Guide to Preparing, Organizing and Formatting a Thesis or Dissertation 2nd Edition

for the

Department of Soil Science

UNIVERSITY OF SASKATCHEWAN

College of Agriculture and Bioresources

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This guide contains elements derived from numerous sources including: the College of Graduate Studies and Postdoctoral Studies, University of Saskatchewan; the Graduate School of the University of Tennessee, Knoxville; the Graduate School of the University of Central Arkansas; the University of Saskatchewan Department of Food and Bioproduct Sciences; the Faculty of Graduate Studies at the University of Alberta; the Office of Graduate Studies University of Calgary; the Graduate College, Iowa State University; and the American Society of Agronomy (ASA), Crop Science Society of America (CSSA) and the Soil Science Society of America (SSSA) Publications Handbook and Style Manual.

The first edition of this guide was developed by Dr. Rich Farrell and approved by the Graduate Committee, Dept. of Soil Science, University of Saskatchewan. The second edition was revised by Dr. Diane Knight on behalf of the Graduate Committee, Dept. of Soil Science, University of Saskatchewan. Tables, figures and illustrations used as examples, and included in the appendix, were taken from theses and dissertations prepared by students in the Department of Soil Science and were used with permission.

PURPOSE OF THIS GUIDE

This guide provides basic information about thesis and dissertation preparation in the Department of Soil Science at the University of Saskatchewan. It establishes the technical parameters within which all students must work. These parameters include margins, formatting and style, sequence of pages, and spacing. The guide does not address issues of content such as grammar, punctuation or wording. Correction of content is the responsibility of the student as overseen by his/her supervisor(s) and graduate advisory committee (GAC).

While a student's GAC evaluates the technical quality and content of a thesis or dissertation, the Department of Soil Science—in conjunction with the College of Graduate and Postdoctoral Studies (CGPS)—imposes formatting requirements to ensure an appropriate and consistent academic appearance of the document. This *Guide* sets forth basic requirements for organizing and formatting a thesis or dissertation, but students in consultation with their GAC have some leeway in determining the look and feel of their document. However, once a student chooses a specific formatting standard, the student must apply that standard consistently throughout the document.

Graduate students in the Department of Soil Science are required to follow the guidelines established by the Soil Science Society of America[1] for bibliographic form (i.e., how to cite references both in the body of the text and in the References section), symbols used to denote statistical significance, symbols used to denote footnotes in tables and figures, and other conventions that are discipline specific (e.g., SI and non-SI units used in the various soil science disciplines). Students should examine recent SSSA publications, such as the Soil Science Society of America Journal, to assist them in preparing their thesis or dissertation. It is imperative that the student understand the various elements of a manuscript and general formatting requirements in academic publishing. Although knowledge and use of journal-specific publication formatting is essential, ***the regulations established in this Guide take precedence over any other style manuals for final submission of a thesis or dissertation***.

Students should NOT rely on previously accepted theses or dissertations as the final guide for formatting. Examples taken from other theses and dissertations may be out of context, out of date, or incorrect. The existence of a particular style or usage in a previously accepted thesis or dissertation ***does NOT establish precedent*** for its continuation. Students are responsible for obtaining and following up-to-date guidelines. When in doubt, check with the Graduate Chair or your GAC for guidance.

[1] American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America. 2013. Publications Handbook and Style Manual https://www.soils.org/publications/journals/author-resources/style-manual/

TABLE OF CONTENTS

GENERAL INFORMATION

The thesis, or dissertation (more on that later) is a major component of the Department's graduate program—you cannot graduate without having completed one—and can rightfully be viewed the 'crowning achievement' of your program. Strictly speaking, a thesis is a "statement or hypothesis that can be tested or rationally argued", while a dissertation is a "document or discourse that offers new insight as the result of structured research". From an academic standpoint, however, a **thesis** summarizes and discusses independent, original research carried out by the student on a specific subject, and is the final project for a Master of Science Degree. A **dissertation** is different in that—although it too summarizes and discusses independent research carried out by the student—it ***must contribute new knowledge that is original, substantial and verifiable***. A dissertation is the final project for a Doctoral Degree.

Your thesis/dissertation is intended to demonstrate that you can take on a project, execute it, and bring it to a genuine conclusion

Your thesis/dissertation must: (i) deal in an academically satisfactory way with a defined topic related to your major research field, (ii) demonstrate your ability to do independent study and investigation, (iii) be written using formal scientific and scholarly language—conforming to the style requirements approved by the Department and detailed in this *Guide*. In addition, all students whose programs of study require a Thesis or Dissertation must comply with the College of Graduate and Postdoctoral Studies (CGPS) requirements[2] in order to graduate.

The University of Saskatchewan requires that all Theses and Dissertations be electronically submitted. Theses and dissertation may be bound, but the copy that is submitted to CGPS and deposited in the University Library MUST BE AN ELECTRONIC VERSION. The CGPS works with the University Library, and other members of the academic community to offer sustainable and accessible digital repositories for dissertations and theses written by *U of S* students. In addition to the electronic (thesis.pdf) version of the thesis/dissertation that is required by CGPS and the University Library, the Department of Soil Science requires that one hardbound copy of the thesis/dissertation—formatted as described in this *Guide*—be provided to the Graduate Chair PRIOR to Convocation.

Although not required, it is highly recommended that you obtain one or more bound copies of your thesis/dissertation for your personal use. Your supervisor also may request a bound copy of

[2] CGPS requirements and guidelines for thesis preparation, defence, and submission can be viewed at: https://students.usask.ca/graduate/thesis-preparation.php

the thesis/dissertation and, as a matter of courtesy, you should ask the members of your graduate advisory committee if they would like a copy (hard or soft bound, or electronic) for themselves. The cost associated with the preparation, printing and binding of a thesis is the responsibility of the student. However, you should consult your supervisor concerning his/her personal policy regarding cost sharing.

A thesis/dissertation that does not follow the Department's prescribed format, or which fails to meet CGPS requirements, will not be accepted and the required Departmental recommendation for award of the graduate degree will not be forwarded to CGPS until the acceptable standard has been met.

Thesis Confidentiality

Your thesis/dissertation is a public document and once submitted for the degree is placed into the public domain—*unless the candidate and the thesis supervisor request that it be temporarily withheld from circulation*. The specific reason(s) for the request must be indicated; e.g., you have the option to delay publication of a thesis/dissertation for copyright or other reasons. Requests to withhold an electronic thesis or dissertation (ETD) are valid for one year. For each additional year (to a maximum of three years), a request outlining the rationale for the extension must be submitted to the CGPS prior to the previous year's expiry date.

You can request limited access to your thesis/dissertation when uploading your PDF file to the ETD website (https://etd.usask.ca/). Note that any decision to limit access to your thesis/dissertation should be made in consultation with your supervisor(s) and/or GAC.

STUDENT INTEGRITY

Theses and dissertations are placed in the public domain; thus their preparation and presentation must adhere to sound academic and ethical standards (e.g., no plagiarism). There are two areas in which graduate students should be particularly cautious: (i) the proper acknowledgment of the contribution of others, and (ii) the use of copyrighted materials.

Proper Acknowledgment

All graduate students are expected to act in accordance with the University's standards for academic honesty, integrity and fairness (https://cgps.usask.ca/policy-and-procedure/conduct-discipline/academic-integrity.php#141STUDENTCONDUCT). It is the job of each and every student to ensure that she/he does not use the intellectual property or product of someone else without giving proper credit; i.e., students must take care not to plagiarize. Plagiarism is defined by the University as *"the presentation of the work or idea of another in such a way as to give others the impression that it is the work or idea of the presenter. Adequate attribution is required. What is essential is that another person have no doubt which words or research results are the student's and which are drawn from other sources*".

Any material taken from another source must be fully acknowledged. This is especially important in instances where the student is involved in collaborative research, in which case the work of all contributors must be appropriately acknowledged. Suspected plagiarism will be investigated and appropriate action taken.

If any chapter in the submitted thesis or dissertation has been published previously, or has been submitted for publication, this too must be disclosed. If in doubt, check with your supervisor.

The Use of Copyrighted Material[3]

Copyright law in Canada protects a wide range of works. If you wish to reproduce a substantial part of a copyrighted work, you may copy the work only if the *Copyright Act* specifically allows you to do so, or if you have express permission from the copyright owner. The law governing copyright infringement is based on a principle called "fair dealing"[4]. Fair dealing is an exception to the *Copyright Act*, which permits the use of "*less than substantial passages and quotations from*

[3] General information about copyrights and the most recent copyright guidelines can be viewed at: https://library.usask.ca/copyright/index.php.

[4] The University of Saskatchewan has established a set of Fair Dealing Guidelines, which all students should read and understand before using materials protected by copyright in their thesis/dissertation. https://library.usask.ca/copyright/general-information/fair-dealing-guidelines.php#Background

material protected by copyright for the purpose of private study, research, criticism, review, newspaper reporting, education, parody, or satire".

Authors invoking fair dealing must still give full credit to the original author and must ensure that quotes are not taken out of context, making the author of the quoted passage seem to be saying something different from, what was intended. Even when permission is not needed, students must cite the original author's work fully.

If extensive material from a copyrighted work (e.g., more than 30% of a figure or table) is included in the student's thesis/dissertation, permission from the owner must be obtained in writing. The publisher usually has the authority to grant permission to quote excerpt from a copyrighted work, or can refer requests to the copyright owner or designated representative. Note, however, that Publishers/Copyright holders are under no obligation to provide you with permission to use their material, and may charge for permission to use copyrighted material.

It is the responsibility of the student to obtain permission from the owner of material not in the public domain. A letter should be sent requesting permission and, if you receive permission, you are required to abide by the terms set out by the owner of the copyright. Please keep copies of any permissions you receive and include the letter (blocking out the signature) granting permission in the appendix to your thesis/dissertation.

Obtaining letters of copyright permission can take a considerable amount of time—be sure to allow yourself sufficient time to get the necessary letter(s).

Permissions should be credited on the acknowledgments page, and the source should appear in the list of references or bibliography section.

Use of Internet Links (Embedding)

Although it is not prohibited, **the use of hyperlinks in a thesis or dissertation is strongly discouraged** because, unlike material published in paper journals and books, the content and location of websites changes frequently. For this reason alone, students should **not** link to material that is **integral** to their thesis or dissertation. Instead, they should seek permission to include that material in their thesis or dissertation.

As with any content that is not the student's own work, internet and other electronic sources must be cited as fully as print materials. At the very least, such works will have a title and a date, as well as the address or URL for internet materials. The date is normally the date consulted or date accessed. The Soil Science Society of America has specific guidelines for citing electronic materials—consult the society's *Publications Handbook and Style Manual* when including internet or electronic resources in your thesis/dissertation.

ELEMENTS AND STYLE OF THE THESIS/DISSERTATION

The main consideration in formatting the thesis/dissertation is consistency of both form and style. Whereas the College of Graduate Studies and Postdoctoral Studies (CGPS) has specific rules and parameters that all theses and dissertation writers must follow, students—in consultation with their graduate advisory committee—do have some flexibility in formatting their thesis/dissertation. Once a specific formatting standard is selected, the student must apply that standard consistently throughout the document.

Students must use a uniform and consistent style, typeface, and font size throughout their thesis/dissertation.

Typeface or Font

Typeface (font) will affect the physical appearance of the thesis/dissertation more than any other single element. Word processing software provides the opportunity to use different typefaces, type sizes, and font attributes, such as bold or italics.

Type Size. The size of type is determined by point size. Text is most readable in 12, 11, or 10 point, depending on font. The standard font and size is Times New Roman, 12 pt **or** equivalent (e.g., Arial, 10.5 pt or Cambria, 11.5 pt). Other sizes may be used for headings, footnotes, table contents, captions, etc. . .

Consistency of Font Attributes. In terms of typeface, consistency is key. Students should use specific type sizes and font attributes to establish styles or conventions that are then followed consistently throughout the document. For example, if the student chooses to use bold for table numbers, all table and figure numbers should be bold. Use of the style features of your word processor or other software can help ensure consistent application of font size and other attributes.

The typeface selected for the text will be the base style (i.e., the starting point) for all type selection and will establish the framework for the entire document. All of the following items must be in the family of type selected as the base style:

- the font must be **black**
- all prefatory pages (e.g., permission to use, acknowledgements, abstract, . . .)
- all text
- all tables, even those from other sources
- figure numbers and titles (the text within figure may be of a different typeface)

- all page numbers, including appendix page numbers

Line Spacing

The entire thesis or dissertation can be one-and-a-half or double spaced. The convention chosen must be followed throughout the body of the document. For example, if you choose to make the document double spaced, and make all quotes within the document single spaced, then these conventions should be used for all text and quotes.

- if paragraph indentions are used, they should be uniform throughout the document
- footnotes should be single-spaced and left-justified
- direct quotations should be single-spaced, centre-justified, indented and **not** enclosed in quotation marks
- the bibliography/references, figure captions and legends, table titles, and appendices may be single-spaced

Page Orientation

The text of the thesis or dissertation must use portrait (vertical) orientation. Individual figures and tables may be placed on landscaped pages, as long as the page number is located in the same place as the other pages in the thesis/dissertation.

Figures or tables too large to place within the margins on a landscaped page should be placed in the appendix to the thesis/dissertation.

Margins and Text Justification

The CGPS requires that the inside margin must be no less than 1 inch on all sides. All material in the document, including text, tables, and figures, must fit within the margins.

Page numbers must be at least ½ inch from the bottom of the page.

Justification refers to whether the text of a document is lined up evenly along the left margin, the right margin, or both margins. Either full-justified (both margins) or left-justified margins are permissible.

- the use of justified margins must be consistent throughout the document
- dividing the text into columns (journal/newspaper style) is not permissible

Page Numbering

Page numbers must appear on all pages in the thesis/dissertation except the title page.

Title page: not numbered

Prefatory pages: (includes, but not necessarily limited to: permission to use, acknowledgements, abstract, table of contents, list of tables and list of figures).

- numbered using small Roman numerals (i, ii, iii, iv, . . .)
- the "permission to use" page is designated i

Body of the thesis/dissertation: begins with the first page of Chapter 1.

- numbered using Arabic numerals (1, 2, 3, . . .)
- pages are numbered consecutively throughout the thesis/dissertation; i.e., page numbering does **not** restart with each new chapter

Placement and formatting of page numbers: must be consistent throughout the document.

- the page number must be positioned at the bottom center of the page
- as mentioned in the previous section, page numbers must be placed at least ½ inch from the bottom edge of the page
- page numbers using letter suffixes (e.g., 10a, 10b) are **not** permitted

Footnotes and Endnotes

Following the advice of the GAC, a student may use any appropriate combination of footnotes at the bottom of pages in the text, or endnotes at the end of a chapter. The approach taken must be used consistently throughout the thesis.

Note that the use of footnotes and endnotes is uncommon in scientific publications except for the use of footnotes in Tables and on prefatory pages. In the case of a chapter reporting a manuscript that has been published or submitted for publication, a footnote to the chapter title should be included to indicate the detailed citation to the submitted or published paper.

- the font used in notes is the same as that used in the text, but may be one size smaller[5]

The use of endnotes is discouraged; however, if used, they should appear at the end of the chapter

[5] The general placement of a footnote is beneath the text; leaving one double-space, a solid line is drawn that extends approximately 2 inches from the left-hand margin. The footnote number as shown in the text appears one single-space below this line. The text of the footnote is typed using a single-spaced format; it can be full- or left-justified, and starts 1/16th to 1/8th inch from the footnote number. Footnote numbering must be done consecutively and separately for each chapter.

- endnotes should be single-spaced with a one-half-space (6 pt) between notes
- numbering must be done consecutively and separately for each chapter

Paper and Printing

The standard paper size is 8.5 inches x 11 inches (21.5 cm x 28 cm). Use only acid-free archival quality paper (minimum 50% cotton), 20-lb bond with a hard, bright and even surface texture. For reasons of appearance and preservation, only one type and brand name of paper must be used throughout the thesis.

Laser printing is required. All pages, and all copies of the thesis/dissertation must be clean, clear and error-free with letter-quality printing. All coloured originals must be duplicated in colour—black and white copies are **not** acceptable.

The hardbound copy for the Department must be single-sided only.

A Note of Caution

Some faculty are very concerned about formatting guidelines and have specific ideas about document presentation. Students are advised to discuss the formatting of their thesis/dissertation with their faculty advisor(s) early in the process of preparing the document. This is especially true for students planning to submit a document that presents complex formatting considerations (e.g., the inclusion of digital data or documents with a large number of figures/tables).

Questions regarding formatting that cannot be answered by the supervisor(s) or GAC should be directed the Department's Graduate Committee.

Ultimately, it is the student's responsibility to ensure a smooth revision and submission process.

Every student should learn to edit and proofread his or her own work!

ORGANIZING YOUR THESIS/DISSERTATION

Although there is no page limit on a thesis/dissertation, it is recommended that a M.Sc. thesis be no shorter than 50 pages and no longer than 150 pages in length. The recommended length for a Ph.D. dissertation is 100 – 250 pages.

The University of Saskatchewan requires all theses and dissertations to be electronically submitted using the ETD (https://etd.usask.ca/) process. The CGPS has certain requirements for formatting a thesis/dissertation (which can be found at the CGPS website at https://students.usask.ca/graduate/graduate-students.php#ThesisandDissertation); in addition, all students enrolled in the Soil Science Graduate Program MUST follow the guidelines specified in this manual.

Although each student's thesis/dissertation will vary somewhat, depending on the nature and scope of the research, the body of the thesis/dissertation contains chapters arranged in a logical order, each with its own title.

The appendix to this *Guide* contains examples of many of the elements discussed in this chapter. Additional examples are available through the CGPS web site. These examples are representative of the many acceptable formatting techniques for particular parts of the thesis or dissertation.

> Please note that the style, typeface, and font size used in the samples may vary from example to example because they are drawn from different theses and dissertations. However, as noted in the previous section, ***students must use a uniform and consistent style, typeface, and font size throughout their own document***.

A thesis may be organized in either a ***traditional*** (Table 1) or ***manuscript*** (Table 2) style. Regardless of which style you choose, all theses and dissertations must follow a specific sequence of pages; the general organization (page order) of the thesis/dissertation is described in Tables 1 and 2.

Each student's thesis or dissertation must be organized as a complete, cohesive document!

Table 1. Required and optional elements of a thesis/dissertation prepared in the ***traditional style***.

Sequence of pages (Major Headings)	Required or Optional	Page Numbering
Title Page	Required	no page number
Permission to Use and Disclaimer Statement	Required	lower case Roman numeral (i)
Abstract	Required	lower case Roman numeral (ii, iii, ...)
Acknowledgements	Required	lower case Roman numeral (iv, v, ...)
Dedication	Optional	lower case Roman numeral (v, vi, ...)
Table of Contents	Required	lower case Roman numeral (vi, vii, ...)
List of Tables	Required	lower case Roman numeral (vii, viii, ...)
List of Figures	Required	lower case Roman numeral (viii, ix, ...)
List of Nomenclature (Abbreviations) or other lists needed	Optional	lower case Roman numeral (ix, x, ...)
Introduction	Required	Arabic (the Introduction always starts with page 1)
Literature Review	Required	Arabic (5, 6, …)
Methods and Materials	Required	Arabic (20 21, …)
Results	Required	Arabic (20, 21, …)
Discussion	Required	Arabic (40, 41, …)
Summary and Conclusions	Required	Arabic (95, 96, …)
Bibliography or References	Required	Arabic (100, 101, ...)
Appendix(ices)	Optional	Arabic (102, 103, ...)
Vita	Optional	Arabic (104, 105, ...)

Table 2. Required and optional elements of a thesis/dissertation prepared in ***manuscript style***.

Sequence of pages (Major Headings)	Required or Optional	Page Numbering
Title Page	Required	no page number
Permission to Use and Disclaimer Statement	Required	lower case Roman numeral (i)
Abstract	Required	lower case Roman numeral (ii, iii, ...)
Acknowledgements	Required	lower case Roman numeral (iv, v, ...)
Dedication	Optional	lower case Roman numeral (v, vi, ...)
Table of Contents	Required	lower case Roman numeral (vi, vii, ...)
List of Tables	Required	lower case Roman numeral (vii, viii, ...)
List of Figures	Required	lower case Roman numeral (viii, ix, ...)
List of Nomenclature (Abbreviations) or other lists needed	Optional	lower case Roman numeral (ix, x, ...)
Introduction	Required	Arabic (the Introduction always starts with page 1)
Literature Review	Required	Arabic (5, 6, …)
Research Chapter(s)	Required†	Arabic (20 21, …)
Synthesis and Recommendations	Required‡	Arabic (95, 96, …)
Summary and Conclusions	Required¶	Arabic (95, 96, …)
Bibliography or References	Required	Arabic (100, 101, ...)
Appendix(ices)	Optional	Arabic (102, 103, ...)
Vita	Optional	Arabic (104, 105, ...)

† Research chapters must be arranged and formatted following the guidelines set out by the Soil Science Society of America Journal.

‡ A "Synthesis and Recommendations" chapter is **required** for all theses and dissertations containing more than one research chapter (manuscript).

¶ Theses and dissertations containing **only** one research chapter (manuscript) must include a "Summary and Recommendations" either as a separate chapter or as the last section in the manuscript.

Thesis/Dissertation Options

Every student should discuss the organization of the thesis/dissertation with her/his supervisor before beginning to write the document. Together, you should decide on the style of the thesis/dissertation; i.e., will it be in traditional or manuscript style? For example, an M.Sc. thesis built around a single piece of research, may best be formatted in the traditional style (see Table 1; p. 10). On the other hand, it may be easier to organize an M.Sc. thesis or Ph.D. dissertation built around multiple pieces of research in manuscript style (see Table 2; p. 11).

Regardless of the style selected, the first chapter is always an **INTRODUCTION**; the last chapter is always a **SYNTHESIS** (if more than one manuscript is included) or **SUMMARY AND CONCLUSIONS** (if only one manuscript is included).

The basic organization of a thesis or dissertation written in ***traditional style*** is as follows:

1. Introduction
2. Literature Review
3. Methods and Materials
4. Results
5. Discussion
6. Summary and Conclusions
7. References

Appendices (optional)

Vita (optional)

The basic organization of a thesis or dissertation written in ***manuscript style*** is as follows:

1. Introduction
2. Literature Review
3. Title of Manuscript #1
   - 3.1 Preface
   - 3.2 Abstract
   - 3.3 Introduction
   - 3.4 Materials and Methods
   - 3.5 Results
   - 3.6 Discussion
4. Title of Manuscript #2
   - 4.1 Preface
   - 4.2 Abstract
   - 4.3 Introduction
   - 4.4 Materials and Methods
   - 4.5 Results
   - 4.6 Discussion
5. Synthesis and Conclusions
6. References

Appendices (optional)

Vita (optional)

The individual elements of the body of the thesis/dissertation are discussed in the following sections.

Prefatory Pages

The prefatory pages are those pages that are placed before the Introduction; they include, but are not limited to the title page, permission to use, abstract, acknowledgements and the table of contents. They may also include a dedication, list of tables, list of figures, and list of symbols and/or abbreviations. Refer to Tables 1 and 2 to determine the required elements of the thesis/dissertation. All prefatory pages are numbered with small Roman numerals.

Title Page

The title of a thesis or dissertation should include meaningful key words that describe the subject and content. This is particularly important for doctoral candidates, because titles are the basis for computer searches from which subject lists of dissertations are prepared by the ProQuest reference service. It should be brief and grammatically correct, as well as accurate and complete enough to stand alone.

- the use of italics is acceptable
- avoid using acronyms and abbreviated word forms in the title when possible
- spell out words fully
- ProQuest will not display diacritics or special characters on its website
- the TITLE page is the only page in the thesis/dissertation that is NOT numbered.

The **TITLE page** must contain the following information (see **example on page A2**):

- the title of the thesis
- the name of the College of Graduate and Postdoctoral Studies
- the degree for which the thesis/dissertation is submitted
- the name of the department
- the name of the institution
- the full name of the author, and
- the copyright notation, which should be as follows:

  © Copyright, Jane Doe, June 2013. All Rights Reserved.

  (Note: The date refers to the date of oral examination of the thesis.)
- **No other information should appear on the title page.**

Permission to Use

Students hold the copyright to their thesis. They are expected to include in the front of their thesis a statement in paragraph form granting permission to use the thesis under specifically stated conditions and indicting the address of the position, department, or college to which requests for such permission should be sent (see **example on page A3**).

Disclaimer

Reference in a thesis/dissertation to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, **does not constitute or imply its endorsement, recommendation, or favoring by the University of Saskatchewan**. The views and opinions of the author do not state or reflect those of the University of Saskatchewan, and shall not be used for advertising or product endorsement purposes. The Disclaimer statement is required when there are proprietary brand names, etc. used in the thesis/dissertation.

- "**PERMISSION TO USE**" and "**DISCLAIMER**" are in SMALL CAPS and centered one (1) inch below the top of the page, with the text beginning one-and-a-half lines (18 pt) below
- use the same font size and style as the text; the line spacing (1.5) and paragraph style margins are the same as used in the text
- the page is numbered using lower case Roman numerals, bottom center
- see **example on page A4**

Abstract

Your Abstract must be a "complete snapshot" of your thesis or dissertation and be a stand-alone piece. The abstract will be seen and read by more people than will read the thesis/dissertation itself; thus, everything that is important in the thesis/dissertation should be reflected in the abstract.

The abstract should include an introductory statement of the rationale and objectives or hypotheses, an overview of the methods and materials, a brief summary of the most important results and the overall conclusions of the thesis/dissertation. The abstract should call attention to new techniques, observations, or data. It must be accurate, self-contained, concise, and specific!

Note: The thesis/dissertation abstract is what will be published in on-line databases; thus, although most dissertations and theses are now written in manuscript format—with each chapter having its own abstract—the overall thesis or dissertation abstract must be more than just a "plain language" summary (i.e., more akin to an executive summary). That is, the individual papers contribute to a "larger story"—it is this larger (or overall) story that the thesis/dissertation abstract should address.

The **Abstract** must follow the following format (see **example on page A5**):

- **ABSTRACT**, in small capital letters, is centered, one (1) inch from the top of the page, with the text beginning one-and-a-half lines (18 pt) below
- use the same font style (Times New Roman, or equivalent) and size (12 pt) as the text; the line spacing (1.5) and paragraph style margins are the same as used in text
- indent the first paragraph of your Abstract like other paragraphs in your thesis
- the page is numbered using lower case Roman numerals, bottom center
- the abstract should clearly and succinctly identify the purpose of the research, the methods used, the results obtained and the significance of the results or findings
- avoid the use of citations, figures, tables, illustrations, and equations
- limit the use of abbreviations, and define the ones that you do use
- the abstract **must not exceed 350 words** [NOTE: any term (or numeral) with a space on either side is counted as one word]

Acknowledgements

The inclusion and content of the Acknowledgements section is left to the discretion of the student, but should be limited to a single page.

It is suggested that the Acknowledgements page make reference to guidance received by the author from his or her supervisor(s) and Advisory Committee members.

Any financial assistance received to carry out the project (granting agency, scholarships, etc. . .), including any "in-kind" support, must be properly acknowledged. Likewise, any extraordinary assistance received by the student—for example in word processing, sample collection and processing, data collection, data analysis, and so on—should be properly acknowledged.

The **Acknowledgements** must contain the following information (see **example on page A6**):

- **ACKNOWLEDGEMENT** in small capital letters, is centered one (1) inch below the top of the page, with the text beginning one-and-a-half lines (18 pt) below
- use the same font style (Times New Roman, or equivalent) and size (12 pt) as the text; the line spacing (1.5) and paragraph style margins are the same as used in text
- indent the first paragraph like other paragraphs in your thesis
- the page is numbered using lower case Roman numerals, bottom center
- must not exceed 250 words

Dedication (Optional)

The inclusion and content of the Dedication section is left to the discretion of the student, and should be limited to a single page.

If appropriate, the student may include a short quote or other text in this section.

The **Dedication** must be formatted as follows (see **example on page A7**):

- **DEDICATION** in small capital letters, is centered between the left- and right-hand margins
- the dedication can be positioned in the center of the page, with the text starting two lines (36 pt) below the heading
- use the same font style (Times New Roman, or equivalent) and size (12 pt) as the text; the line spacing (1.5) and paragraph style margins are the same as used in text
- the page is numbered using lower case Roman numerals, bottom center

Table of Contents

The **Table of Contents** shows the relationship between the headings listed in the thesis and displays the correct page numbers. Major headings (prefatory page headers, chapter titles, etc.) are listed at the left margin. One or two levels of subheadings can be indented below the major headings.

It is very important that the page numbers in the Table of Contents are correct!

All titles in the thesis – including those that precede the TOC – must be listed in the table of contents; however, "Table of Contents" is not listed in the TOC. It is not necessary to include all levels of headings in the table of contents. However, any inclusion must be consistent; i.e., if a particular level is included at any point, all headings of that level must be included. At a minimum, titles of all the major divisions in the thesis/dissertation (i.e., sections of the preliminaries, parts, chapters, appendices, etc.) must be listed in the TOC. First, second, or third-level entries should be added in an indented style.

All entries must be an exact match to the corresponding titles in text. However, neither underlining, use of boldface or italics for stylistic purposes in text, nor reference numbers appearing with text headings are placed in the Table of Contents listing.

The **Table of Contents** must contain the following information (see **examples on pages A8, A9 and A10**):

- the heading, **TABLE OF CONTENTS**, in small capital letters, is centered between the left-

and right-hand margins, one (1) inch from the top of the page, with the text beginning one-and-a-half lines (18 pt) below

- for the prefatory pages, numbers are lower case Roman numerals
- page number columns in Table of Contents, List of Figures, and List of Tables are aligned to the right digit (i.e., right justified)
- dots between titles and page numbers are optional
- line titles must not run into the page number column
- single-space all entries; leaving an extra 6 pt of space above each chapter entry
- titles have all the same capitalization, size, and same font
- number each chapter title, but do not include the word "Chapter" in the title.

NOTE: for a given level, all headings and sub-headings must be consistent in style (including capitalization) between chapters. For example, all first-order headings should use Title Case (i.e., All Major Words are Capitalized); second- and third-order headings should be capitalized using Sentence case (i.e., Only the first word is capitalized). The use of additional (fourth-order or greater) headings is strongly discouraged.

Students are encouraged to use the indexing function of their word processing software (or other program) to ensure the accuracy and utility of the Table of Contents.

List of Tables / List of Figures

Where appropriate, the CGPS requires that a List of Tables and a List of Figures be included in all theses/dissertations.

The **List of Tables/Figures** must be formatted as follows (see **examples on page A11 and A12**):

- each list starts on a new page regardless of how many entries are on the page
- the heading, **LIST OF TABLES** or **LIST OF FIGURES**, in small capital letters, is centered between the left- and right-hand margins, one (1) inch from the top of the page, with the text beginning one-and-a-half lines (18 pt) below
- page is numbered using lower case Roman numerals, bottom center
- page number columns in List of Figures and List of Tables are aligned to the right digit
- Table or Figure titles include the number of the table/figure, the title, and the page number

- line titles must not run into the page number column
- single-space all entries; leaving an extra 6 pt of space between each entry
- titles have all the same capitalization, size, and same font

List of Abbreviations (Optional)

Includes **all non-standard abbreviations** used in the text of the thesis and follows the List of Figures. Typically abbreviations for elements (e.g. C, N, P etc.) or units (m, d, h etc.) are not included as these are considered standard abbreviations.

The **List of Abbreviations** must be formatted as follows (see **example on page A13**):

- the heading, **LIST OF ABBREVIATIONS**, in small capital letters, is centered one (1) inch from the top of the page, with the text beginning one-and-a-half lines (18 pt) below
- page is numbered using lower case Roman numerals, bottom center
- single-space all entries; leaving an extra 6 pt of space between each entry

Permission to Reproduce (As Needed)

Where a thesis includes a "substantial part" of a work or other proprietary material in the thesis (e.g. previously published figures), permission from the rights-holder must be obtained. This should be included as a ***separate appendix***. No signatures should be included.

Students must be aware that obtaining this permission may take some time and may require a fee. Allowance must be made for this.

The document granting permission to reproduce must be included in whatever form it is received (letter, form, email etc).

Introduction

Regardless of whether you choose to write your thesis or dissertation in the traditional or manuscript format, the thesis/dissertation must include a general introduction that provides a brief orientation to the reader; i.e., it sets the stage for why you carried out the research.

The Introduction is not a Literature Review!

The **Introduction** should provide sufficient background to orient the reader. It should include a brief statement of the research problem; explain the significance of the problem (addressing the importance of the problem to your discipline); and provide a clear, concise statement of the purpose of the study. The introduction also may include a description of the theoretical or conceptual framework for the study.

The Introduction **must** include a statement of the objectives, hypotheses and research questions addressed in the thesis/dissertation.

If the thesis/dissertation is written in ***manuscript style***, the **Introduction** must include a subsection that details the "Organization of the Thesis/Dissertation" and includes an explanation of how the manuscript were included in the thesis/dissertation and specific information about the organization of your thesis. This is normally the last section in the Introduction (see examples on **page A18–A19).**

- the heading, **INTRODUCTION**, in small capital letters, is centered between the left and right margins, without punctuation or underlining, two (2) inches from the top of the page, with the text beginning one-and-a-half lines (18 pt) below
- use the same font style (Times New Roman, or equivalent) and size (12 pt) as text; the line spacing (1.5) and paragraph style margins are the same as used in text
- the **Introduction** should not be divided into sections; in which case, the "organization of the thesis/dissertation" is the concluding paragraph of the chapter
- the pages are numbered using Arabic numerals, bottom center

Literature Review

The thesis/dissertation must include a general review of the literature that provides an overview of the ***essential*** information that will guide the study and illustrates that the student researcher has a command of the current knowledge in his/her discipline as it relates to the research question.

Writing a literature review is one of the most complicated and time-consuming components of the thesis/dissertation writing process. **Start early** and **leave ample time for revision**.

For a thesis/dissertation written in the ***traditional style***, the **Literature Review** should be comprehensive, critical and contextualized. That means that it will provide the reader with a basis for the research, a survey of published works that pertain to your investigation, and an analysis of that work. It is a critical, factual overview of the work that came before your research. **Start broad and then narrow your focus to work directly related to your own study**.

For a thesis/dissertation written in ***manuscript style***, the **Literature Review** should provide a broad introduction to the thesis/dissertation topic and methods employed to carry out the research. Remember, each research chapter (i.e., manuscript) will have its own review of the literature in the Introduction —one that is targeted to the specific topic of that manuscript—so avoid repetition.

The thesis/dissertation **Literature Review** should be broad and comprehensive, should include the highlights of previous research relevant to the author's thesis project, and should be written as a critical examination of the previous works in the field. Conduct a careful analysis of the literature—do not just catalogue a long list of authors and titles. The review should draw general conclusions concerning the current state of knowledge in the field and should integrate the present study as an extension of this body of knowledge.

The **Literature Review** must be formatted as follows:

- the heading, **LITERATURE REVIEW**, in small capital letters, is centered two (2) inches from the top of the page, with the text beginning one-and-a-half lines (18 pt) below
- use the same font style (Times New Roman, or equivalent) and size (12 pt) as text; the line spacing (1.5) and paragraph style margins are the same as used in text
- the pages are numbered using Arabic numerals, bottom center

Citation Style[6]

The Department of Soil Science requires that all theses/dissertations use the "author–year" notation for within text citations—with references listed chronologically, from earliest to latest.

[6] The Department requires that all theses/dissertations follow the citation style described in detail in the *Publications Handbook and Style Manual* published by the Soil Science Society of America. The *Style Manual* is available on-line at https://www.soils.org/publications/journals/author-resources/style-manual.

For within-text citations of papers with:

Two authors: name both authors separated by ampersand (&) (e.g., Anderson & Schoenau, 2008).

Three to five authors: the first time cited include the surname of all authors (e.g. Gillespie, Walley, & Farrell, 2005). For subsequent citations, use the first author's surname plus et al. (Gillspie et al., 2005).

> **Exceptions**: if two references with the same year shorten to the same form, cite as many of the authors' surnames as needed to distinguish the two references. E.g. (Murphy, Smith, Davis, & Xu, 2018) and (Murphy, Xu, Smith, Jones & Davis, 2018) – shorten to (Murphy, Smith, et al., 2018) and (Murphy, Xu, et al., 2018).

Six or more authors: use the first author's surname plus "et al." (e.g., Peak et al., 2011).

For two or more articles by the same author(s) in the same year: Add a distinguishing lowercase letter (a, b, c, etc.) to the year in both the text (e.g., Yates et al., 2006a, 2006b) and the list of references.

Authors with the same last name: include first initial with the surname. E.g. Y. Xu et al., 2001 and S. Xu et al., 2013.

Separate in-text citations with a semicolon (e.g., Farrell and Elliott, 2008; Ens et al., 2013).

Citing Unpublished Sources

Only literature available through libraries or other readily accessible public media may be listed in the Reference section. All other material, such as *personal communications* (i.e., information from someone other than the author) and *unpublished data* (information from one or more author named in the byline), is cited in the text as parenthetical matter.

- provide both the source and the date for the information; for example: (R.E. Farrell, personal communication, 2013) or (Bentz & Farrell, unpublished data, 2011)

The terms *in review* and *in press* are not synonymous. Material that is *in press* has been accepted for publication but has not yet appeared in print; as such, this material may be listed in reference section

Material *submitted for publication,* but not yet accepted may **not** be included in the reference list.

As one of the last steps before submitting your thesis/dissertation, you should check the alphabetical reference list against the citations in the body of the manuscript.

It is up to the student to verify the accuracy of the literature citations.

MANUSCRIPT STYLE THESIS/DISSERTATION

In addition to the traditional format for a thesis/dissertation, CGPS and the Department of Soil Science allow for the use of an alternate format—that is, manuscript format. The ***manuscript format*** refers to the use of journal articles and/or book chapters instead of the standard thesis/dissertation chapters. Publication of the manuscript(s) is **NOT** a requirement of this format.

For a thesis/dissertation prepared in "manuscript" format, each paper will appear as a separate chapter. ***Each chapter must be introduced with a "Preface" that consists of a brief description of how the chapter relates to the thesis as a whole.***

Issues of copyright must be addressed when one or more of the manuscript has been accepted for publication or is already in print.

General considerations for manuscript style theses/dissertations are as follows:

- for a Ph.D., the dissertation must include at least two (2) manuscripts; only one (1) manuscript is required for an M.Sc.[7]
- the content of the manuscript must be based on research conducted as part of the student's research program at the University of Saskatchewan
- each manuscript starts a new chapter and includes: Preface, Abstract, Introduction, Materials and Methods, Results and Discussion[8] (as separate sections or combined; and including tables and figures).
- use the title of the paper as the main chapter title
- references are **not** included as part of the chapter, but rather are combined in a common reference section at the end of the thesis.
- the graduate student must be the major contributor and writer of the manuscript(s)
- indicate the publishing status and the name(s) of the author(s) in a footnote
- if a manuscript has multiple authors, include an explanation of your role and/or the co-authors' roles in the research/preparation of the paper; this should be included either in the Preface or as a footnote to the Preface
- use the same font style (Times New Roman, or equivalent) and size (12 pt) as the text; the line spacing (1.5) and paragraph style margins are the same as used in the text
- pages are numbered using Arabic numerals, bottom center

[7] NOTE: a Preface is not required for a M.Sc. thesis consisting of only one manuscript.

[8] NOTE: a separate conclusions section is not required, though a summary statement may be given as the closing paragraph.

Research Chapter Title Page

For a thesis/dissertation prepared in "manuscript" format, each research chapter starts with a Title Page that includes a "Preface" and, in the case of a manuscript that has been submitted for publication or is already in print, outlines the role(s) of the co-authors and addresses issues of copyright.

Preface

Each research chapter is introduced with a "Preface" that consists of a brief description of how the chapter relates to the thesis as a whole (see **examples on page A14–A17**).

- The chapter (manuscript) title page should include only the **CHAPTER TITLE** itself and the preface; the text of the chapter should start on a new page
- the **CHAPTER TITLE**, in Title Case and small capital letters, is centered between the left and right margins, without punctuation or underlining, two (2) inches from the top of the page, with the Preface beginning one-and-a-half lines (18 pt) below
- use the same font style (Times New Roman, or equivalent) and size (12 pt) as text; the line spacing (1.5) and paragraph style margins are the same as used in text
- the **Preface** is numbered as the first sub-section in the chapter, is bolded and aligned along the left-hand margin (e.g., **3.1 Preface**)
- the page is numbered using lower case Arabic numerals, bottom center

Materials and Methods

Traditional style thesis. A thesis/dissertation written in the traditional style must include a chapter that details the materials and experimental methods used to carry out the research—including the statistical design and methods used to evaluate the significance of the data. You must provide *enough detail to allow a competent scientist to repeat the experiments, mentally or in fact* (ASA-CSSA-SSSA, 2008).

Manuscript style thesis. For a thesis/dissertation written in the manuscript style, the materials and methods is included as a first-order sub-division (e.g., **3.2. Materials and Methods**) within the chapter/manuscript.

The following information applies to the Materials and Methods section of both traditional and manuscript style theses/dissertations:

In the **materials** section, describe the preparation method, equipment, and measurements, **including SI units**. Descriptions of materials may or may not be necessary (discuss this with your supervisor or GAC), but if included should list the source of each item. Whenever possible, avoid the use of brand names. If, however, a product must be identified by trade name, then list the name of the manufacturer or a major distributor parenthetically after the first mention of the product. For example: "Soil N_2O flux was measured using an FTIR-gas analyzer (Model DX-4015, Gasmet Technologies Oy, Helsinki, Finland)." If the particular product is essential to the research, but no longer commercially available, describe a suitable substitute and its source.

In the case of specially procured or proprietary materials, give the pertinent chemical and physical properties (e.g., purity, pH, concentration). **Chemical rather than trade names are preferred**.

Soils should be classified according to the *Canadian System of Soil Classification (3rd Ed.)*, which is available on-line at: http://sis.agr.gc.ca/cansis/publications/manuals/1998-cssc-ed3/cssc3_manual.pdf Soils should, at the very least, be ***classified to the Subgroup level*** and ***identified by soil association*** (e.g., "the soil was a Calcareous Dark Brown Chernozem of the Asquith Association"). Plants and other organisms (e.g., viruses, insects, bacteria, and pathogens) should be identified at first mention by their scientific name (and cultivar name if applicable); e.g.:

> "Field pea (*Pisum sativum* L. cv. CDC Meadow) were inoculated with *Rhizobium leguminosarum* (Nodulator®, Becker Underwood, Saskatoon, SK) at 1.5 times the recommended rate and sown into each pot."

General methodologies should be described in sufficient detail to allow a reader to replicate the work. In the **methods** section, cite previously reported methods and describe any modifications you may have made to the methods. Note: whereas you must describe any substantial modification to a method, trivial modifications (e.g., substitution of brand name item for another) need not be

described. If a technique is widely familiar, use only its name (e.g., the Walkley-Black method for determining total organic carbon).

Provide details of unusual experimental design or statistical methods.

Statistical Design and Analysis

(ASA-CSSA-SSSA, 2008)

The selection of a particular statistical method and its appropriateness depend upon the questions or information sought, the validity of theoretical assumptions, the adequacy of the sampling design, and the type, quantity, and quality of the observations. Several excellent papers on the use of statistics in soil science are available (see **Appendix B**) and should be consulted before you write your thesis or dissertation.

The reporting of the results from each analysis should include a brief description of the statistical method and a literature citation providing its full detail, verification of the degree to which assumptions have been met, and complete descriptions of sampling design and experimental observations in relation to the efficacy of the statistical analysis. In all cases, a measure of the statistical confidence should be reported and interpreted in relation to the question answered or conclusion reached by the authors.

Designing a controlled experiment requires two components: treatment design and experimental design. **Treatment design** includes the factors of interest, the levels of each factor, the relationship among the factors (e.g., a factorial treatment structure), and the selection of blocking variables and covariates. **Experimental design** refers to the method of arranging the experimental units and the method of assigning treatments to the units. Included should be any information about blocking, multiple experimental unit sizes (e.g., in split and strip plots), the number of sites and years or independent runs of the experiment, the number of replicates, a description of conditions at field sites and in greenhouse or controlled environmental chambers, and how measurements were made for specific traits. In studies where the experimental units and observational or sampling units were not the same, each should be clearly identified. The number of experimental units used and the number of samples taken from each unit should be clear to the reader.

The treatment and experimental designs dictate the proper method of statistical analysis and the basis for assessing the precision of the treatment means. A measure of the precision achieved, either as a standard error or a confidence interval, should be reported for all data on which conclusions are drawn.

A number of commonly used and accepted abbreviations in statistics are listed in Table 3. These abbreviations and symbols **do not** require definition before use in the text of a thesis/dissertation.

Table 3. Recommended abbreviations and symbols widely used in statistics

Name	Abbreviation	Name	Symbol
Analysis of variance	ANOVA	Arithmetic mean	$\bar{x}$ (μ)
Coefficient of variation	CV	Chi-square statistic	χ^2
Completely randomized design	CRD	Correlation coefficient	r (ρ)
Degrees of freedom	df	Coefficient of determination	r^2
Multivariate analysis of variance	MANOVA	Coefficient of multiple determination	R^2
Mean square error	MSE	Probability of a Type I error	α
Nonsignificant (or not significant)	NS	Probability of a Type II error	β
Randomized complete block design	RCB or RCBD	Probability	p
Root mean square error	RMSE	Regression coefficient	b (β)
Standard deviation	SD	Sample size	n
Standard error	SE	Standard deviation	s (σ)
Standard error of the mean	SEM	Standard error of the mean	$s_{\bar{x}}$ ($\sigma_{\bar{x}}$)
Standard error	SE	Student's t statistic	t
Standard error of the mean	SEM	Snedecor's F statistic	F
		Variance	s^2 (σ^2)

† In addition, the symbols *, **, and *** are used to show significance at the $\alpha = 0.05$, 0.01, and 0.001 levels, respectively. Significance at other levels is designated by additional footnotes, using the next available symbol from the standard sequence (†, ‡, §, ¶, #, ††, ‡‡, etc.).

‡ Symbols in parentheses are for the population analog of the corresponding sample quantity.

The **Materials and Methods** must be formatted as follows:

- the heading, **MATERIALS AND METHODS (**or **EXPERIMENTAL)**, in small capital letters, is centered two (2) inches from the top of the page, with the text beginning one-and-a-half lines (18 pt) below
- use the same font style (Times New Roman, or equivalent) and size (12 pt) as text; the line spacing (1.5) and paragraph style margins are the same as used in text
- the pages are numbered using Arabic numerals, bottom center

Results

The **Results** section summarizes the data collected and the statistical treatment of the data. Call attention to significant findings and special features (e.g., one quantity is greater than another; identify a linear relationship between variables, one value is optimum), but do not repeat in detail what is already clear from an examination of the tables and figures. Use tables, figures, photographs and illustrations to give the reader a clear understanding of the experimental data.

Include only relevant data, and give sufficient detail to justify your conclusions.

Use transitional and topic sentences to ensure that the narrative flows from one result to the next.

The Results section does not include significant interpretation or discussion!

Discussion

The **Discussion** section provides an objective discussion of the significance of the research—placing it in context with the published literature. This is where you interpret your data and compare your results to the published literature. Scientific speculation is encouraged; however, it should be identified as such and should be reasonable, firmly founded in observation and subject to testing. A good discussion will:

- relate back to the hypotheses and objectives identified in the Introduction
- explain the principles, relationships and generalizations that can be supported by the results
- address any exceptions or lack of correlation that qualify the findings, or difficulties that point to areas for further investigation
- explain how the results relate to previous findings, whether in support or contradiction
- summarize the evidence and present conclusions; end with a positive conclusion concerning the most significant result from the study

NOTE: for a thesis/dissertation written in ***manuscript style***, the discussion need not include separate summary and conclusions section as this would duplicate the function of the abstract.

For a thesis/dissertation written in the ***traditional style***, the **Summary and Conclusions** is the final chapter of the thesis/dissertation.

NOTE: You can present your results and discussion as two separate sections, or you can combine them into a single section.

Once you make a choice, you must use that style throughout the thesis/dissertation.

The **Results** and **Discussion** must be formatted as follows:

- the heading, **RESULTS, DISCUSSION,** or **RESULTS AND DISCUSSION**, in small capital letters, is centered two (2) inches from the top of the page, with the text beginning one-and-a-half lines (18 pt) below
- use the same font style (Times New Roman, or equivalent) and size (12 pt) as text; the line spacing (1.5) and paragraph style margins are the same as used in text
- the pages are numbered using Arabic numerals, bottom center

Tables, Figures and Illustrations

Tables and figures are an integral part of a well-written scientific paper; it is up to the student (in consultation with her/his supervisor) to decide whether the data are best presented in a Table or Figure. **Do not present the same data in a table and a figure!**

Preparing a table or figure requires attention to detail and can be time-consuming. Be sure you know what you want to present, and how you want to present it, before you begin. Tables provide a convenient way of presenting extensive numerical data in an organized manner. Tables summarize data and present numbers for comparison with one another. Figures (graphs) are used to illustrate trends or highlight selected features of the data. In both cases, however, they should be easy to read and should be able to stand alone; i.e., the reader should be able to understand the information presented in a table or figure without having to refer to the text.

Tables, figures and illustrations ***adapted from the literature*** must be identified as such. That is, you must include a parenthetical statement such as "(adapted from Pennock et al., 2006)"

- **NOTE:** material adapted from the literature must involve a "significant" change in presentation (e.g., altering a figure, presenting data published in a table as a figure; combining material from multiple published sources into a single table)

Likewise, credit lines for tables, figures and illustrations ***reproduced from the literature*** must appear as a parenthetical statement at the end of the title or caption; e.g., "[reproduced with permission **(see Appendix B**) from Olk, 2008a, 2008b]"

General considerations for table titles and figure captions are as follows:

- all Tables and Figures should be numbered consecutively within a chapter using Arabic numerals and include the chapter number (first) and the table number (second) (e.g., Table 4-1 or Table 4.1)
- Tables and Figures must conform to the margin requirements of the thesis format—i.e., they must not extend beyond the 1-inch margin
- Table titles and Figure captions should be simple, clear and concise, and descriptive

- for a Table, the title goes at the **top**; for a Figure, the caption goes at the **bottom**
- the title/caption should be complete enough to be understood without referring to the text
- the title or caption should not include interpretations of the data
- titles and captions use the same typeface (Times New Roman, or equivalent) as the text; it is recommended that the font size be smaller than that in the text (e.g., Times 11 instead of Times 12) and that the title/caption be bolded
- table titles should be single-spaced, with 24 pt of additional space above the title and 6 pt of additional space below the title; the paragraph style should be the same as that used in text and the title should end with a period
- refer to figures with the abbreviation "**Fig.**" in both the text and the caption; spell out figure only when it appears as the first word in a sentence
- figure captions should be single-spaced, with 24 pt of additional space below the caption; the paragraph style should be the same as that used in text and the caption should end with a period
- oversized tables should be reduced in size in such a way as to be clearly legible. Tables should NOT be folded.

Tables

(see **examples on page A20–A23**)

DO NOT create tables using the space bar or tab keys! Always use your word processor's "Table" function.

Tables must have three horizontal, black lines:

- at the top of the table, above the header row but below the title
- between the header row and the body of the table, and
- at the bottom of the table, below the last row, but above any footnotes
- other horizontal lines can be included to differentiate sub headings (see examples A20-A23)

Vertical lines are to be avoided!

Tables must have at least two columns with headers. The headers describe the data in the entire column, though it is permissible to use sub-headers below the column header.

- the column header should be as short as possible and be consistent with the text; use abbreviations and symbols
- if a column header applies to more than one column, place a horizontal black line

between the header and the columns to which it applies

Columns can be aligned in one of four ways: (i) on the left, (ii) on the right, (iii) centered, or (iv) on the decimal.

- words are usually aligned on the left
- numbers are usually aligned on the decimal, using a period (not a comma) to denote the decimal point
- for fractional numbers, use a zero before the decimal point (e.g., 0.25 **not** .25)
- groups of numbers connected by a plus/minus (±) sign can be aligned on the symbol and centered in the column

Two types of notes are used with tables: (i) notes that show statistical significance, and (ii) notes that provide supplementary information:

- the absence of data in a cell should be indicated with a dash (–), or as ND (not determined) or NA (not applicable) and **must be explained** in a supplemental note
- lower case superscripted letters are used in order for supplemental notes ($^{a, b, c, d, e, etc.}$)
- cite these symbols just as you would read a table—from left to right and from top to bottom, and reading across all spanner and subheadings for one column before moving on to the next
- significance at the 0.05, 0.01, and 0.001 levels of probability is always denoted using the *, **, and *** symbols, respectively
- lack of significance is indicated by "ns" (not significant)
- the significance note always comes <u>after</u> any supplemental notes keyed to the other letters
- use italic or bold typeface to highlight individual values in a table; any highlighting must have a supplemental note of explanation, with the note letter attached to the first value that is highlighted
- spell out nonstandard abbreviations on first use in the table—even if they have been defined in the text; alternatively, spell them out in a supplemental note

Figures, Illustrations and Photographs

(see **examples on page A24–A31**)

Figures should be used to convey trends and relationships and to facilitate comparisons; they should help clarify the text and highlight important relationships.

The term "figure" applies to: graphs (scatter, line, bar, pie, etc. . .), line drawings or maps, and photographs or micrographs.

The style of the graphs and charts—including the size and appearance of letters and numbers within the graph—should be consistent throughout the thesis/dissertation. **NOTE:** it is suggested that you make the original as large as possible and then reduce it to the size needed for your thesis/dissertation.

Considerations regarding the preparation and formatting of **Figures** are as follows:

- refer to figures with the abbreviation "**Fig.**" in both the text and the caption
- figures containing panels should be labeled with capital letters (A, B, C, …) placed in one of the four corners of the panels
- avoid creating figures that have unnecessary white space
- the use of footnotes in figure captions is not allowed
- traditionally, the typeface (font) used for lettering on figures is different from that used in the text; e.g., the recommended typeface for the text is Times Roman, thus it is recommended that you use a sans serif type font (e.g., Ariel or Helvetica) for the text in your figures
- the size of the letters and numbers in the figure printed in the thesis/dissertation should range from 8- to 12-point type—i.e., **after** it is reduced to fit on the page
- use sentence style capitalization (only the first word and any proper nouns are capitalized) or title style capitalization (each major word is capitalized) for all figure legends, labels and axes titles
- use a **bold** font for all axes titles and labels
- define all abbreviations in the caption, even if they appear in the list of abbreviations
- italicize variables in equations
- check the spelling of the text in each figure
- **Axis scale:** do not crowd the axes with labels—fewer is generally better; a coordinate grid usually just adds clutter and its use is strongly discouraged
- **Legend:** identify symbols, lines and patterns in the legend **not** the caption; place the legend inside, above, or to the right of the figure—**never** to the left or below the figure
- **Symbols and patterns:** choose symbols and patterns of similar weight and tone to avoid making one set of data appear more important than another
- **Lines:** should be of consistent weight (> ½ point) to ensure high-quality reproduction
- **3-D graphs:** use 3-D graphs **only** to show three dimensional data
- **Colour:** the use of colour in graphs, illustrations and photographs is allowed; however, check with your supervisor **before** including colour figures as this increases the cost of printing

- when using colour graphics, also use symbols, dashed lines, or patterns so that no information is lost if the document is printed in black and white
- **Photographs:** use photographs **only** if they are essential to making your point; including photographs (or micrographs), especially colour ones, will significantly increase the digital size of your thesis/dissertation—so, without compromising the quality of the photo, reduce the resolution as much as possible
- if you include a photograph that you did not personally take, or own, you must include a credit line at the end of the caption
- if you include a photograph of a person (e.g., summer students collecting soil samples), you must obtain written permission from that person(s) to reproduce the photograph; the signed permission form should be included in the appendix to your thesis/dissertation
- if you include a photograph of any commercial equipment (e.g., the Leco CNS analyzer), you must obtain written permission from the manufacturer to reproduce the photograph; the signed permission form should be included in the appendix to your thesis/dissertation

Placement of Tables and Figures

Tables or figures can be placed in the thesis or dissertation in the following three ways: (i) on a separate page ***immediately following the text page in which the table or figure is first mentioned***; (ii) embedded within the text; or (iii) in an appendix. Students may use any combination of these methods within their thesis or dissertation, as long as they follow the rules governing each method.

On a separate page. Large figures (i.e., figures that occupy more than one-half a page) should be placed on a separate page immediately following the text page where the figure is first referenced. Likewise, large tables should be placed in landscape format on a separate page immediately following the text page where the figure is first referenced. Placing tables and figures on pages separate from the text will help avoid problems in shifting during last-minute revisions.

Embedded within the text. If the students wishes to incorporate tables or figures within the text (realizing it is the hardest method of figure or table placement), the following criteria must be met:

- the table or figure must be separated from the text by at least a one double spaced (24 pt) line,
- the table or figure must be confined to a single page and may not occupy more than two-thirds the page below or above the text, including the title and 24-pt space,
- the table or figure must be placed between paragraphs, never within a paragraph, and
- multiple tables or figures mentioned together on a page may be placed on a page together, provided there is at least one double spaced (24 pt) line between each table or figure and the figures (plus titles and space) do not occupy more than two-thirds of the page.

In an appendix. The location of tables or figures mentioned in an appendix must be clearly indicated in the text at the point where it is first mentioned (e.g., Table A-1). Normally tables and figures included in the appendix present ancillary data. In general, if a table or figure is referred to in the text more than once, it should be included in the body of the thesis/dissertation and not placed in an appendix. Tables and figures in an appendix must be referred to (cited) in the body of the thesis/dissertation.

Landscape placement. To accommodate large tables/figures, it may be necessary to orient them horizontally on the page (i.e., in landscape orientation). In such a case, the top of the table should be aligned to the "bound" edge of the page. Moreover, the page number must be consistent with the placement on the other pages in the thesis/dissertation.

NOTE: The simplest way to insert the page number in a landscape page is to (i) use a white text box to cover the page number automatically generated by your word processor and then (ii) insert a text box containing the page number (in the correct orientation) where it should be located—i.e., centered at the bottom of the page (not the bottom of the table!).

Equations

Equations are considered to be part of the text; they should be numbered consecutively within a chapter using Arabic numerals (e.g., Eq. 4.1) and must be formatted consistently throughout the thesis or dissertation. **Note:** each symbol used in an equation that has not been previously defined in the text, must be defined immediately following the equation. For example (reproduced with permission from Gillespie, 2010):

$$E_B = h\nu - E_K - \phi \qquad \text{(Eq. 4.1)}$$

where E_B is the binding energy, $h\nu$ is the incident photon energy, E_K is the kinetic energy, and ϕ is a work function (which is the minimum energy needed to remove an electron from a solid), (Hrbek, 2002; Ratner and Castner, 2009).

Considerations regarding the formatting of **Equations** are as follows:

- line spacing for equations should be the same as the body of the text, but with one and one-half spaces (18 pt) above and below the equation to separate it from the text
- leave a space before and after most mathematical operators; the main exception is the solidus sign (/) used for division (x/y not x / y)
- use in-line fractions (e.g., x/y) as much as possible—especially when the equation is incorporated within the text

- use parentheses, brackets and braces in the following order: {[( )]}
- do not leave a space between variables and their quantities (e.g., $5x$) or between multiplied quantities when the multiplication sign is not explicitly shown [e.g., a/(bcd)]
- do not leave a space between an expression and its power, or between or any superscripted or subscripted modifier (e.g., $x^{1/2}$)
- do not leave a space after trigonometric functions
- with single integral signs, the upper and lower limits should **always** be placed to the right of the integral sign, **never** above and below (e.g., $\int_0^{\pi/2} 2\pi xy\, dx$)
- use the symbol "exp" for exponents [e.g., $\exp(a^2 + b^2)^{1/2}$] not $e^{(a2 + b2)1/2}$
- express large numbers using standard scientific notation not computer exponentials (4.0 x 10^{-3} not 4.0 E-03)

Numerals

Reported data should include no more significant digits than the precision of the experimental methods warrants. For agronomic data, the use more than three significant digits is rarely justified. An acceptable rule is to round treatment means to one-tenth of their estimated standard error. For example, if the estimated standard error is 1.43, the means should be rounded to the nearest 0.1; if the standard error is 18.4, the means should be rounded to the nearest 1.0.

Considerations for the formatting of **Equations** are as follows:

- the decimal separator for numbers with five or more digits is the comma and a comma separates every three digits to the left of the decimal point (e.g., 10,000)
- dates, page numbers, percentages, time, numbers preceded by capitalized nouns, and numbers followed by units of measure are expressed as numerals (e.g., Table 1, Chapter 1, 2%, Journal Article no. 1, Treatment 3, 1 g, 5 s)
- numerals are used for single numbers greater than or equal to 10—**except** when the number is the first word of the sentence
- numerals are used to designate the numbers nine and below when two or more numbers are used and any of them are greater than nine; e.g., ". . . 2, 5, and 20 pots were planted," but "a group of 12 plants was incubated at three temperatures."
- ordinal numbers are treated like cardinal numbers: third, fourth, 33rd, 100th, except in references, where digits are preferred (e.g., 5th ed., 7th Congress).
- for large numbers ending in zeros, use a word or prefix for part of the number (e.g., 1.6 million, not 1,600,000); the same applies for very small numbers preceded by zeros (e.g., 23 µg, not 0.00023 g)
- a zero is used before decimal numbers less than 1.0 (e.g., 0.1 and 0.5)
- use an en-dash in a range of numbers (e.g. 15-30 cm depth)
- do not use the ambiguous term billion, which can mean either a "thousand million"

(British usage) or a "million million" (American usage)

Use of SI Units and Specialized Terminology

Generally, the SI system (Système International d'Unités) of reporting measurements is **required** in all theses and dissertations submitted to the Department of Soil Science. However, other units may be reported parenthetically if this will help with the interpretation of the data or facilitate comparisons with the published literature (e.g., expressing yield in bu ac^{-1}).

Students should refer to the *Publications Handbook and Style Manual* (ASA-CSSA-SSSA, 2008: *Chapter 7. Units and Measurements*) for a detailed description of the style requirements for units and measures.

Some **non-SI units** may be used, but these units are limited to those that are convenient for soil scientists.

- area can be expressed as hectare (1 ha = 10^4 m^2)
- the use of liter (1 L = 10^{-3} m^3) in the denominator of derived units is permitted, but cubic meters is encouraged
- the use of centimeter (cm) is acceptable for short measurements such as plant height, row width, soil depth, etc.
- soil bulk density can be expressed as g cm^{-3}, but Mg m^{-3} is encouraged and t m^{-3} is allowed (see below)
- angstroms (Å) are allowed for atomic spacing, and wave number can be reported as reciprocal centimeter (cm^{-1})
- the SI base unit for thermodynamic temperature is kelvin (K); however, the Celsius scale may be used to express temperature
- the degree sign should be used with Celsius temperature (°C) but not with the kelvin scale (K)
- the base unit second (s) is the preferred unit of time; other units (i.e., minute, min; hour, h; day, d; week, wk; year, yr) are acceptable
- periods of time shorter than 182 d (26 wk) should **not** be expressed in months (mo) without a qualifying word such as 'about' or 'approximately'
- the unit 'month' may be used for periods of 6 mo or greater in text, tables, or figures; the word 'month' may be used to mean calendar month. Named units (e.g., July rainfall) are also acceptable
- in SI, a tonne (t) equals 10^3 kg, or 1 Mg, and is understood to mean metric ton; **do not** use the term 'metric ton'
- when expressing yields or application rates, the term Mg ha^{-1} is preferred; t ha^{-1}, which is widely used outside the USA, is acceptable

- use Tg (**not** Mt) for a million tonnes
- radian (rad) is the derived unit for measurement of plane angles, but degree is also acceptable
- other acceptable non-SI units are: dalton (Da), electron volt (eV), poise (P), Svedberg units (S), degree (°), minute (′), and second (″)

Special attention is required for reporting concentration, exchange composition and capacity, energy of soil water (or water potential), and light (Table 4). **NOTE:** prefixes, other than those shown in Table 4, may be used so that numerical values fall between 0.1 and 1000.

Table 4. Preferred and acceptable units for quantities related to concentration, exchange parameters, light, and water potential (ASA-CSSA–SSSA, 2008).

Quantity	Application	Preferred unit	Acceptable Unit
Concentration	known molar mass (liquid or solid)	mole per cubic meter (mol m^{-3}) mole per kilogram (mol kg^{-1})	mole per litre (mol L^{-1}) gram per litre (g L^{-1})
	unknown molar mass (liquid or solid)	gram per cubic meter (g m^{-3}) gram per kilogram (g kg^{-1})	gram per litre (g L^{-1})
	known ionic charge	mole charge per cubic meter (mol_c m^{-3})	mole charge per litre (mol_c L^{-1})
	gas	mole per cubic meter (mol m^{-3})	gram per cubic meter (g m^{-3}) gram per litre (g L^{-1}) litre per litre (L L^{-1}) microlitre per litre (μL L^{-1}) mole per litre (mol L^{-1}) mole fraction (mol mol^{-1})
Exchange parameters	exchange capacity	mole charge of saturating ion per kilogram (mol_c kg^{-1})	centimole charge of saturating ion per kilogram ($cmol_c$ kg^{-1})
	exchangeable ion composition	mole charge of specific ion per kilogram (mol_c kg^{-1})	
	sum of exchangeable cations	mole charge of ion per kilogram (mol_c kg^{-1})	
Light	irradiance	watt per square meter (W m^{-2})	
	photosynthetic photon flux density (400–700 nm)	micromole per square meter per second (μmol m^{-2} s^{-1})	
Water potential	driving force for flow	joule per kilogram (J kg^{-1})	kilopascal (kPa) meter of water in a

Percentage (%). The use of percentage is **unacceptable** when you are describing the composition of a mixture and it is possible to express the elements of the mixture in SI units; e.g., plant nutrient concentration should be expressed as mg N g^{-1} dry weight **not** %N.

The use of percentage is **acceptable** when the elements of an event cannot be described in SI units or when a well-known fractional comparison is being described. Examples of acceptable usage of percentage are as follows:

- coefficient of variation
- botanical composition, plant stand, and cover estimates
- percentage increase (or decrease) in yield
- percentage of an applied element that is recovered by a plant, in an extractant, etc…
- fertilizer grades
- relative humidity
- as an alternative unit to soil texture (e.g., 35% sand, 27% silt and 38% clay; this is acceptable because each component is well defined and is a fraction on a mass basis)
- as an expression of fractional base saturation
- atom percent abundance of a stable isotope (e.g., 0.3663 atom% ^{15}N)

Parts per thousand (‰). The term "parts per thousand" is a dimensionless term used to report isotope ratios relative to a standard. It is also acceptable in some mineralogy references.

Parts per million (ppm). The term "parts per million" is ambiguous, and its use is strongly discouraged—it should be replaced by the appropriate SI units (e.g., µL L^{-1}, mg L^{-1}, or mg kg^{-1}).

- the **only exception** is when ppm associated with nuclear magnetic resonance (NMR) measurements; i.e., parts per million is the official term used to express the relative shift of a NMR line of a given nucleus from the line associated with the standard for that nucleus—when used in this way the term is dimensionless

Time and date. Time is indicated using the 24-h system, which is indicated by four digits—the first two for hours and the last two for minutes.

- the day begins at midnight (0000 h) and the last minute is 2359 h; thus, 2400 h on 31 Dec. 2003 is the same as 0000 h on 1 Jan. 2004.
- clock time is expressed with four digits, with leading zeroes as needed (e.g., 0015 h, 0845 h, or 2129 h)
- calendar dates are written as **day** (one or two digits), **month** (the name spelled out in full

or abbreviated), and **year** (four digits), without punctuation

- abbreviate the month when giving both day and year; otherwise, spell out the month in full (exception: abbreviate the month in table column or row headings)
- standard abbreviations for months are Jan., Feb., Mar., Apr., Aug., Sept., Oct., Nov., and Dec.; **May, June, and July are never abbreviated**.
- dates may be identified as day of the year (abbreviated DOY)
- **Note that Julian day does not mean day of the year.** A Julian day describes a date in terms of days elapsed since Greenwich noon on 1 Jan. 4713 BC (a date chosen by ancient Roman astronomers to synchronize their lunar and solar calendars)
- Julian dates are used primarily in astronomy, information science, and space science

Summary / Synthesis and Conclusions

Traditional style thesis. A thesis/dissertation written in the traditional style must include a summary chapter that incorporates (i) your conclusions regarding the research and its contribution to your field of study; (ii) the implications (both theoretical and practical) of your work—remember that though some speculation is encouraged, it based on your observations and knowledge of the subject area, and should be reasonable; and (iii) your suggestions for future research.

This chapter also should include a discussion of the limitations of your work—**do not**, however, concentrate on the negatives.

Manuscript style thesis. For a thesis/dissertation written in the manuscript style, the final chapter must be a synthesis of the entire thesis/dissertation. Just as the preface places each chapter into the context of the thesis/dissertation as a whole, the synthesis must "tie together" the individual research chapters to tell the larger story of what the entire body of work was all about; i.e., each "manuscript" contributes to the larger purpose of the study—this is where you show the reader how it all fits together.

Remember, a thesis or dissertation is not just a collection of manuscripts!

Regardless of the style you choose in which to write your thesis or dissertation, you should use the summary or synthesis chapter to ensure that the reader does not walk away thinking *"So what?"*.

References

The student—not the supervisor and not the GAC—is responsible for the completeness and accuracy of all the references.

Refer to the Soil Science Society of America Publications Handbook and Style Manual for Detailed Examples of Reference Formatting a Wide Range of Published Materials

The Style Manual is available at:
https://www.agronomy.org/publications/journals/author-resources/style-manual/

If you are using Mendeley for managing your references DO NOT select the SSSAJ format – as of October 2020 – the newest changes to the SSSAJ formatting had not been updated in Mendeley. Instead select APA 7th edition as the citation style - the SSSAJ has adopted the APA style.

To access the APA 7th edition in Mendeley Go to 'View' > 'Citation Style' > 'More styles' > then select the APA 7th edition to add it to the main list.

The **References** must be formatted as follows:

- single spaced, leaving one-half line (6-pt) between each entry
- references must be arranged alphabetically by the surnames of authors
- all single-authored articles by a given individual precede multiple-author articles of which the individual is senior author
- alphabetize entries with the same first author according to surnames of succeeding coauthors and then by year (oldest to newest), when the names are repeated exactly
- two or more articles by the same author (or authors) are listed chronologically (oldest to newest) and then by title
- articles by the same author or authors published within a single year are referenced by adding lowercase letters (a, b, c, . . .) to the date
- for works with two authors, use and ampersand (&) between the names
- for works with three to seven authors, list all authors with and ampersand before the final author
- for works with more than seven authors, list the first six authors. After the sixth author use an ellipsis (. . .) in place of the author names, then provide the final author's. There

should be no more than seven author names

- list the surname of an author followed by a comma and then the author initials for each author (e.g., Liu, L., Farrell, R. E., Lemke, R. L. & Knight, J.D.)
- use sentence-style capitalization for titles and subtitles of articles and book chapters; i.e., capitalize only the first letter of the first word and any proper nouns and adjectives
- journal titles are written in full (not abbreviated)
- single-word titles are **not** abbreviated
- use acronyms or commonly understood abbreviations (e.g., SSSA, USEPA, ICRISAT) for publishers in the reference list and in the within-text citation
- for institutional authors, it is usual to spell out acronyms and abbreviations; however, acronyms are used for the international agricultural research centers of the Consultative Group on International Agricultural Research (CGIAR) system (www.cgiar.org)
- use standard English abbreviations for names of provinces and states in journal titles
- for publisher locations, use U.S. postal system or Canada Post abbreviations to identify U.S. states and Canadian provinces

Reference Style[9]

- each reference to a journal publication must include, in order: the author(s), year of publication (in parentheses), full title of the article, publication in which it appears, and volume and inclusive page numbers
- only include the issue number for publications without consecutive pagination [i.e., if each issue within the volume begins with page 1; e.g., 11(2):5–10]
- treat electronic sources (i.e., internet content) as you would a print version of the same material: author, date, title, and publisher
- where a DOI is available provide the *digital object identifier* (DOI) at the end of the citation – this can be added automatically in the Mendeley referencing software
- for original on-line content other than formally published documents, include as much of the following information as can be determined: author of the content, title or description of the web page, the owner of the site, the *uniform resource locator* (URL) or DOI if one is given and the date the site was accessed (dd-mm-yyyy)
- for non-print media (e.g., CD, DVD), identify the type of medium [in brackets] after the

[9] Refer to the SSSA *Publications Handbook and Style Manual* for a complete list of the styles used for different types of reference material (e.g., journal articles, foreign language articles, book and chapters in books, conference proceedings, papers and posters presented at meetings, dissertations and theses, patents, standards). The *Style Manual* is available on-line at https://www.soils.org/publications/journals/author-resources/style-manual/

title

Consult the SSSA Style Manual or recent articles (2020 or newer) published in the Soil Science Society of America Journal (SSSAJ) for examples!

Appendices

Material that is relevant to the thesis/dissertation but is not considered suitable for inclusion in the text (e.g., raw data files, extensive photographs, detailed statistical tables, etc…) should be included in an appendix.

The types of material contained in an appendix include (but are not limited to):

- proof of equations
- raw data for analyses, figures, or tables
- details of methods used on a specialized topic not of crucial importance to the discussion
- a lengthy debate on a topic of secondary importance to the issues discussed
- computer programs
- illustrative material
- maps

The appendix should be preceded by a separation sheet with the title **Appendix** or **Appendices** at the top or center of the page. The formatting for this heading should follow that of the chapter headings—but is **NOT** numbered. Page numbering continues in sequence from the end of the Reference section.

If appropriate, the appendix may be subdivided; each subdivision can begin with its own separation sheet with the number (Appendix 1, Appendix 2, Appendix 3 OR Appendix A, Appendix B, Appendix C) and title at the top or center of page, and the appendix material beginning on the next page. Alternatively, each subdivision can begin with the separate appendix number and title at the top of the page where material begins. In either case, the main separation sheet, Appendixes or Appendices, is still required.

Vita (Optional)

A brief (one page maximum) biography of the student is permitted.

- write the vita as a narrative rather than as a resume or *curriculum vitae*
- include appropriate academic and professional information, but **do not** include personal information (such as your address or phone number)—remember, the thesis/dissertation will be available to the public

Tips for writing a thesis/dissertation using Microsoft Word

Resources describing how to write a thesis/dissertation using Microsoft Word are available on-line (and can be downloaded as pdf files). Two excellent examples are:

Using Microsoft Word 2011 (Mac) for Your Dissertation **(University of Michigan)**

&

Formatting a Thesis with Microsoft Word **(University of Calgary)**

THESIS / DISSERTATION CHECKLIST

Use the following checklist to carefully check the formatting of your thesis or dissertation. Carefully checking these items will speed up the acceptance process for your thesis.

Sequence of Pages

- ☐ Are the parts of your thesis in the correct order? (refer to Table 1 or Table 2 in the *Guide*)

Title Page

Matches the CGPS example (see example on page A2)

- ☐ No page number is displayed on title page
- ☐ Title should centered across the page about 1.25 inches from the top of page
- ☐ Use UPPERCASE letters for all words in the title
- ☐ No period after the title
- ☐ Spacing matches the *Guide* and on-line examples
- ☐ Copyright statement—listing the month and year of the oral examination. Your name should be listed exactly as it is written earlier on the Title Page

Table of Contents

- ☐ **TABLE OF CONTENTS**, is in small caps and centered like Chapter Titles
- ☐ In prefatory pages, numbers are lower case Roman numerals, bottom center
- ☐ Page number columns in Table of Contents, List of Figures, and List of Tables are aligned to the right digit
- ☐ Line titles do not run into the page number column
- ☐ Single-space all entries. Leave one-half line (6 pt) above each chapter entry
- ☐ Titles have all the same capitalization, size, and same font

Page Numbering

- ☐ Prefatory pages are numbered with lower case Roman numerals
- ☐ The **INTRODUCTION** starts with page 1
- ☐ All page numbers are at the bottom center of the page, in the same size font
- ☐ Each page has a page number and all page numbers are in sequence

Page Margins

- ☐ Choose one style:
  Leftbound: 1-inch margin on TOP, BOTTOM and RIGHT; 1 to 1.2-inch margin on LEFT; Bottom: 1"; Right: 1"; Page numbers (in headers) set at ½-inch from bottom center

Unbound: 1-inch margin on all sides; page numbers ½-inch from top center

- ☐ Consistent margins throughout the thesis
- ☐ All tables and figures are within the margins

Line Spacing

- ☐ Text should be one-and-one-half or double-spaced and, consistent throughout document
- ☐ References, tables, appendices, footnotes, endnotes, and block quotes may be single-spaced, with 6-pt of space between listings
- ☐ Consistent spacing before and after titles, headings and subheadings
- ☐ Indent the first line of all paragraphs, including Abstracts

Fonts

- ☐ Standard proportional fonts, such as Times New Roman, Calibri, Cambria, Arial, or a similar proportional font
- ☐ 12 point size for text of thesis/dissertation; tables, figures, footnotes, and endnotes may use a smaller font (do not use a font size smaller than 10 point)
- ☐ Same font used throughout thesis text (figures may differ)

List of Tables and List of Figures

- ☐ LIST OF TABLES or LIST OF FIGURES is in small caps and centered like chapter titles
- ☐ Page is Numbered using lower case Roman numerals, bottom center
- ☐ Page number columns in Table of Contents, List of Figures, and List of Tables are aligned to the right
- ☐ Table or Figure titles do not run into the page number column
- ☐ Single-space all entries. Leave one-half line (6 pt) between each entry
- ☐ Titles have all the same capitalization, size, and typeface (font); all end with a period

Abstract

- ☐ ABSTRACT, is in small caps and centered 1-inch from the top of the page, with the text beginning one-and-one-half spaces (18-pt) below
- ☐ Numbered using lower case Roman numerals, bottom center
- ☐ Abstract should be one-and-one-half spaces or double-spaced like the text of the thesis
- ☐ Indent the first paragraph of your Abstract like other paragraphs in your thesis

Top Level (Major) Headings

- ☐ All Top Level (Prefatory Pages, Chapter Title, Reference/Bibliography, and Appendix) headings must be in small caps, the same size font, and location at the top of the page

- ☐ Top Level headings may be no larger than 16 point

Body of Thesis/Dissertation or Manuscript(s)

- ☐ Paragraphs are indented
- ☐ No blank pages
- ☐ No excessive white space in text - start next section immediately not on next page unless a new chapter
- ☐ Organized in a coherent and consistent manner, same size, location, font, etc.
- ☐ All Top Level (Prefatory Pages, Chapter Title, Reference/Bibliography, and Appendix) headings must be in all caps, the same size font, and location at the top of the page
- ☐ Top Level headings may be no larger than 16 point
- ☐ Headings are used in a consistent manner, same size, location, font, etc.
- ☐ Differentiation exists between heading levels
- ☐ Chapter titles include the number and are centered in SMALL CAPS (e.g., INTRODUCTION)
- ☐ Secondary headings are left-justified using Title Case capitalization
- ☐ Third level headings are left-justified using Sentence case capitalization
- ☐ 12 point proportional font

Journal Paper Format

- ☐ Follows *Soil Science Society of America Journal* requirements for a Journal Paper
- ☐ Each paper starts a new chapter, which can include Abstract, Introduction, Results and Discussion (separate or combined), Tables, and Figures. References and Appendices are **not** included as part of the chapter
- ☐ If combining Results and Discussion do so consistently for all research chapters
- ☐ Use paper's title as main chapter heading
- ☐ Indicate the publishing status and the name(s) of the author(s) of each manuscript in a footnote to the Preface
- ☐ Include an explanation of your role and the co-authors' roles in the research and preparation of the paper
- ☐ Begin the text of the paper on the same page as the title

Citations and References

- ☐ Consistent SSSAJ style
- ☐ Website URLs must contain complete descriptions and dates of the information used and dates of access of that information
- ☐ Single space references; leave one-half line (6 pt) between each entry

Appendices

- ☐ Each appendix must have a Top Level heading, in the same location as, and formatted like, all the other Chapter titles
- ☐ Must be displayed as Top Level headings in your Table of Contents
- ☐ All pages are numbered in the same font and location as text pages
- ☐ If there is only one appendix, do not put an A or I after Appendix. If multiple Appendices use letters or numbers such as Appendix A, Appendix B, etc.
- ☐ Letters and documents **must not** contain signatures

Biographical Sketch or Vita (optional in thesis)

- ☐ Follows *U of S* requirements for Biographical Sketch or Vita. **Do not include personal or contact information**

It is important that you have met all the formatting requirements so that your thesis can be promptly approved for your graduation.

- ☐ I verify that I have checked all the formatting guidelines listed in the Thesis Checklist.

APPENDIX A

(Examples of elements of a thesis or dissertation)

TITLE OF THESIS/ DISSERTATION

A Thesis Submitted to the College of Graduate Studies and Research

in Partial Fulfillment of the Requirements

for the Degree of Doctor of Philosophy

in the Department of Soil Science

University of Saskatchewan

Saskatoon

By

Jane Marie Doe

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Reference in this thesis/dissertation to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement, recommendation, or favoring by the University of Saskatchewan. The views and opinions of the author expressed herein do not state or reflect those of the University of Saskatchewan, and shall not be used for advertising or product endorsement purposes.

ABSTRACT

Soil organic N (SON) comprises 90% of all N in surface soils, yet as much as half remains in forms which are chemically unknown or, at best, poorly understood. Analytical methods such as pyrolysis field-ionization mass spectrometry (Py- FIMS) and ^{15}N cross polarization magic-angle spinning nuclear magnetic resonance (CPMAS-NMR) spectroscopy are widely used for the characterization of SON; however, these methods have limitations which contribute to the gaps in our understanding of SON chemistry. For example, Py-FIMS may produce heat-induced secondary compounds, and ^{15}N-NMR may lack sensitivity and resolution for experiments at natural ^{15}N abundance. X-ray absorption near edge structure (XANES) spectroscopy probes the bonding environment of individual elements. The application of this technique to complex environmental samples such as soil is still in its infancy, but early studies suggest that this technique may help resolve SON molecular structure. This dissertation sought to develop and apply synchrotron-based N and C *K*-edge XANES spectroscopy to the study of soil and soil extracts to determine the structures in which SON is bound; Py-FIMS was coupled with XANES as a corroboratory technique.

Soil organic N composition was largely controlled by topographic position, and to a lesser degree, by cultivation. Divergent (i.e., water shedding) positions were enriched in carbohydrates and low molecular weight lignins, whereas convergent, depressional and level positions showed enrichment in lipid-type compounds. These differences were attributed to tillage-induced redistribution of soil, and water movement from upper to lower slope positions. Nitrogen XANES revealed a unique form of organic N, identified as N-bonded aromatics, particularly in the divergent positions.

Rhizosphere soil was enriched in higher molecular weight lipid-type materials and depleted in low molecular weight polar compounds. This was attributed to increased input of fresh plant material and higher microbial turnover in the rhizosphere. Nitrogen-bonded aromatics also were detected in the rhizosphere.

This dissertation demonstrated that N XANES is a sensitive and novel method for characterizing SON, and can be used complementarily with other analytical techniques such as Py-FIMS and proteomics. The continued development of XANES will provide a useful tool for SOM research into the future. (*adapted from Adam Gillespie, 2010*)

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to Dr. A.D. Scott for his guidance, inspiration, encouragement and continued support throughout the course of this investigation. I would especially like to thank him for his patience in putting up with me . . . I know it was sometimes challenging and not always easy!

A special thanks goes to Dr. Dennis Johnson for his helpful insights and timely conversations throughout this investigation. My thanks also go to the members of my graduate advisory committee: Drs. Tom Fenton, Richard Handy and John Hanway.

This investigation was funded by grants from the Potash and Phosphate Institute and the Hach Chemical Company of Ames, IA. I am greatly indebted to both organizations. Likewise, I am extremely grateful for the financial support afforded me by Iowa State University as a Graduate Research Associate . . . yeah Cyclones!

I couldn't have done this without the support of my "drinking/thinking buddies" Marty and Mae Mascianica, Lynn Rubisch, Nick Stoynoff, Paula Bramel, Sue Simpson and "the roommates". Thanks for the friendship, encouragement and moral support!

DEDICATION

This dissertation is dedicated to the people who made me the person I am today, supported me, and believed in me even when I wasn't sure of what I was doing . . . my parents, John and Arvilla Farrell; my sisters, Terry, Pat and Diane; and my brother, Bill. Thanks guys!

TABLE OF CONTENTS (*TRADITIONAL FORMAT*)

TABLE OF CONTENTS *(MANUSCRIPT FORMAT)*

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS / NOMENCLATURE

ACN	Acetonitrile
AMF	Arbuscular mycorrhizal fungi
BLAST	Basic Local Alignment Search Tool
CP-MAS	Cross polarization-magic angle spinning
CLS	Canadian Light Source
DOM	Dissolved organic matter
ELISA	Enzyme-linked immunosorbent assay
ESCA	Electron spectroscopy for chemical analysis
FLY	Fluorescence yield
Gly	Glycine
GRSP	Glomalin-related soil protein
m/z	mass:charge
NEXAFS	Near-edge x-ray absorption fine structure
NMR	Nuclear magnetic resonance
NMS	Non-metric multidimensional scaling
PAGE	Polyacrylamide gel electrophoresis
Py-FIMS	Pyrolysis field ionization mass spectrometry
SDS-PAGE	Sodium dodecyl sulphate-polyacrylamide gel electrophoresis
SGM	Spherical grating monochromator
SOC	Soil organic carbon
SON	Soil organic nitrogen
SPIDER	Saturation-pulse induced dipolar exchange with recoupling
STXM	Scanning transmission X-ray microscopy
TEY	Total electron yield
TII	Total ion intensity
XANES	X-ray absorption near edge structure
XAS	X-ray absorption spectroscopy
XPS	X-ray photoelectron spectroscopy

The following examples were taken from the Ph.D. dissertation of Lori Philips (2009)

3. Culture-based and culture-independent assessment of the impact of mixed and single plant treatments on rhizosphere microbial communities in hydrocarbon contaminated flare-pit soil

3.1 Preface

Phytoremediation systems for organic compounds such as petroleum hydrocarbons rely on a synergistic relationship between plants and their root-associated microbial communities. Mixed plant treatments are commonly used for phytoremediation, with the underlying assumption that combinations of root types and exudate patterns will allow greater infiltration and stimulation of microbial communities, with a net positive impact on degradation. It is simply not known however, how plant-specific influences on rhizosphere microbial communities are impacted by inter-species competition in mixed plant treatments. In order to begin to elucidate the mechanisms of plant-bacterial interactions and work towards optimizing the potential of phytoremediation, we must first begin to unravel these plant-specific impacts. In this study, we examined six plants commonly used in phytoremediation, planted both singly and as two separate mixes, in order to address these issues.

4. Field-scale assessment of weathered hydrocarbon degradation by mixed and single plant treatments

4.1 Preface

In Chapter 3 we saw that the common practice of using mixed plant species may limit the effectiveness of phytoremediation in flare pit soils contaminated with weathered hydrocarbons. Specific plants such as alfalfa exerted a dominant impact on rhizosphere microbial populations, which suppressed overall degradation. Plant impacts on rhizosphere microbial communities under controlled environment conditions however, may not correlate with those that occur under field conditions, particularly in cold climate regions. Thus, corroborating field studies are required. In this two-year field study changes to both rhizosphere and endophytic bacterial communities were monitored with respect to long term hydrocarbon degradation potential.

The following examples were taken from the Ph.D. dissertation of Joel Ens (2012)

3. Controls of edaphic conditions on site quality for willow (Salix spp.) plantations across a large climatic gradient in Canada

3.1 Preface

The success of a Canadian willow biomass industry requires thoughtful regional planning. Willow plantations need to be centered around processing facilities such that transportation of bulk biomass is minimized. Therefore, it is not enough to simply develop the geographic distribution of the industry by trial and error. Rather, it is essential that the productivity of willow species be predictable from measurable climatic and soil characteristics. In this chapter, the factors which dominate site quality for willow are identified and characterized. In doing this it becomes possible to choose the best regions for willow biomass production in Canada as well as the best sites within those regions. Also discussed in this chapter are the nutritional demands of willow. By highlighting these growth requirements this chapter allows for forecasts of the potential of amendments and management techniques to mitigate nutritional deficiencies at some sites thereby maximizing productivity and use of resources.

4. Effects of fast growing willow plantations on soil carbon and nutrient availability

4.1 Preface

Willow is known to be both water and nutrient demanding particularly when planted at high densities. Therefore it is important to examine the effects of this high demand in order to understand the ability of soils to maintain high rates of productivity well into the future. This chapter compares various soil nutrient pools and soil carbon in willow plantations to that of reference sites. The effects of plantation establishment are discussed with particular attention given to nutrients in demand as highlighted in Chapter 3. Whereas Chapter 3 identified the site requirements for high rates of productivity, this chapter introduces willow grown as short rotation intensive culture as a feedback into the long term productivity of a given site.

The following examples were adapted from the M.Sc. thesis of Aaron Betts (2013)

4. Macroscopic and spectroscopic evaluation of zinc sorption onto meat and bone meal (MBM) biochar

4.1 Preface

Characterization of the physicochemical properties of MBM biochar in Chapter 3 confirmed that it contains a carbonate-substituted hydroxyapatite that maintained a calcium carbonate surface precipitate when suspended in solution. In this chapter, macroscopic Zn sorption experiments were combined with molecular-scale spectroscopic Zn speciation studies of the recovered solid to elucidate the mechanism of Zn sorption by detailing reaction rate, capacity and pH dependence during reaction and the Zn species after reaction. This provided the first XAS-based evidence of Zn bonding mechanisms with a MBM biochar and provided an important standard for modeling the XAS spectra of MBM biochar-amended soils in Chapter 5.

5. Speciation change of zinc in smelter-impacted soils when amended with meat and bone meal (MBM) biochar

5.1 Preface

It was shown in Chapter 4 that MBM adsorbs Zn via monodentate, inner-sphere complexation with phosphate groups. In the present study, linear combination (LC) modeling on spectra from Zn K-edge x-ray absorption spectroscopy (XAS) of MBM biochar treated soil samples were used to identify the presence of MBM biochar adsorption as a significant mechanism in reacted soil samples. Wet chemical and micro-scale synchrotron techniques also were employed on the soils before and after treatment to give supporting evidence for a speciation change. Laboratory-based chemical analysis (total and extractable Zn) was performed on both control and reacted soils to give macroscopic information on Zn mobility changes. Spatially resolved, synchrotron-based x-ray microprobe techniques (i.e., micro x-ray fluorescence (μXRF) maps and micro x-ray absorption near edge structure (μXANES) spectroscopy on points of interest) were employed to further aid identification of single Zn species in the bulk-soil XAS.

The following examples were adapted from the M.Sc. thesis of Aaron Betts (2013)

4. Macroscopic and spectroscopic evaluation of zinc sorption onto meat and bone meal (MBM) biochar

4.1 Preface

Characterization of the physicochemical properties of MBM biochar in Chapter 3 confirmed that it contains a carbonate-substituted hydroxyapatite that maintained a calcium carbonate surface precipitate when suspended in solution. In this chapter, macroscopic Zn sorption experiments were combined with molecular-scale spectroscopic Zn speciation studies of the recovered solid to elucidate the mechanism of Zn sorption by detailing reaction rate, capacity and pH dependence during reaction and the Zn species after reaction. This provided the first XAS-based evidence of Zn bonding mechanisms with a MBM biochar and provided an important standard for modeling the XAS spectra of MBM biochar-amended soils in Chapter 5.

INTRODUCTION

1.x. Organization of the Thesis *(BASIC EXAMPLE)*

The studies presented in Chapters 3 through 9 are interlinked and overlapping, with each addressing more than one of the above hypotheses. Chapter 3 begins with a broad picture by examining the whole suite of plants being used at a phytoremediation site in south-eastern Saskatchewan. From there all studies focus down. By Chapter 9, very specific components of the exudates released by several of these plants are examined for their impact on the degradation potential and activity of soil microbial communities. Although each individual chapter has been written as a stand alone research paper in order to facilitate submission to peer-reviewed journals, the chapter introductions serve to tie in the primary objective for the reader. Due to the paper format, the thesis does contain a certain amount of redundant information. In order to reduce this, references were combined into a final list.

1.x. Organization of the Dissertation *(DETAILED EXAMPLE NO. 1)*

This dissertation is written in the style of a collection of articles for submission to peer-reviewed journals. The first research chapter (Chapter 3) is preceded by an Introduction to the dissertation and a Literature Review that provides an overview for the dissertation as a whole. The four main research chapters address the following objectives:

> Chapter 3: identify the climate and soil variables related to productivity so that, in the future, the best sites for plantations can be selected,
>
> Chapter 4: determine the effect of willow plantations on soil nutrient and carbon storage with emphasis on highlighting potential concerns for maintaining productive sites,
>
> Chapter 5: builds on chapter three, but focuses solely on the effects of developing willow plantations on soil greenhouse gas efflux, and
>
> Chapter 6: development and testing of a non-destructive method of estimating standing biomass with the intent that it will aid in future monitoring of productivity in high density plantations for management and research purposes.

These chapters are followed by a synthesis of the individual research studies (Chapter 7), and includes the overall conclusions of the study as a whole and recommendations for future work. Literature cited throughout the dissertation are compiled in the Reference section that follows immediately after Chapter 7.

1.x. Organization of the Thesis *(DETAILED EXAMPLE NO. 2)*

The research described in this thesis is presented in three (3) chapters, each of which was written as a standalone manuscript for publication. Each chapter begins with a preface that describe of how the chapter relates to the thesis as a whole and includes a brief summary of the research (i.e., abstract), a brief introduction that includes a review of the relevant literature, a detailed materials and methods section that contains enough detail that other workers could repeat your work, a summary of the results and the statistical treatment of the data, and a discussion of the results—relating them to the original research question and placing them into context with the published literature, and my conclusions—including a discussion of the implications of my research.

Chapter 3 presents my work related to characterization of the the physical and chemical properties of a meat and bone meal (MBM) based biochar being considered as a soil amendment to support revegetation efforts in the smelter-impacted area in Flin Flon and Creighton. Chapter 4 describes sorption experiments to characterize the reactivity of Zn with the MBM biochar as a function of time, pH, and Zn concentration; together with spectroscopic studies employing extended x-ray absorption fine structure (EXAFS) spectroscopy to probe the bonding environment of Zn sorbed onto the MBM biochar. Chapter 5 describes work carried out at the Canadian Light Source synchrotron to determine the impact of the MBM biochar on Zn-speciation in smelter-impacted soils from the Flin Flon/Creighton area.

The research chapters (Chapters 3–5) are followed by a unifying synthesis chapter (Chapter 6) that connects the individual manuscripts, summarizes the major findings and implications of the research, and highlights the combined contributions of the individual studies. This chapter also includes a conclusions section together with suggestions for further research. Literature cited throughout the thesis are compiled in the Reference section that follows immediately after Chapter 6. Photographs, soil descriptions and field notes describing the sites from which the soils used in Chapter 5 were collected, are included in Appendix A.

SAMPLE TABLES

Table 3.2. Comparison of current and historical pH values for the surface (0–15 cm) samples collected from the PotashCorp–Cory site (1984–2010).

Site No.	1984	1988	1992	1997	2002	Historical Avg.	2010[a]
	- - - - - - - - - - - - - - -	***Upper Slope Position***				- - - - - - - - - - - - - - -	
1	7.5	7.4	7.6	7.3	7.2	7.4 ± 0.2	**6.6**
2	5.7	6.3	6.6	6.7	6.0	6.3 ± 0.4	6.5
3	7.6	7.3	7.2	7.6	7.2	7.4 ± 0.2	*7.7*
4	7.2	6.1	6.8	7.1	7.3	6.9 ± 0.5	6.5
5	7.7	7.7	7.6	7.7	7.7	7.7 ± 0.1	7.6
6	7.3	7.1	7.0	6.4	6.4	6.8 ± 0.4	7.2
7	8.1	7.8	7.7	7.7	7.4	7.7 ± 0.2	**6.8**
8	7.0	7.0	7.2	7.0	6.5	6.9 ± 0.3	*7.6*
9	7.5	7.5	7.6	7.6	7.5	7.5 ± 0.1	**6.9**
10	7.9	7.2	6.6	6.6	6.3	6.9 ± 0.6	6.8
	- - - - - - - - - - - - - - -	***Lower Slope Position***				- - - - - - - - - - - - - - -	
1	5.9	6.3	6.5	6.2	6.0	6.2 ± 0.2	6.3
2	5.1	6.0	5.6	6.0	6.4	5.8 ± 0.5	6.3
3	7.8	7.5	7.8	7.4	7.3	7.6 ± 0.2	7.8
4	6.1	6.5	6.3	6.4	5.8	6.2 ± 0.3	6.3
5	6.8	6.7	7.4	7.6	7.2	7.1 ± 0.4	7.4
6	6.6	6.2	7.0	7.2	6.6	6.7 ± 0.4	6.5
7	6.6	6.7	6.7	6.8	6.4	6.6 ± 0.2	*6.9*
8	6.0	6.3	6.6	6.5	6.0	6.3 ± 0.3	*6.8*
9	5.8	6.0	6.5	6.0	5.8	6.0 ± 0.3	*7.2*
10	7.4	7.9	7.2	6.8	6.7	7.2 ± 0.5	7.2

[a]Numbers in *italics* indicate pH values more than one standard deviation greater than the historical mean; numbers in **bold** indicate pH values more than one standard deviation less than the historical mean.

Note: Minimal horizontal line, No vertical lines, use of bolding for emphasis

Note: The information in this table is also presented as a Figure (see page A24).

Which is the most informative?

Table 4.1. Physical and chemical characteristics, and metal concentrations in soils from the Sherridon site (reference), the Second Valley North site (lime non-responsive), and the Knight North site (lime responsive) from 0-15 cm depth.

Soil Property (n = 2)[a]	Sherridon	- Second Valley North -		-- Knight North --	
	Reference	Non-limed	Limed	Non-limed	Limed
pH	4.04	4.01	4.25	3.36	5.10
Sand (%)	64.90	48.86	64.00	22.93	21.15
Silt (%)	32.13	51.15	28.21	66.76	78.15
Clay (%)	0.13	0.00	0.12	10.32	0.72
Texture	SL	SL	SL	SiL	SiL
TOC[b] (g kg^{-1})	6.9	8.6	7.4	37.0	10.1
Total S (g kg^{-1})	0.00	0.20	0.11	2.20	0.30
NO_3^- (mg kg^{-1})	0.00	0.07	0.00	8.85	1.69
NH_4^+ (mg kg^{-1})	20.58	7.25	14.34	8.58	8.45
CECe [c] ($cmol_c$ kg^{-1})	2.62	4.15	4.45	8.48	8.16
Exchangeable Ca ($cmol_c$ kg^{-1})	0.59	0.52	1.10	0.48	4.06
Exchangeable Mg ($cmol_c$ kg^{-1})	0.28	0.23	1.01	0.60	3.65
Exchangeable K ($cmol_c$ kg^{-1})	0.12	0.10	0.08	0.13	0.10
Exchangeable Na ($cmol_c$ kg^{-1})	0.07	0.05	0.12	0.18	0.35
Base Saturation (%)	40.51	21.90	52.18	16.34	99.88
Total Cu (mg kg^{-1})	11.47	214.2	85.53	451.4	386.1
Available Cu (mg kg^{-1})	0.09	51.68	9.16	102.5	1.65
Total Zn (mg kg^{-1})	35.76	551.2	296.3	792.4	567.1
Available Zn (mg kg^{-1})	1.20	417.4	154.8	56.80	6.05
Total Cd (mg kg^{-1})	0.34	4.99	2.85	12.33	8.03
Available Cd (mg kg^{-1})	0.25	3.22	1.57	1.51	1.11
Total Pb (mg kg^{-1})	0.00	51.00	27.00	836.0	111.0
Available Pb[d] (mg kg^{-1})	0.00	19.6	1.6	8.0	4.0
Total Ni (mg kg^{-1})	0.24	1.02	0.41	0.47	0.42
Available Ni (mg kg^{-1})	0.00	0.00	0.00	0.00	0.00
Total Al (mg kg^{-1})	2898	3037	3282	3748	3462
Available Al (mg kg^{-1})	78.33	79.29	52.23	460.0	8.02

† (n = 2) for all the measurements except for total S and TOC in which (n = 3).

b TOC = Total organic carbon

c CEC_e = effective cation exchange capacity

d Available Pb was measured using flame atomic absorption spectroscopy (AAS); all other metals were determined using microwave-assisted atomic emission spectroscopy (MP-AES).

Note: The data presented in this table are the means of duplicate analyses of a single, composite sample collected at each site and, as such, are only intended to characterize the soils used in a greenhouse study. Standard deviations for the means are not presented as the analytical precision was discussed in the methods section of the text.

Table 3.5. Net production/consumption of H_2 by excised roots and nodules of pea inoculated with one of four rhizobial strains differing in HUP status, a non-nodulating rhizobium, or a sterile water control. Roots and attached nodules were excised from four week-old pea plants and enclosed in a sealed atmosphere of ambient or H_2-enriched air (n = 4).

		Time			
Treatment	**HUP status**	**30 min**	**60 min**	**90 min**	**120 min**
		– – – net production/consumption of H_2 ($\mu L\ L^{-1}$) – – –			
		Ambient air atmosphere			
128C52	+	1.10 b[a]	1.17 b	1.00 c	1.03 c
128C53	+	1.00 b	1.13 b	1.15 bc	1.29 b
128C79	-	5.88 a	9.30 a	16.67 a	17.64 a
PJB5J1	-	11.43 a	26.67 a	41.67 a	50.00 a
B151	n/a	1.01 b	1.19 b	1.17 b	1.06 bc
Control	n/a	1.04 b	1.05 b	1.10 bc	1.28 bc
$LSD_{0.05}$		**4.29**[b]	**5.46**	**7.00**	**4.86**
		H_2-enriched atmosphere			
128C52	+	-8.10	-15.74 c	-11.62 c	-24.62[§] c
128C53	+	-22.72	-13.05 c	-11.53 c	-13.53 c
128C79	-	9.79	20.98 b	30.15 b	40.25 b
PJB5J1	-	29.96[c]	54.35 a	77.80 a	94.48 a
B151	n/a	-5.48	-3.65 c	-6.03 c	-13.57 c
Control	n/a	-8.35	-14.24 c	-9.50[¶] c	-28.17 c
$LSD_{0.05}$		**ns**[d]	**1.33**	**2.63**	**3.83**

[a] Within columns, means followed by the same letter are not significantly different according to LSD0.05.

[b] LSD results are conservative estimates where some treatments had n < 4 due to missing values.

[c] n = 3; gas samples were lost due to a GC malfunction.

[d] ns denotes no significant difference.

Note: When assigning letters to denote statistical significance, the largest value is assigned the letter "a", the next largest is assigned the letter "b", and so on. Note also that the numbers are aligned at the decimal point.

Table 3.19. Mean soil inorganic N (NO_3^- + NH_4^+) and gravimetric soil water content (GSWC) at different sample depths as affected by termination method of field pea green manure in the previous year. Samples taken at Vonda the fall after wheat harvest in 2010. ANOVA table showing probability level where effect of source of variation considered significant at $p \leq 0.05$.

Termination method	Soil inorganic N					GSWC†			
	Depth (cm)					Depth (cm)			
	0-15	**15-30**	**30-60**	**60-90**	**0-90**	**0-15**	**15-30**	**30-60**	**60-90**
n=12	– – – – – – – – – – kg N ha^{-1} – – – – – – – – – –					– – – – – – – – g g^{-1} – – – – – – – –			
Rolling	11.1	3.7	7.5	8.7	29.6	0.165	0.119	0.087	0.154
Mowing	12.4	4.0	6.4	7.4	30.2	0.188	0.123	0.111	0.122
Tillage	11.6	3.6	6.5	10.0	32.4	0.172	0.128	0.103	0.105
Source of variation	– Probability (p)[a] –								
Termination method (TM)	0.7025	0.7469	0.5870	0.4224	0.6336	0.5200	0.2900	0.3837	0.5455
Termination timing (TT)	0.7776	0.8015	0.7486	0.7547	0.8984	0.4486	0.0522	0.9727	0.9496
TM x TT	**0.0349**	0.3235	0.5587	0.1617	**0.0250**	0.6223	0.8112	0.2682	0.8579

a Bolded values indicate significance at the $p \leq 0.05$ level of probability.

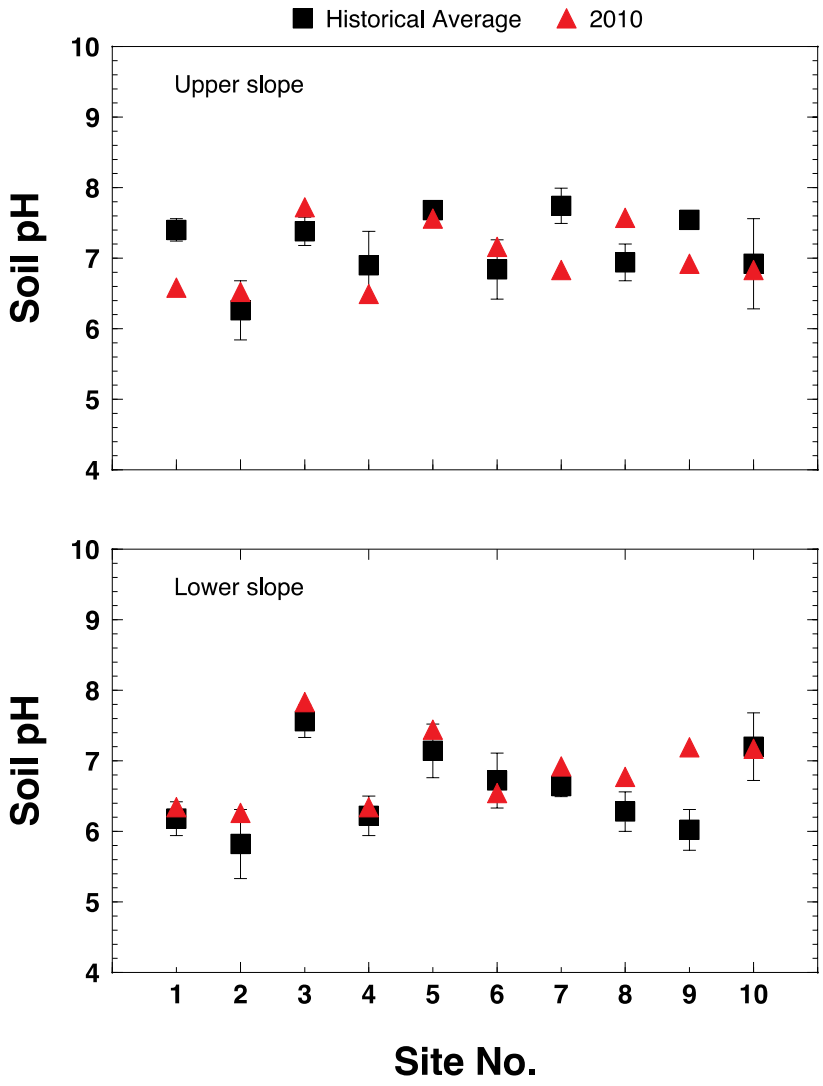

Fig. 3.2. Values of pH for the surface (0–15 cm) soils collected at PotashCorp–Cory. Values are historical averages (1984–2002: Kozak et al., 1984, 1988, 1992; Kozak & Farkas, 1997, 2002) and averages with standard deviation for the 2010 samples.

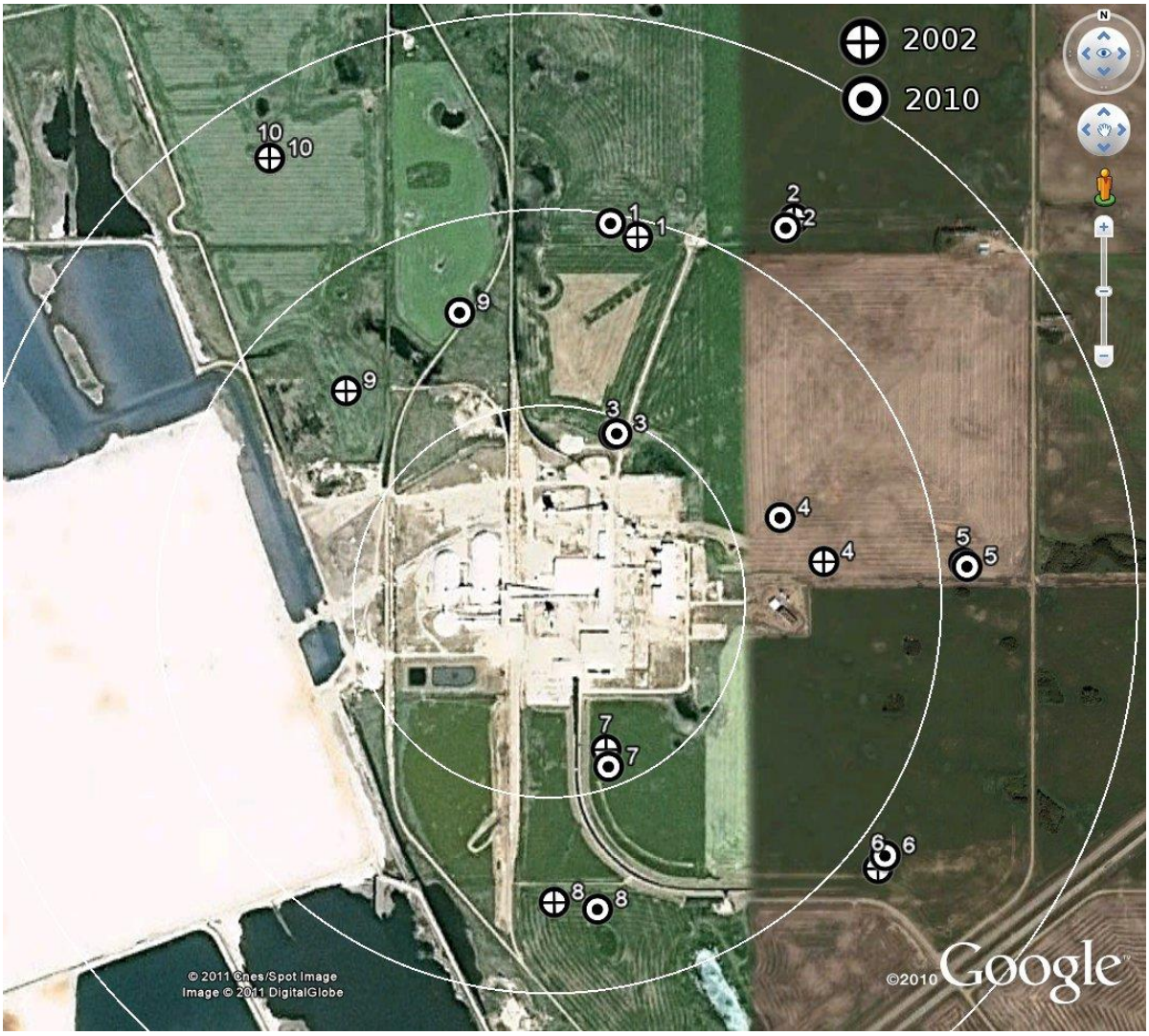

Fig. 1.1. Location of sampling sites in relation to the PotashCorp–Cory Division refinery. The dashed lines mark the distance (in 0.5 km intervals) from the refinery. The original (2002) benchmark sites are numbered and marked as cross-hatched circles (⊗); the 2010 sites are marked as concentric circles (⊙). Satellite image taken from *Google Earth* (*ver. 5.2.1.1588*, image acquired 04 July 2007; accessed 09 January 2010). [Note: the original site map is included as Appendix A1.]

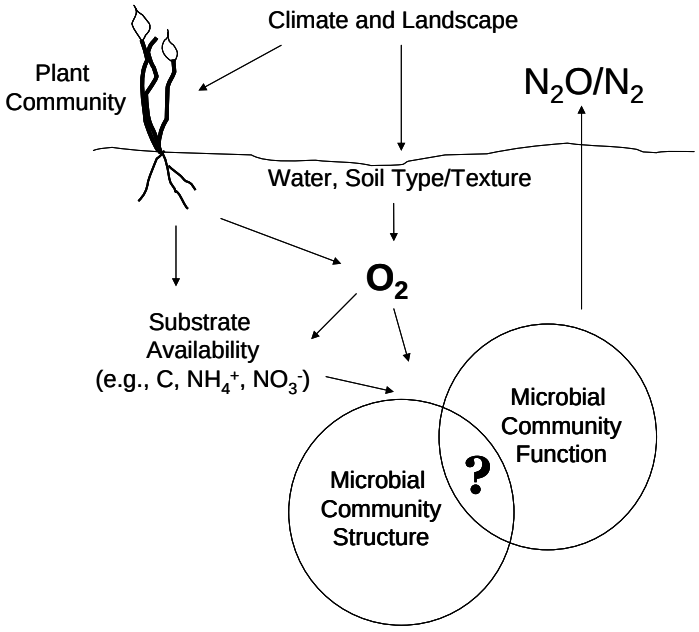

Fig. 2.2. Relationships between controls over microbial activity and N_2O production in soils. The "?" represents the knowledge gap to be addressed by this thesis.

Example of a figure adapted from the literature.

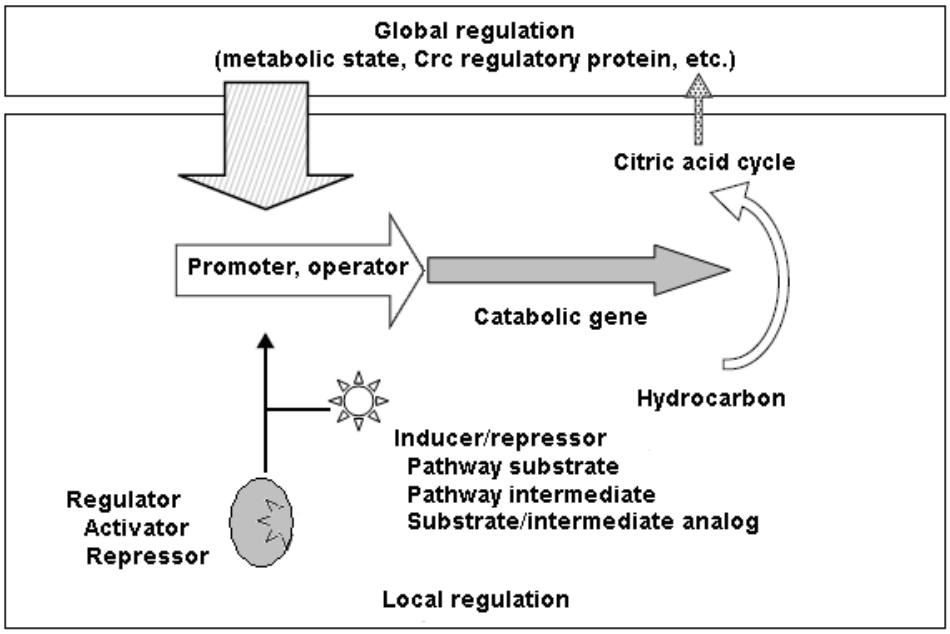

Fig. 2.2. Schematic representation of local and global regulatory mechanisms acting on catabolic operons involved in hydrocarbon degradation. Modified from Diaz and Prieto (2000).

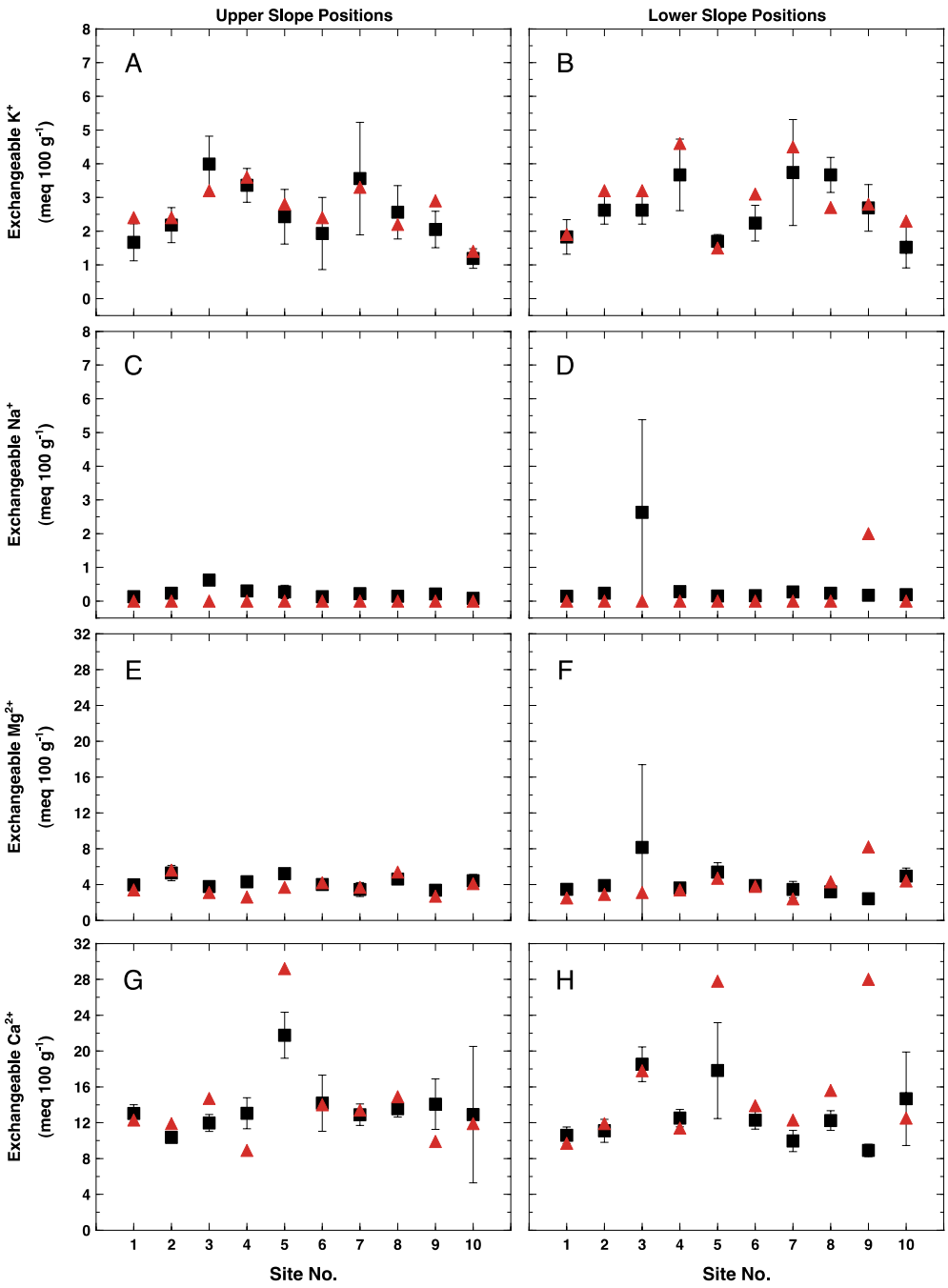

Fig. 3.9. Ammonium acetate extractable cation concentrations in the surface (0–15 cm) soils collected at PotashCorp–Cory. Values are historical averages (1984–2002: Kozak et al., 1984, 1988, 1992; Kozak & Farkas, 1997, 2002) and averages with standard deviation for the 2010 samples.

Note: The units used to express exchangeable cation concentrations (meq 100-g^{-1}) are obsolete and must be replaced with the proper units: cmol$_c$ kg^{-1}.

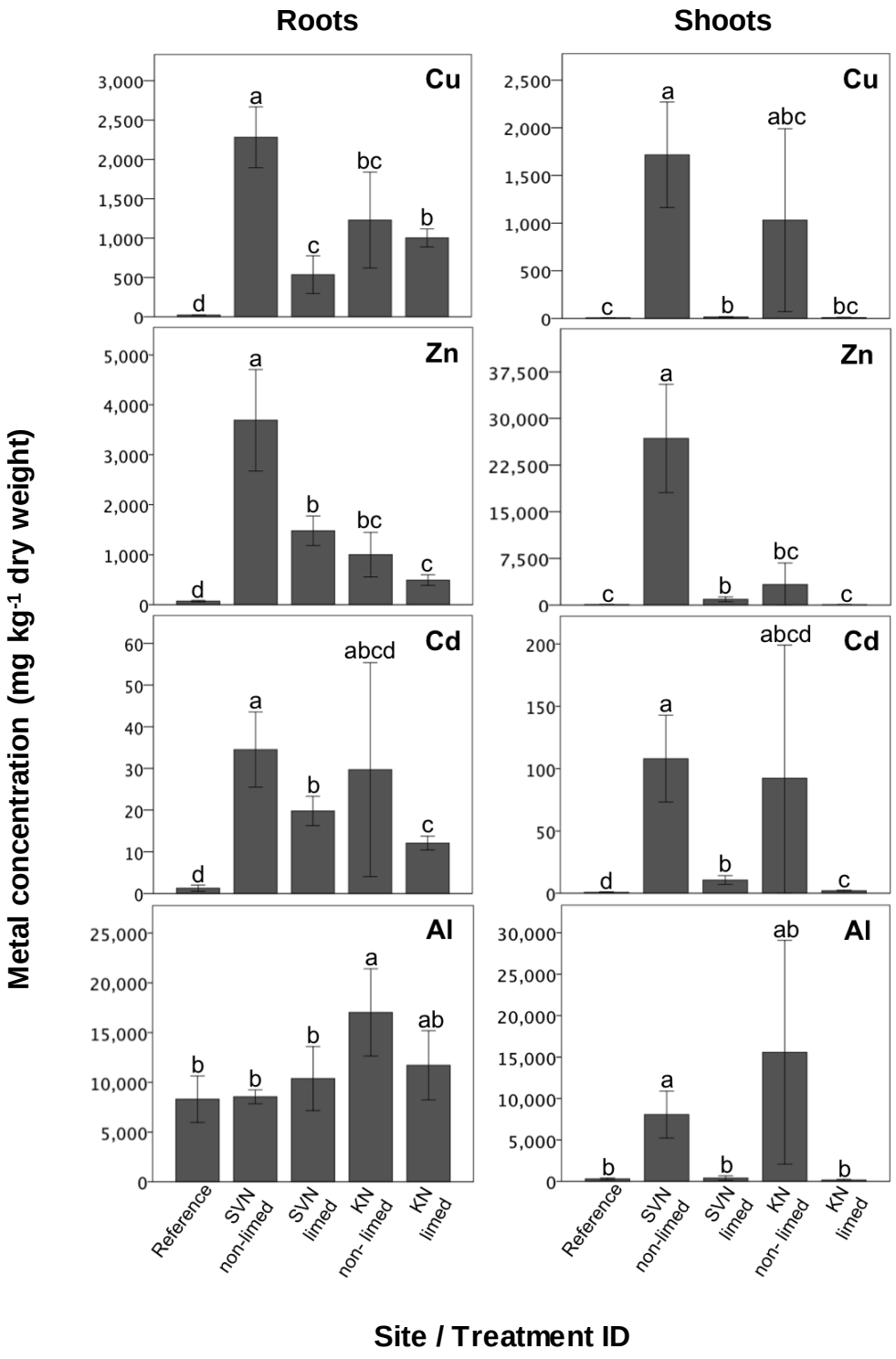

Fig. 4.3. Concentration of heavy metals (mg kg^{-1} dry weight) in the roots (n = 6) and shoots (n = 6) of *Silene vulgaris*. Letters above the bar represent significant differences ($P < 0.10$) based on the Kruskal-Wallis test and Games-Howell test. Error bars represent ± 2 standard errors of the mean. Note the scale differences on the y-axes between the roots and shoots.

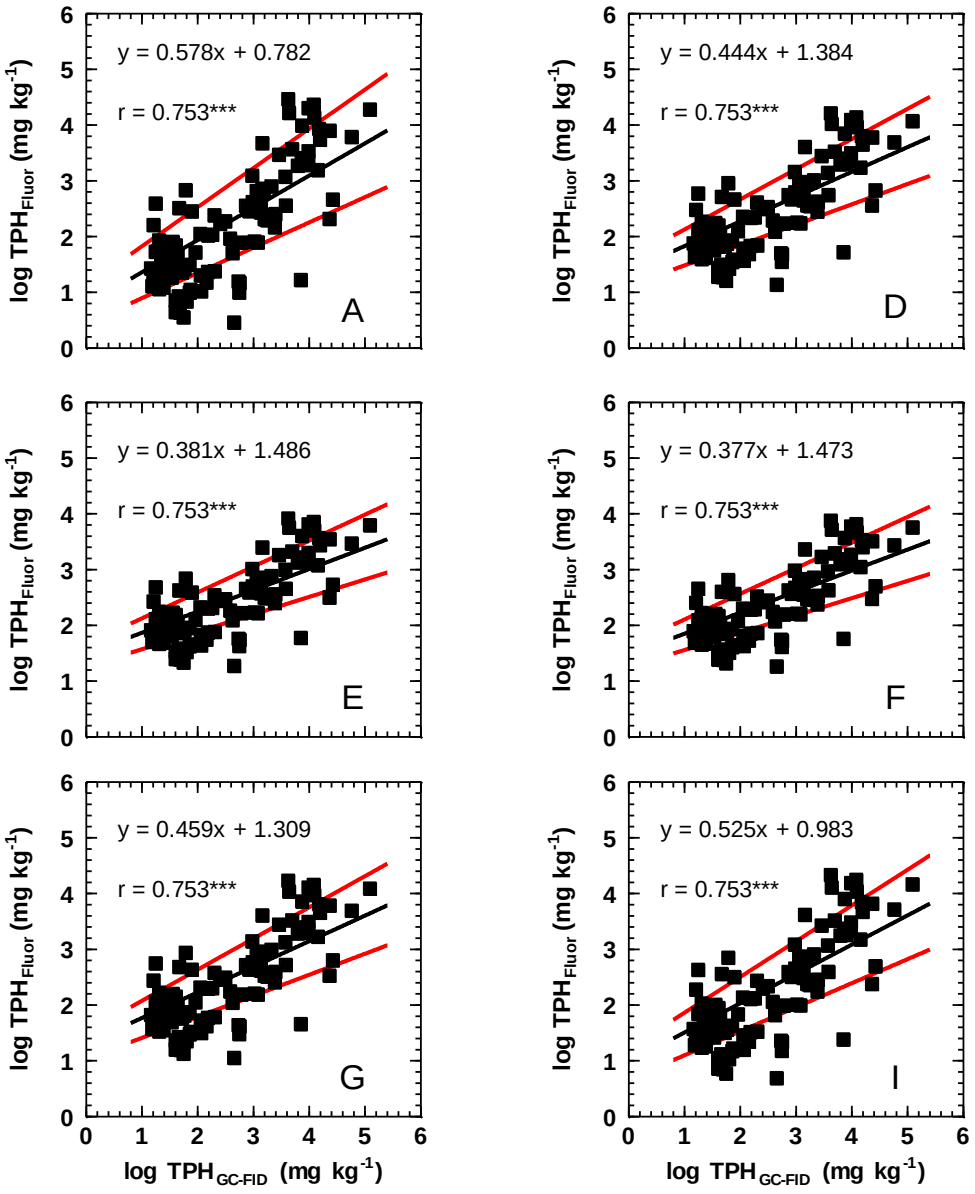

Fig. 3.5. Relationship between TPH concentration measured using the fluorometer and the reference TPH value measured using GC–FID. [Note: Calibration curves were constructed from subsets (n = 10) of the Kamsack samples (see Fig. 3.4); only calibration curves with significant regression coefficients were included.] The solid black line is the linear, least-squares regression line; the solid red lines are the ± 95% confidence limits of the regression. Samples with TPH concentrations less than the MDL are not included.

Note: This figure is part of a suite of related figures; thus the letters identifying the individual panels refer back to a previous figure (see Note in the figure caption) and as such are not sequential.

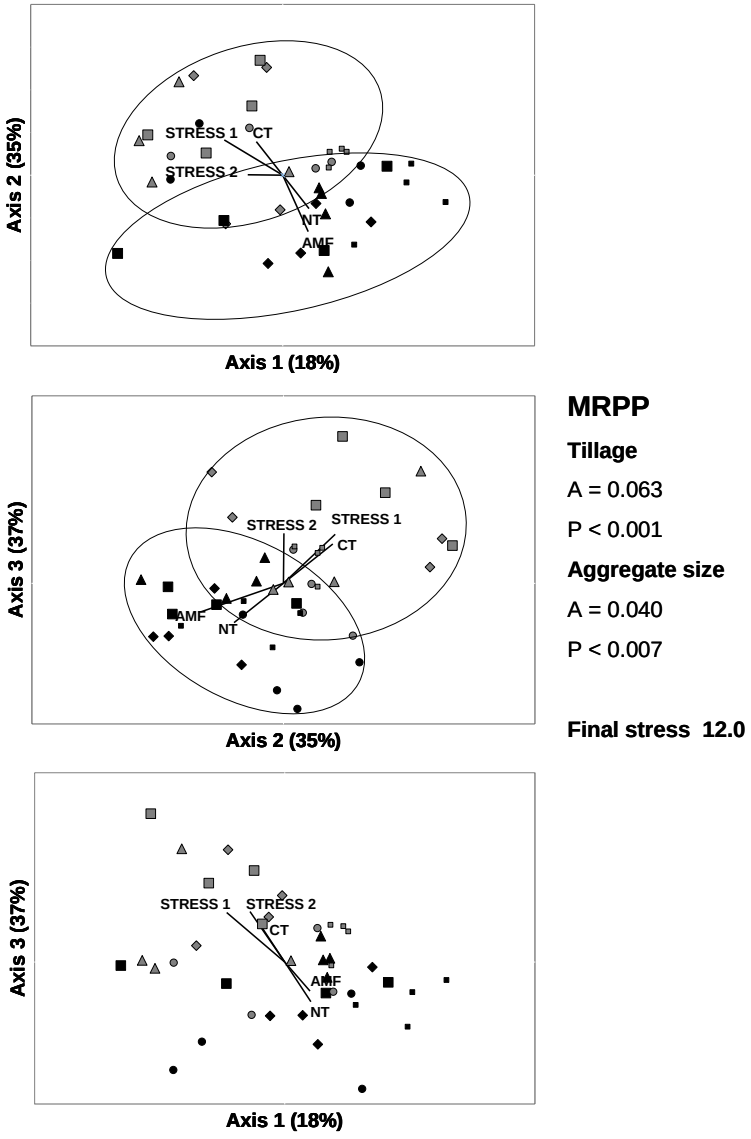

Fig. 4.5. Two-dimensional depiction of the three-dimensional non-metric multidimensional scaling (NMDS) ordination analysis and multiple response permutation procedure (MRPP) of PLFA profiles from dry-sieved aggregates (final stress = 12.0) in no-till (NT) and conventional-till (CT) soils.

Note: Although all three axis combinations were represented in the figure, no new information was revealed in the third plot (Axis 3 vs. 1). Thus, only the first two plots are needed to display all of the relevant information from the ordination analysis.

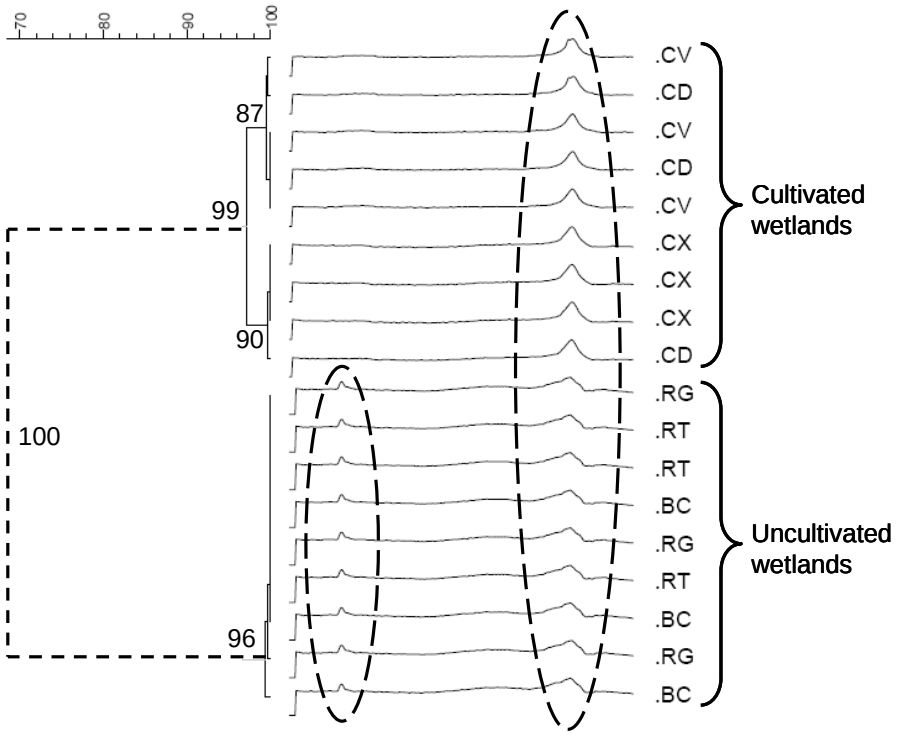

Fig. 4.5. Cluster analysis of nitrifier *amoA* DGGE patterns based on densitometric curves. The scale above the dendrogram is percent similarity between DGGE patterns. The first three nodes are labeled with the cophenetic correlation coefficient. The dashed lines indicate the cluster cutoff level. Broken ovals highlight DGGE bands. CX = Convex, CV = Concave, CD = Depression Centre, RG = Riparian Grass, RT = Riparian Tree, and BC = Basin Centre.

APPENDIX B

(Using and reporting statistics for the soil sciences)

Pennock, D. J. 2004. Designing field studies in soil science. Can. J. Soil Sci. 84: 1–10.

Abstract. Field research in soil science ranges from modal profile descriptions in support of soil survey to elaborate manipulative experimental designs. All of these field approaches make a valuable contribution to soil science, but researchers who do not use either classical manipulative experimental or geostatistical designs have little guidance (or encouragement) available to them. Well-designed field research of any type requires a clear definition of the research question; a thorough review of the literature to establish the state of knowledge; definition of the population under study and the elements that comprise it; and choice of appropriate scales for sampling support, spacing, and study extent based on an understanding of the underlying processes. For studies where hypothesis testing is appropriate, the hypotheses should be based on sound biological or physical reasoning, and sufficient replicates should be taken to ensure a reliable test. The major challenge in field research design is the development of landscape-scale research designs to examine complex interactions among hydrological, climatic, chemical, and biological processes at scales relevant for environmental management.

Webster, R. 2001. Statistics to support soil research and their presentation. Eur. J. Soil Sci. 52: 331–340.

Abstract. Much soil research needs statistics to support and confirm impressions and interpretations of investigations in field and laboratory. Many soil scientists have not been trained in statistical method and as a result apply quite elementary techniques out of context and without understanding.

This article concentrates on the most common abuses and misunderstandings and points authors to proper use. It distinguishes variance and standard deviation for measuring dispersion from standard error to indicate confidence in estimates of means. It describes the strictly limited context in which to use the coefficient of variation. It stresses the importance of quoting means and differences between them in contrast to statistical significance, which is at best of secondary interest. It guides readers to inspect and explore their data before deciding to transform them for analysis and illustrates what can be achieved by taking logarithms of single variates and by principal component analysis of multivariate data.

Webster, R. 2007. Analysis of variance, inference, multiple comparisons and sampling effects in soil research. Eur. J. Soil Sci. 58: 74–82.

Abstract. The analysis of variance is a crucial step in extracting information from efficiently designed experiments and surveys in soil science. It is only the beginning, however. From it, follow the standard errors (SEs) of means, SEs of differences and other effects provided by experiments, which in turn lead to tests of significance. Use the simple least significant difference (LSD) at some acceptable probability for testing comparisons of individual means. Do not use experiment-wise multiple comparison tests. In experiments with graded treatments do not make multiple comparisons of any kind; instead fit a response curve and analyse the data by regression. Sampling fluctuation within experimental units and surveys contributes short-range variation to the residual variance of measured soil properties and increases errors. Diminish this contribution either by replicate sampling and measurement within plots or by bulking before measurement. Sample all replicates in the field; sampling in the laboratory (pseudo-replication) is no substitute. In almost all investigations the mean values for experimental treatments and survey classes are the most important outcomes. So report them with their SEs; readers will then be able to make of them what they will.

Webster, R. and P.W. Lane. 2002. Analysis repeated measurements in soil monitoring and experimentation. Eur. J. Soil Sci. 53: 1–13.

Abstract. Field monitoring, leaching studies, and experimentation in soil biology are often now being done nondestructively using fixed installations so that measurements are made repeatedly on the same units. The resulting data for each unit (suction cup, lysimeter, incubation chamber) constitute a time series in which there may be autocorrelation. The usual methods of statistical analysis, such as the analysis of variance, must be modified or replaced by more suitable ones to take account of the possible correlation.

This paper describes the split-plot design of such experiments, shows how to assess the variance-covariance matrix of residuals for uniformity by the Greenhouse-Geisser statistic, and shows how to use this statistic to adjust the degrees of freedom in a formal test of significance. It also describes more recent methods. Ante-dependence analysis identifies the extent of the temporal correlation in the data and provides approximate significance tests for the treatments. Alternatively, the paper also shows how the traditional analysis of variance may be replaced by a restricted maximum likelihood analysis which gives Wald statistics.

The techniques are illustrated with data on CO_2 evolved from soil incubated for 75 days in closed chambers, during which time the gas was measured on 24 occasions to give time series for three replicates of each combination of two soils (limed and unlimed) and three types of ryegrass amendment. An ante-dependence structure (extending to ninth order) weakened the usual significance test within the subunit stratum. The Wald statistics showed that there was, nevertheless, a strong interaction between the treatments and time.

Lane, P.W. 2002. General linear models in soil science. Eur. J. Soil Sci. 53: 241–251.

Abstract. Classical linear models are easy to understand and fit. However, when assumptions are not met, violence should not be used on the data to force them into the linear mould. Transformation of variables may allow successful linear modeling, but it affects several aspects of the model simultaneously. In particular, it can interfere with the scientific interpretation of the model. Generalized linear models are a wider class, and they retain the concept of additive explanatory effects. They provide generalizations of the distributional assumptions of the response variable, while at the same time allowing a transformed scale on which the explanatory effects combine. These models can be fitted reliably with standard software, and the analysis is readily interpreted in an analogous way to that of linear models. Many further generalizations to the generalized linear model have been proposed, extending them to deal with smooth effects, non-linear parameters, and extra components of variation. Though the extra complexity of generalized linear models gives rise to some additional difficulties in analysis, these difficulties are outweighed by the flexibility of the models and ease of interpretation. The generalization allow the intuitively more appealing approach to analysis of adjusting the model rather than adjusting the data.

Cumming, G., F. Fidler and D.L. Vaux. 2007. Error bars in experimental biology. J. Cell Biol. 177(1): 7–11.

Abstract. Error bars commonly appear in figures in publications, but experimental biologists are often unsure how they should be used and interpreted. In this article we illustrate some basic features of error bars and explain how they can help communicate data and assist correct interpretation. Error bars may show confidence intervals, standard errors, standard deviations, or other quantities. Different types of error bars give quite different information, and so figure legends must make clear what error bars represent. We suggest eight simple rules to assist with effective use and interpretation of error bars.

Spöck, G. 2011. Spatial sampling design and soil science. In: B.E. Ozkaraova Gungor (ed.) Principles, Application and Assessment in Soil Science. ISBN: 978-953-307-740-6, InTech, Available from: http://www.intechopen.com/books/principles-application-and-assessment-in-soil-science/spatial-sampling-design-and-soil-science.

Abstract. Spatial statistics is the science of the analysis of geo-referenced data and loosely speaking may be divided into the three sub-areas analysis of point processes, analysis of areal data and geostatistics. Point processes naturally arise for example in geophysics, when the locations of earthquakes are noticed, in epidemiology, where new illness cases of certain epidemies are mapped geographically or in biology, where cell centers of a certain tissue are mapped under the microscope. Areal data are data that are attached to areas like number of illness cases in certain medical districts, percent of grassland in a certain county or number of votes in certain political districts. The topic of this article is but geostatistics, the science of continuous stochastic processes or so-called random fields that are defined over some region in 2- or 3-dimensional geographic space or in space-time.

Castle, R. 2006. Teaching spatial statistical techniques and concepts. In: Proceedings of the Seventh International Conference on Teaching Statistics (ICOTS-7), Salvador, Bahia, Brazil.

Abstract. The last decade has seen a rapid increase in the use of Geographical Information Systems (GIS) and the analysis of spatial data is an important component of this development. Spatial statistics is a relatively young subject and, although there are useful textbooks on spatial statistics theory, there is virtually no literature on how to teach spatial statistical concepts and techniques. This paper suggests ways of teaching some of spatial statistical analysis without recourse to matrix algebra and vectors. By using the graphical features in Excel it is possible to illustrate and explain the concepts behind the statistical techniques in GIS. The interactive and dynamic features of Excel enable students to investigate the effects of changing the spatial location of the data and to develop an understanding of spatial dependence and its impact on Kriging and regression techniques.

APPENDIX C

(CGPS and Departmental Policies)

NOTE: Students should consult the College of Graduate and Postdoctoral Studies (CGPS) and familiarize themselves with all regulations, guidelines and policies concerning thesis/dissertation preparation as well as the requirements for completion of their graduate program.

CGPS & Departmental Policies for the Thesis or Dissertation Defense

It is the **responsibility of the student, the supervisor and the Graduate Advisory Committee (GAC)** to ensure that the language of the thesis reflects the highest standards of proper and scholarly expression, and that all grammatical and typographical errors and punctuation have been corrected BEFORE the thesis is approved for the defence.

It is the **Department's responsibility** to ensure that the student file contains all necessary documentation and that the academic requirements for the degree have been met.

It is the **student's responsibility** to ensure that all requirements of the Program of Studies have been completed, registration is current, outstanding fees are paid, and University deadlines are respected in view of any particular Convocation.

> **NOTE:** It is the responsibility of any student who may have a disability that could interfere with his/her conduct or ability to respond to questioning at an oral defence, to reveal the problem in sufficient time prior to the defence to allow the Examining Committee and the CGPS to take measures to mitigate the situation at the oral exam. The student must inform her/his Supervisor or Graduate Chair, who in turn must inform the CGPS of any potential problems.

M.Sc. defence:

Academic units schedule their own Master's theses defences and appoint the External Examiners for these defences (as long as the external is a member of grad faculty, otherwise the proposed external's CV must be sent to CGPS for approval)

After the student's GAC determines that the thesis is ready for defence, the Graduate Chair should send a *Memo to Schedule a Master's Defence eForm* to the CGPS using the CGPS jira service desk.

The CGPS must be notified a **minimum of three weeks** prior to the desired oral defence date. Upon receipt of the aforementioned memo, a convocation check will be carried out by the CGPS to verify that all program requirements have been met—including current registration—before approval of the External Examiner is given. The CGPS will inform the academic unit when the thesis may be released to the External Examiner.

Ph.D. defence:

Ph.D. defences are organized jointly by the Academic unit and the CGPS.

After the student's GAC determines that the dissertation is ready for defence, the Graduate Chair should send form GSR 300.1 (*Recommendation for Examination of the Ph.D. thesis and Award of the Ph.D. Degree* in the form of a *Memo to Schedule a Graduate Defense eForm*) to the CGPS. The curriculum vitae of the first choice of External Examiner, a rationale for the choice, and a copy of the student's dissertation must be submitted to the CGPS.

The CGPS must be notified a **minimum of four weeks** prior to the desired oral defence date. The defence should be scheduled at a time when all examiners are available. The academic unit should work with the CGPS Programs Officer to determine a suitable date for the defence.

At least seven days prior to the defence, the student must provide a Dissertation Summary (which is not bound with the thesis) to the CGPS Programs Officer. This Summary (**350 word maximum**) will be published in the UMI Dissertations Abstracts International.

The CGPS Programs Officer forwards the thesis and any necessary documentation to the External Examiner, but all arrangements for the Ph.D. dissertation examination (time, date, location) are made by the academic unit. The CGPS will contribute up to CDN$2000 towards the expenses of the External Examiner—all additional expenses are to be provided by the supervisor.

Any special equipment requirements for the defence should be brought to the attention of the Programs Officer.

When no other reasonable option exists, the External Examiner or a member of the Graduate Advisory Committee, may attend the oral defence via video-(preferable) or tele-conference. Arrangements can be made through the CGPS Programs Officer. Whenever possible, video-conferencing should be arranged through the Westgrid Collaboration and Visualization Facility located in Room 2D71 in the Agriculture Building. The Westgrid facility can be reserved either by contacting ITServices (WestGridRoomBooking@usask.ca).

Oral Examination of the Thesis

The adequacy of the written thesis and oral defence is decided by an Examining Committee consisting of the Supervisor, other members of the GAC, and the External Examiner.

- for a Master's defence in the Department of Soil Science, the examination is chaired by the Chair of the GAC, who is appointed by the Graduate Chair in consultation with the supervisor;
- For a Ph.D. defense in the Department of Soil Science, the examination is chaired the CGPS Dean or the Dean's Designate;
- **under no circumstances can the research supervisor serve as the Chair of the Examining Committee**.

In the Department of Soil Science, the examination is preceded by a public seminar (25-45 minutes) by the candidate, which summarizes the major themes and findings of the thesis, followed

by questions from the audience (with the exception of the members of the Examining Committee, who will hold their questions until the closed defence). The defence itself will take place in private, with the External Examiner beginning the questioning.

- the candidate is expected to defend the work and to answer general questions in a clear, direct, and knowledgeable fashion;
- in general, examination questions are limited to work done by the candidate for the thesis and to knowledge of matters directly related to this work;
- regulations regarding the operating procedures of the Examining committee are printed on the back of form GSR 403.2: *Report of the External Examiner*.

At the conclusion of the examination, the candidate withdraws from the meeting, while the Examining Committee decides by majority vote whether the thesis as submitted and the candidate's oral defence meet the requirements for the degree. Once a decision has been reached, the candidate will be brought back into the room and informed of the decision.

The decision will be one of the recommendations outlined on the Policies and Procedures for Master's and Ph.D. Defences (all forms can be found on the CGPS website). The Committee's decision is reported to the CGPS Dean using form GSR 403.3: Report of Thesis Oral Examination. Where the Examining Committee's decision is not unanimous, the majority view shall prevail provided the External Examiner shares the majority view. If those voting in favor of the majority opinion do not include the External Examiner, the examination shall be adjourned and the person chairing the examination shall so inform the Dean. The Dean then shall investigate the circumstances and decide upon an appropriate course of action. Recommendations 3 and 4 are only available to students taking the oral exam for the first time. Students receiving Recommendation 5 will be automatically required to discontinue from their graduate program. This decision can be appealed to the appropriate