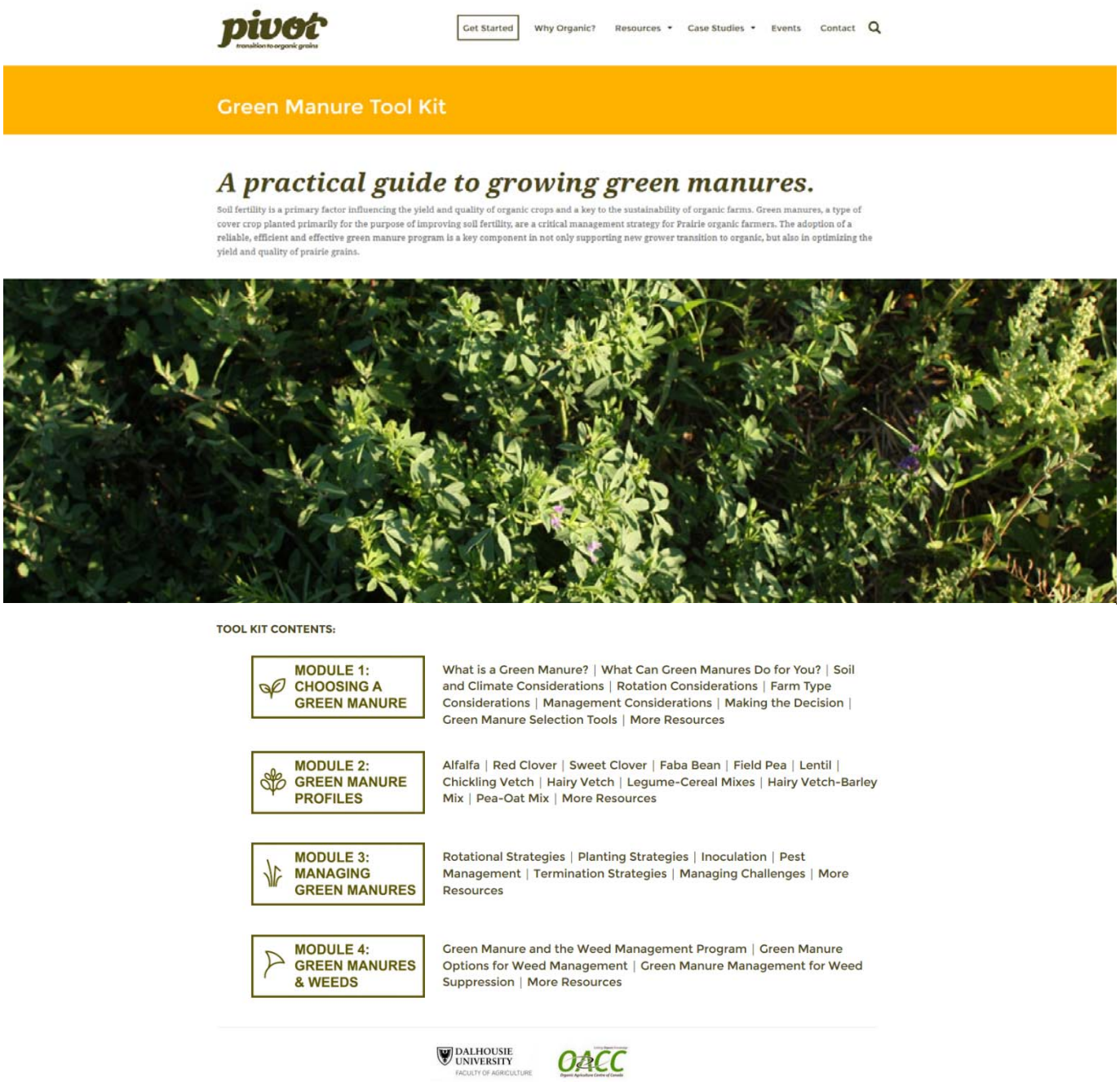

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Regionally Appropriate Information

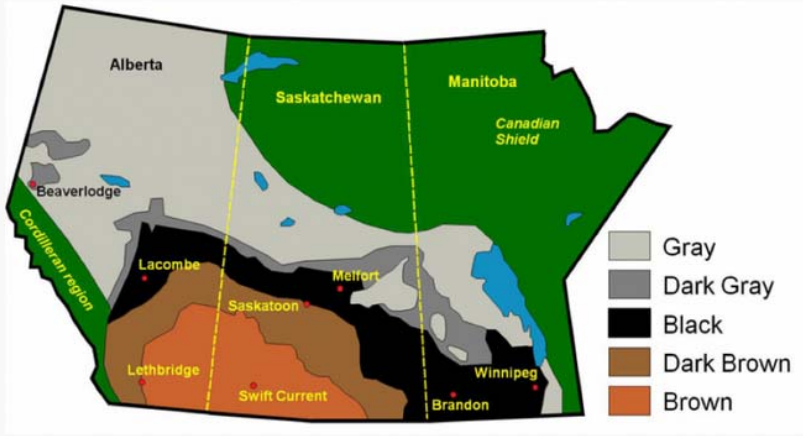
Green Manure Toolkit

Module 1: Choosing a Green Manure

Back to all modules | Next: Module 2

3. SOIL AND CLIMATE CONSIDERATIONS

It is very important to consider the soil, climate and water availability on your farm before choosing a green manure. On the Canadian Prairies, the soil zone is a good, but general, indicator of soil moisture. The moisture availability for a crop is lowest in the Brown soil zone, and increases as you move through the Dark Brown, Black, Dark Gray and Gray soil zones.



Soil zones of the Canadian Prairies

3.1. SOIL MOISTURE

Green manures, like all crops, draw water from the soil as they grow. In areas where moisture can be

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Detailed & Accessible Information

Green Manure Toolkit

Module 1: Choosing a Green Manure

- 1. What is a Green Manure?
- 2. What Can Green Manures Do For You?
- 3. Soil and Climate Considerations
- 4. Rotation Considerations
- 5. Farm Type Considerations
- 6. Management Considerations
- 7. Making the Decision
- 8. Green Manure Selection Tools
- 9. Digging Deeper - More Resources

4. ROTATION CONSIDERATIONS

Green manures can be an essential part of the organic field crop rotation. With the value they can provide to the farm, green manure crops should be treated with care equal to that given to cash crops in the rotation. The establishment of a good stand can optimize the benefits provided by the green manure, both in terms of nitrogen fixation [link to N info from COG Handbook] as well as secondary benefits [Link to Benefits section].

There are a number of options that can allow green manure inclusion in most rotations. Options for full- or partial-season green manure crops [link to this section below], annual or longer lasting crops [link to this section below], and pure or mixed stands [link to this section below] can provide flexibility and allow most goals to be met.

4.1. ANNUALS, BIENNIALS AND PERENNIALS

There are annual (peas, lentils, beans, vetches), biennial (sweetclover) and perennial (alfalfa, clovers) legume options for green manures (Figure 9). With this variation, there is a suitable green manure for most any rotation on the Prairies. Annual green manures can occupy a full season in the rotation, or can even be planted after the harvest of a winter grain where the climate allows. Biennial green manures are often underseeded into grain crops, so although they grow for two years, only one year of the rotation is dedicated solely to the green manure. Perennial green manures are also generally underseeded into a grain crop, and can then be grown on their own for one or more years. Each green manure lifecycle brings its own unique advantages and challenges, which are outlined in Table 1.

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nure9.png

Quick Reference Materials

SUITABILITY OF COMMONLY USED GREEN MANURE LEGUMES TO THE MAIN PRAIRIE SOIL ZONES (PDF DOWNLOAD)

Suitability of commonly used green manure legumes to the main Prairie soil zones.

	Brown	Dark Brown	Black	Dark Gray	Gray
Alfalfa	Not recommended *High water use*	Ok *Adapt management to reduce water use*	Ok	Best suited	Not recommended *Low tolerance of excessive soil moisture or flooding*
Red clover	Not recommended *High water use*	Ok *Adapt management to reduce water use*	Ok	Best suited *Tolerant of high moisture, but may be a short-lived perennial in cold regions*	Best suited *Tolerant of high moisture, but may be a short-lived perennial in cold regions*
Sweetclover	Ok *Adapt management to reduce water use*	Ok *Adapt management to reduce water use*	Best suited	Best suited	Best suited
Indianhead lentil	Best suited *Adapt management to reduce water use*	Best suited	Ok	Not recommended *Does not perform well under higher moisture conditions*	Not recommended *Does not perform well under higher moisture conditions*
Field pea	Ok *Adapt management to reduce water use and expect lower biomass*	Best suited *Performs well, but high seed cost*	Best suited *Performs well, but high seed cost*	Ok *Performs well, but higher seed cost than some other options*	Ok *Performs well, but higher seed cost than some other options*
Faba bean	Not recommended *Requires high moisture availability*	Ok *Requires high moisture availability, so may not be suited to all regions*	Best suited *Some indications that faba bean fixes nitrogen even under high soil fertility, but high seed cost*	Ok *Sufficient moisture, but high seed cost*	Ok *Sufficient moisture, but high seed cost*
Chickling vetch	Best suited *Low water use*	Best suited *Low water use*	Ok	Ok	Ok
Hairy vetch	Ok *Be cautious of soil water use and high seed cost*	Ok *Be cautious of soil water use and high seed cost*	Best suited *Abundant biomass and nitrogen, but high seed cost*	Ok *Likely not winter hardy in more northern regions, but can be spring-seeded*	Ok *Likely not winter hardy in more northern regions, but can be spring-seeded*

This table provides information based on typical climate and moisture conditions in the five Prairie soil zones. In atypical years, refer to the recommendations for zones with typical conditions closest to what you are experiencing. For instance, in droughty years in the Black or Gray soil zones, refer to recommendations for the Brown or Dark Brown soil zones.

This table provides information based on typical climate and moisture conditions in the five Prairie soil zones. In atypical years, refer to the recommendations for zones with typical conditions closest to what you are experiencing. For instance, in droughty years in the Black or Gray soil zones, refer to

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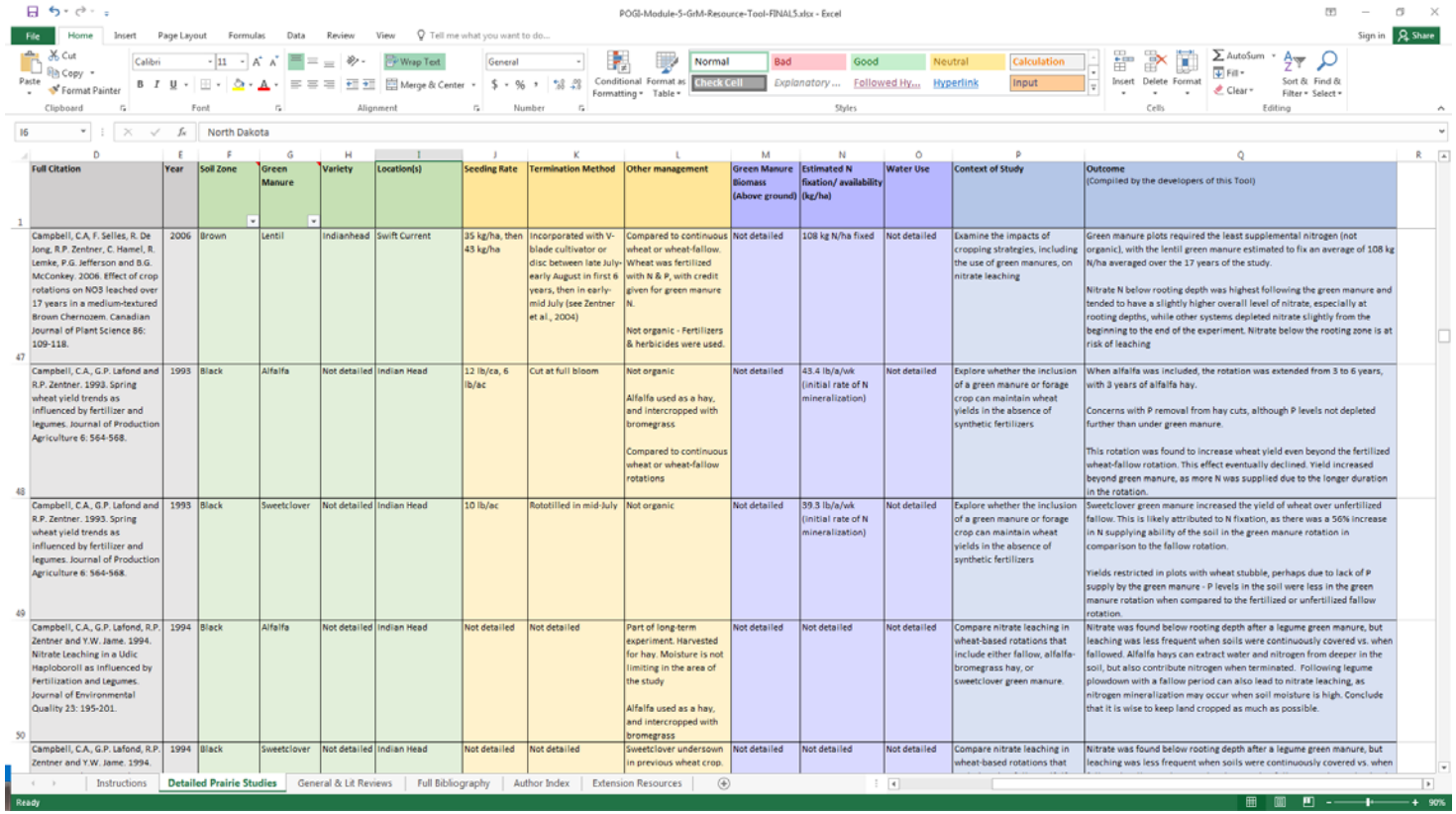
Reference Tool



POGI-Module-5-GrM-Resource-Tool-FINAL5.xlsx - Excel

I6: North Dakota

Full Citation	Year	Soil Zone	Green Manure	Variety	Location(s)	Seeding Rate	Termination Method	Other management	Green Manure Biomass (Above ground)	Estimated N fixation/ availability (kg/ha)	Water Use	Context of Study	Outcome (Compiled by the developers of this Tool)
Campbell, C.A, F. Selles, R. De Jong, R.P. Zentner, C. Hamel, R. Lemke, P.G. Jefferson and B.G. McConkey. 2006. Effect of crop rotations on NO3 leached over 17 years in a medium-textured Brown Chernozem. Canadian Journal of Plant Science 86: 109-118.	2006	Brown	Lentil	Indianhead	Swift Current	35 kg/ha, then 43 kg/ha	Incorporated with V-blade cultivator or disc between late July-early August in first 6 years, then in early-mid July (see Zentner et al., 2004)	Compared to continuous wheat or wheat-fallow. Wheat was fertilized with N & P, with credit given for green manure N. Not organic - Fertilizers & herbicides were used.	Not detailed	108 kg N/ha fixed	Not detailed	Examine the impacts of cropping strategies, including the use of green manures, on nitrate leaching	Green manure plots required the least supplemental nitrogen (not organic), with the lentil green manure estimated to fix an average of 108 kg N/ha averaged over the 17 years of the study. Nitrate N below rooting depth was highest following the green manure and tended to have a slightly higher overall level of nitrate, especially at rooting depths, while other systems depleted nitrate slightly from the beginning to the end of the experiment. Nitrate below the rooting zone is at risk of leaching
Campbell, C.A., G.P. Lafond and R.P. Zentner. 1993. Spring wheat yield trends as influenced by fertilizer and legumes. Journal of Production Agriculture 6: 564-568.	1993	Black	Alfalfa	Not detailed	Indian Head	12 lb/ca, 6 lb/ac	Cut at full bloom	Not organic Alfalfa used as a hay, and intercropped with bromegrass Compared to continuous wheat or wheat-fallow rotations	Not detailed	43.4 lb/a/wk (initial rate of N mineralization)	Not detailed	Explore whether the inclusion of a green manure or forage crop can maintain wheat yields in the absence of synthetic fertilizers	When alfalfa was included, the rotation was extended from 3 to 6 years, with 3 years of alfalfa hay. Concerns with P removal from hay cuts, although P levels not depleted further than under green manure. This rotation was found to increase wheat yield even beyond the fertilized wheat-fallow rotation. This effect eventually declined. Yield increased beyond green manure, as more N was supplied due to the longer duration in the rotation.
Campbell, C.A., G.P. Lafond and R.P. Zentner. 1993. Spring wheat yield trends as influenced by fertilizer and legumes. Journal of Production Agriculture 6: 564-568.	1993	Black	Sweetclover	Not detailed	Indian Head	10 lb/ac	Rototilled in mid-July	Not organic	Not detailed	39.3 lb/a/wk (initial rate of N mineralization)	Not detailed	Explore whether the inclusion of a green manure or forage crop can maintain wheat yields in the absence of synthetic fertilizers	Sweetclover green manure increased the yield of wheat over unfertilized fallow. This is likely attributed to N fixation, as there was a 56% increase in N supplying ability of the soil in the green manure rotation in comparison to the fallow rotation. Yields restricted in plots with wheat stubble, perhaps due to lack of P supply by the green manure - P levels in the soil were less in the green manure rotation when compared to the fertilized or unfertilized fallow rotation.
Campbell, C.A., G.P. Lafond, R.P. Zentner and Y.W. Jame. 1994. Nitrate Leaching in a Udic Haploboroll as Influenced by Fertilization and Legumes. Journal of Environmental Quality 23: 195-201.	1994	Black	Alfalfa	Not detailed	Indian Head	Not detailed	Not detailed	Part of long-term experiment. Harvested for hay. Moisture is not limiting in the area of the study Alfalfa used as a hay, and intercropped with bromegrass	Not detailed	Not detailed	Not detailed	Compare nitrate leaching in wheat-based rotations that include either fallow, alfalfa-bromegrass hay, or sweetclover green manure.	Nitrate was found below rooting depth after a legume green manure, but leaching was less frequent when soils were continuously covered vs. when fallowed. Alfalfa hays can extract water and nitrogen from deeper in the soil, but also contribute nitrogen when terminated. Following legume plowdown with a fallow period can also lead to nitrate leaching, as nitrogen mineralization may occur when soil moisture is high. Conclude that it is wise to keep land cropped as much as possible.
Campbell, C.A., G.P. Lafond, R.P. Zentner and Y.W. Jame. 1994.	1994	Black	Sweetclover	Not detailed	Indian Head	Not detailed	Not detailed	Sweetclover undersown in previous wheat crop.	Not detailed	Not detailed	Not detailed	Compare nitrate leaching in wheat-based rotations that	Nitrate was found below rooting depth after a legume green manure, but leaching was less frequent when soils were continuously covered vs. when

Sheet tabs: Instructions | Detailed Prairie Studies | General & Lit Reviews | Full Bibliography | Author Index | Extension Resources

Ready

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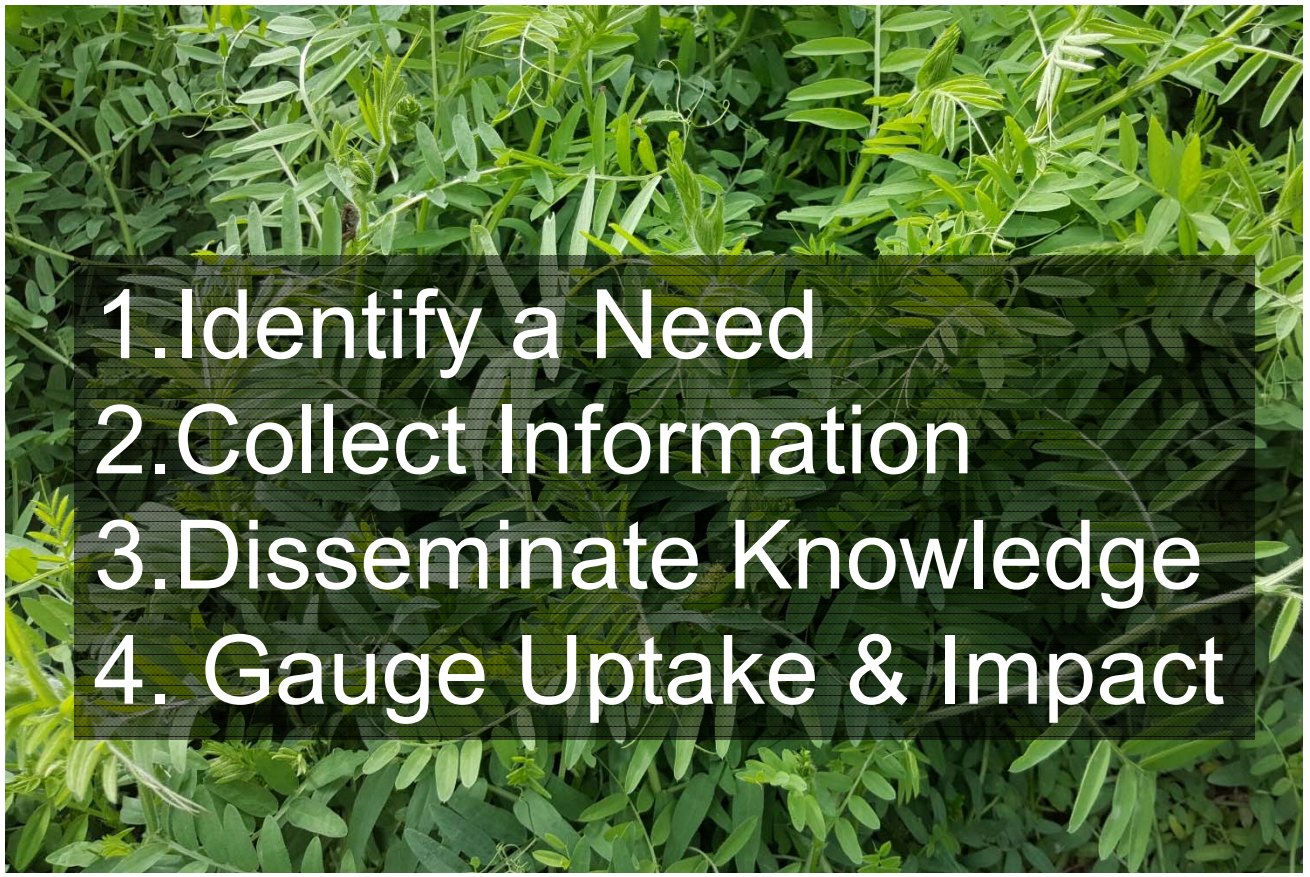

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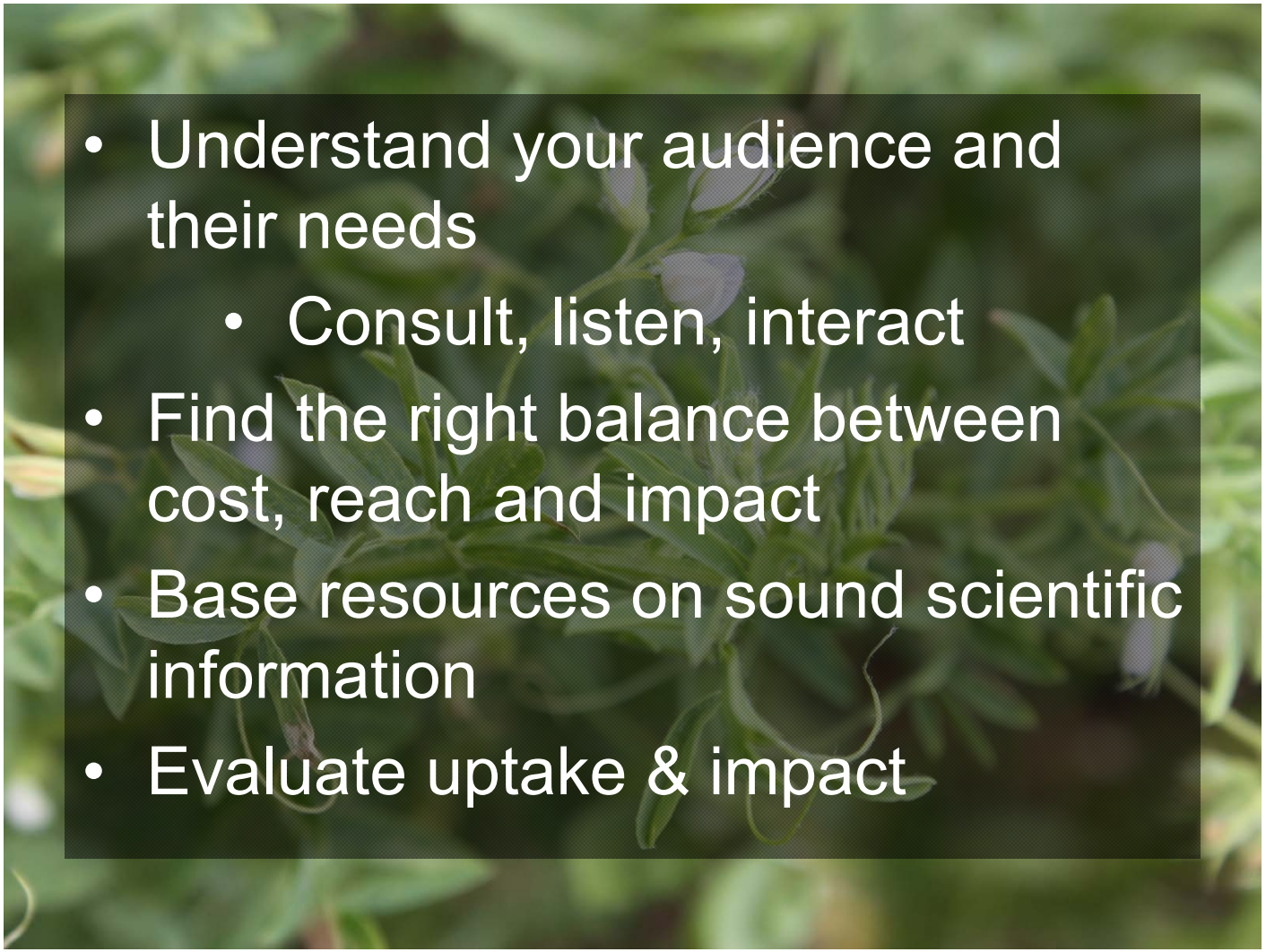
Take Away Messages



- Understand your audience and their needs
    - Consult, listen, interact
- Find the right balance between cost, reach and impact
- Base resources on sound scientific information
- Evaluate uptake & impact

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Thank you

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Questions?

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