UNL Spatial Science Teaching Summit

Summary Report

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Executive Summary

Spatial science is a rapidly evolving field comprised of a broad range of technologies, analytical methods and geographic concepts and theories that are broadly applied across the natural, physical and social sciences to investigate, understand and communicate the spatial patterns, processes and interactions among and between natural and human systems. The field includes remote sensing, geographic information systems (GIS), global positioning systems (GPS), geovisualization, spatial modeling, geostatistics and spatial databases and mapping applications.

The collection of a vast array of spatial and locational data is now commonplace and many scientific fields, government agencies and sectors of private industry are seeking innovative spatial methods and tools to collectively analyze these data to address a broad range of societal issues and support many practical applications. As a result, students are increasingly seeking training in spatial science, which is becoming a desired skill by employers, and researchers across many disciplines.

Many universities are investing in spatial science to support growing teaching and research demands across their campuses through the formation of research and service centers, hiring clusters of faculty in various areas of spatial science and expanding course offerings and degree options. Central to this investment process are strategic discussions on how to effectively coordinate and facilitate the development and advancement of the spatial science teaching and research across campuses given the rapid adoption of spatial technologies and methods in many fields and job sectors.

A Spatial Science Teaching Summit was convened May 13, 2019 to engage faculty from across the University of Nebraska-Lincoln (UNL) to discuss the campus-wide spatial curriculum and credentialing options, as well as identify opportunities and needs to advance the field of spatial science for students and faculty. The Summit was attended by 28 faculty representing 11 academic departments and units including the Dean of the College of Agriculture and School of Natural Resources (CASNR), 3 unit heads and faculty representing 5 IANR centers and institutes.

Summit discussions were focused on three key challenges facing the advancement of spatial science teaching and research at universities identified by the National Research Council (2006) that included:
1. engagement of multiple disciplines working in the spatial science area to develop consensus on a comprehensive campus education and research agenda,
2. development and implementation cross-disciplinary, education-sharing mechanisms for spatial courses and degree options
3. establishment of a 'focal' point on campus to support, promote and enhance the integration of spatial science across the curriculum and innovative new research directions.

The following were key outcomes from Summit discussions related to current needs, gaps and opportunities in spatial science at UNL:

1. Given the breadth and rapidly evolving applications of spatial science across UNL, there is **a need for a more formal spatial science community of practice and designated focal point to engage, promote and advance the field across campus**. UNL has experienced tremendous turn over in spatial science faculty since 2010 with a large number of faculty retirements, as well as the addition of several new faculty in various units utilizing and teaching various aspects of the spatial field, However, the awareness and collaboration of these new additions has been

limited. Faculty would also benefit from coordinated professional development opportunities (e.g., formal training, webinars, and brownbag presentations) and forums (formal and informal) to present and learn about spatial science activities at UNL.

2. **High demand for a spatial science minor** for undergraduate students given the demand for spatial skills by prospective employers. With the interdisciplinary nature and broad student career interests in using spatial methods and techniques, there is strong support to develop several **specialization tracts within the minor that include: 1) precision agriculture (existing minor), 2) natural resources, 3) social science/human dimensions and 4) computer science.**

3. **The student demand for introductory spatial courses is at or near the maximum teaching capacity of existing spatial science faculty.** Several existing and proposed degree programs and minors require these courses and the demand is anticipated to increase. The number of faculty positions to teach these courses has not kept pace with the demand.

4. **The number and types of advanced spatial courses at the 400- and/or 800-level is limited in key areas (particularly remote sensing) to fully support the needs of upper-level undergraduate and graduate students**. Gaps in faculty expertise currently exist in key areas such as lidar remote sensing, advanced image analysis and data fusion and geovisualization.

5. **Advanced courses with a spatial component are offered in a number of academic units, but coordination and awareness of many of these classes is lacking across campus.** Proposed UNL spatial science resource webpages (under development by CALMIT and SNR) of current UNL spatial faculty and their expertise highlight existing UNL spatial courses and promote of spatial research and training opportunities on campus.

1. INTRODUCTION

Spatial science is a rapidly evolving field comprised of a broad range of technologies, analytical methods and geographic concepts and theories that are broadly applied across the natural, physical and social sciences to investigate, understand and communicate the spatial patterns, processes and interactions among and between natural and human systems (Figure 1). The field includes remote sensing, geographic information systems (GIS), global positioning systems (GPS), geovisualization, spatial modeling, geostatistics and spatial databases and mapping applications.

We have entered an era of 'big spatial data' where vast arrays of spatial data in forms ranging from digital imagery from satellites, manned aircraft and unmanned aerial systems (UAS) to GPS-enabled locational data related to natural and human systems are now routinely collected. Many scientific fields, government agencies and sectors of private industry are seeking innovative methods and tools collectively analyze these spatial data to address key societal issues, as well as support many practical applications and decision making activities. As a result, many universities throughout the United States have made significant investments in spatial sciences both in the form of faculty hires and the establishment of centers of spatial science excellence in an effort to advance both teaching and research on their campuses. Prime examples include the Center for Geographic Analysis at Harvard University, Spatial Analysis Center at Stanford University, Geospatial Innovations Facility at University of California-Berkeley, Center for Geospatial Analytics at North Carolina State University, USpatial Program at the University of Minnesota, CyberGIS Center at the University of Illinois-Champaign and Spatial Sciences Institute at the University of Southern California.
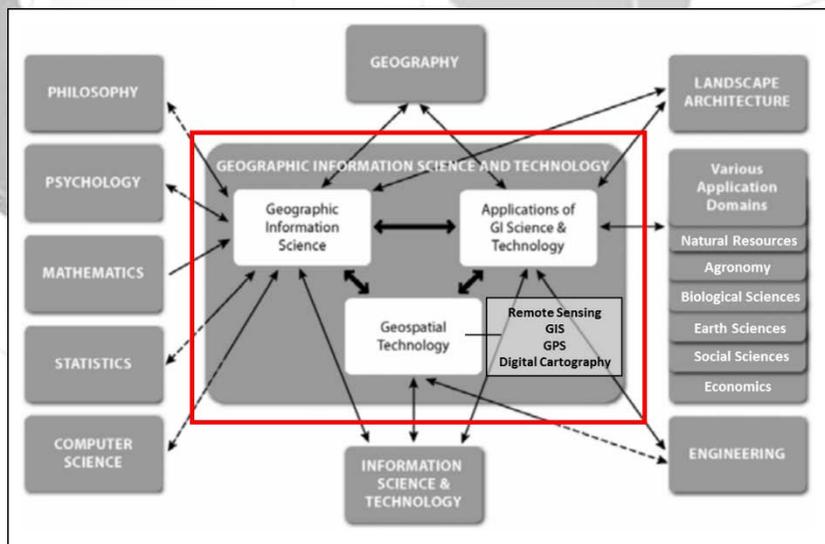
Figure 1. Interdisciplinary connections of various elements of spatial science (highlighted in red box) including the theories and concepts of spatial (geographic) information, technologies (e.g., remote sensing, GIS and GPS) and various research and practical applications.

Spatial technologies and data have become central to the ways many government agencies, private companies and non-profit organizations do business and researchers perform science (NAS, 2006). The University Consortium for Geographic Information Science (UCGIS, https://www.ucgis.org/) reports that

geographically-referenced (locational) information and applications that integrate various types of spatial data for many types of decision making activities will have an annual, global value of $600 billion by 2020 (McKinsey Global Institute Survey, 2017). Career prospects for spatially-skilled students is tremendous with the U.S. Bureau of Labor Statistics (2018) projecting a 19% increase in spatial-related jobs over the next decade.

Students are increasingly seeking training in spatial science because of the high demand for spatial skills by employers and a large number of applications utilizing spatial elements in both research and practical applications. The National Academy of Science (NAS, 2006) reported the number of trained professionals in various areas of spatial science was not keeping pace with the demand for innovative applications of spatial information in the private and government sectors. In order to help address this gap, the NAS provided several recommendations to academic institutions that included:

1. Academic disciplines engaged in various elements of spatial science should develop a consensus on a comprehensive and coordinated education and research agenda;
2. Collaboration among academic disciplines should be promoted and cross-disciplinary, education-sharing mechanisms established; and
3. Academic institutions should consider the establishment of a 'focal point' on campus to facilitate the advancement of spatial science research and teaching among departments with interests in this field.

## 2. SPATIAL SCIENCE TEACHING SUMMIT OVERVIEW

A Spatial Science Teaching Summit was convened on May 13, 2019 to engage faculty from UNL to consider the current spatial science curriculum and future options to support this growing demand for training and expertise by both undergraduate and graduate students across campus. Summit discussions were centered around responding to the three NAS recommendations listed above in an effort to understand the current state of spatial science and the associated curriculum at UNL, identify key gaps and needs to adequately support student demands related to both courses and credentialing options and identify other campus needs to support the advancement of spatial science teaching and research (e.g., facilities, technical support, computational resources and professional development) (Summit agenda in Appendix A). The Summit was attended by 28 faculty representing 11 academic departments and units including the Dean of CASNR, 3 unit heads and faculty representing 4 IANR centers (full listing of participants in Appendix B).

3. BACKGROUND

History of Spatial Science at UNL

UNL has a long, rich history of teaching and research excellence in spatial science dating back to 1972 with the formation of the Nebraska Remote Sensing Center approved by the Nebraska Board of Regents, which was later renamed the Center for Advanced Land Management Information Technologies (CALMIT) in 1986 to reflect the expanding suite of spatial technologies that included GIS, remote sensing and GPS. During that time, UNL also maintained a strong, nationally-recognized Department of

Geography. The value and broad, interdisciplinary impact of a dedicated Center to remote sensing and GIS instruction and research at UNL was demonstrated by the 29 faculty from academic units on both City and East Campus that served on the Center's initial advisory committee (Figure 2). Historically, most spatial science courses were taught by CALMIT and Geography faculty producing many graduates that now lead spatial programs in private industry, several Nebraska state government agencies and federal government agencies (i.e., USGS, NASA and USDA), as well as faculty at a number of universities.
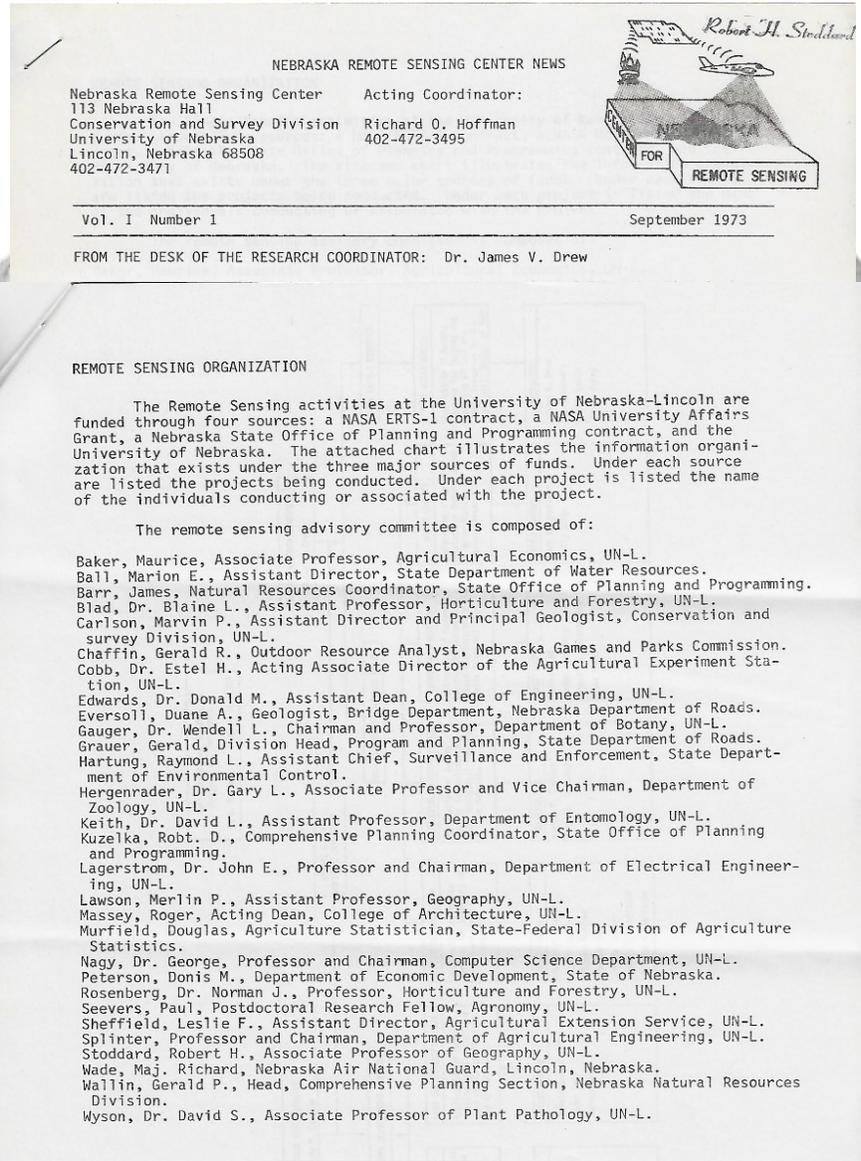
Figure 2. Pages from the inaugural newsletter of the newly formed Nebraska Remote Sensing Center (later renamed CALMIT in 1986) in 1972 showing the broad, interdisciplinary interest in spatial technologies (specifically remote sensing and later GIS) among many academic units across UNL as demonstrated by the composition of faculty on the Center's advisory committee.

Over the past decade, the number of faculty supporting the 'core' spatial science curriculum at UNL were significantly reduced with the departure of 5 faculty from CALMIT and several other Geography faculty (primarily due to retirement) with limited new faculty hires within these groups. Faculty in CALMIT still support most 'core' technical spatial courses in remote sensing and GIS that are required by several degree programs. In addition, the move of the Geography program from the School of Natural Resources back to the College of Arts and Sciences resulted in reduced coordination of course offerings and degree options. During this same period, new faculty with spatial expertise or interests were hired in other academic units across UNL with several offering specialized or discipline-specific courses with some spatial component. Collectively, faculty additions and the development of supporting courses has tended to be unit specific and minimal coordination has occurred among academic units in developing a comprehensive spatial curriculum and credentialing options for both undergraduate and graduate education despite the widespread interest among students for many disciplines.

UNL Spatial Science Curriculum and Survey

In 2017, CALMIT (led by Dr. John Gamon) conducted a survey of 28 UNL faculty with interests in spatial science to gauge the 'current' state of the 'core' spatial science curriculum and identify specific needs and priorities that are critical to supporting students in various academic programs. Key survey results included:

- The number and breadth of spatial courses available to students is limited by a shortage of spatial faculty, which is further restricted by computer lab space limiting the student enrollment, particularly in 'core' introductory remote sensing and GIS courses.
- The separation of the Geography program from SNR in combination with a lack of faculty exacerbated gaps and uncertainty in the spatial curriculum.
- Enrollment in introductory remote sensing and GIS courses are either near or at capacity and the demand for these courses is expected to increase as more degree programs and minors (i.e., Precision Agriculture) require them. The current number of faculty dedicated to these courses is not sufficient to meet an increased demand.
- The spatial science curriculum should be guided by clear pedagogical goals providing a comprehensive and holistic understanding of spatial science (i.e., foundational spatial principles, concepts and tools, as well as analytical and computational methods and application experience in a topical domain).

In 2018, CALMIT (led by Dr. Yi Qi and Dr. Brian Wardlow) followed up this survey by developing a listing of spatial science and related courses currently offered across UNL. Appendix C presents this course listing. The Geography Program also offers a Certificate in GIS, which has existed for more than a decade, but several supporting courses for this certificate are not currently offered because of faculty departures. Recent progress has been made through the development of a Precision Agriculture minor offered by CASNR starting in Fall 2019, which has a strong spatial component in the required courses for this minor.

4. SUMMIT DISCUSSIONS AND PROPOSED OUTCOMES

UNL Spatial Science 'Community of Practice'

Faculty expressed a strong interest in developing a cohesive 'community of practice' for faculty working and/or interested in spatial science. Several faculty expressed the concern of a general disconnect among faculty teaching and conducting spatial science research across UNL. Many were unaware of the fully range of spatial course offerings, the types of spatial research being conducted on campus and the new faculty that were recently hired at UNL. This disconnect can be partially attributed to the tremendous breadth and interest of spatial science among faculty and students across many academic units and a lack of mechanisms to engage people working in spatial science on other parts of campus. Given the interdisciplinary nature of spatial science, faculty and students are missing opportunities to build new collaborations and learn from others to enrich and advance their respective research and teaching programs.

Based on this discussion, the following suggestions were made to strengthen ties among faculty and students through the formation of a community of practice:

- Consider developing a 'focal' point such as a Spatial Commons for faculty, students and staff to interact, share information about their work and other activities (both teaching and research), learn about resources (e.g., courses, professional training, data, technology and software) available across campus and obtain technical support. Support among faculty to build upon UNL's existing capacity infrastructure and establish a physical location, such as a Spatial Commons space, for UNL faculty and students to collaborate, access professional development opportunities and access spatial technologies and technical support for research and instructional purposes.

  Actions items:
    o **Develop a UNL Spatial Science Resources website** to disseminate information about faculty, courses, degree options and types of research being conducted. CALMIT and SNR is currently working to develop the site. A website domain (spatialscience.unl.edu) has been created and a directory of spatial faculty and courses is being developed.
    o SNR will **evaluate possible space options within CALMIT and Hardin Hall for a Spatial Commons area**. Additional input from faculty will be collected regarding the types of support that such a space could offer to the campus.

- Develop forums for faculty to present their research and have access to professional development opportunities to learn about new and emerging areas in spatial science to enhance their teaching and research skills.

  Action item:
    o **Further discussion among faculty on both formal and informal engagement options for campus**. Examples could include: Spatial Science Research Forum during Geography Awareness Week, brownbag research and training seminars, webinars and informal social events designed for information sharing and collaborative discussions among faculty and students.

UNL Spatial Science Curriculum and Credentialing

Summit participants reviewed the listing of UNL course offerings and provide input on revisions to the list based on recent faculty changes. Spatial science degree options in CASNR were also reviewed, as well as other spatial credentialing options currently available that included the Precision Agriculture minor offered by CASNR and the Geographic Information Science certificate available through the College of Arts and Science and the Geography Program. Other potential credentialing options to better were also discussed including spatial science minor, certificate and badge options.

The development of a Spatial Science minor available to undergraduate students across UNL garnered strong support from faculty participants. The minor option was appealing to faculty because the development, approval and implementation of a minor is quicker process than a certificate and can be offered across several academic units. Given the breadth of applications and interests among students, the establishment of different specialization tracks within this minor was also strongly supported to accommodate the varying interests of students in agriculture, natural and physical sciences, social science, and computer science. The existing Precision Agriculture minor was suggested to represent the agriculture track within a Spatial Science minor along with the addition 3 other specialization tracks: 1) natural resources, 2) social science and 3) computational science.

Faculty raised questions about the current status of the Geographic Information Science certificate offered through the Geography Program and whether it can be implemented given several required and elective courses are not currently offered at UNL. Faculty discussed the need to update the requirements for this certificate and process to make these changes.

> *Action items:*
> - **Development of an undergraduate Spatial Science minor with 4 specialization tracks in: 1) precision agriculture, 2) natural resources and Earth system science, 3) social science and 4) computational science**. CALMIT will engage faculty from across UNL to develop the requirements for the specific tracks with a faculty lead appointed to each track. Implementation of minor will done through both CASNR and Arts and Sciences to increase student access to this option throughout UNL.
> - **Seek opportunities to cross-list spatial courses** among academic units to increase enrollment by offering more credit options for a given class.

Campus Needs and Support for Spatial Science Teaching

Summit participants highlighted several needs and types of support that would be useful to sustain and advanced spatial science instruction and research at UNL. The following topics and key points from this discussion included:

- **Facilities** – Faculty identified the lack of dedicated computer lab space as a challenge for both 'core' and advanced spatial science courses. Currently, general teaching computer labs are used to teach computer-based spatial courses on both City and East Campus. Course enrollment is often capped based on the number of computer lab seats available in these labs and often the number of students wanting to enroll, particularly in the introductory courses, is either at or exceeds the computer lab seating capacity. There is also a lack of a 'collaboration' space for

students for various department to interact and share experiences to further their understanding and technical skills in various spatial technologies and methods. Such a space could be part of a Spatial Commons area being proposed by CALMIT and SNR that was highlighted earlier in this document.

- **Computational Resources** – Access to data storage and sharing mechanisms, as well as high performance computing options was another key needed highlighted by several faculty. In an era of big 'spatial' data, the ability to store, share and analyze large volumes of spatial data, as well as storing and distributing these types of data sets is needed to support research of both faculty and students. Currently, individual faculty and in some cases academic units partially support computing resources, but it varies across campus. Access to Holland Computing Center (HCC) partially alleviates some of this issue, but improved access and use of centralized spatial data storage and analysis platforms would advance faculty research and student training opportunities. Significant upgrades to existing campus computational capabilities are needed.
- **Spatial Software Access and Cost** – Commercial GIS and remote sensing software commonly used by prospective employers and of interest to students can be costly and is often addressed individually by academic units. A prime example is ArcGIS software, which is the industry standard for GIS and utilized by many spatial courses and in graduate student research. UNL Procurement purchases ~300 ArcGIS licenses each year at an annual cost of ~$25K and individual academic units and faculty are responsible to purchase these licenses from Procurement for ~$260/license. The result is academic units teaching spatial courses using ArcGIS cover most of the cost and possess most of the licenses. This is problematic when students outside these academic units try to apply their GIS experience outside the classroom and have little or no access to ArcGIS after a course is completed. Currently, SNR has purchased the majority of ArcGIS licenses to support the NRES spatial courses being taught by CALMIT faculty. In addition, CALMIT is actively developing online courses to support CASNR's online education initiatives. Online spatial courses have shown promising potential for large enrollment classes (e.g. NRES 312 during the Summer 2019), but software licenses and access to computational resources, both remotely and in person, are major issues currently being faced to accommodate student course needs. Many universities have moved to a 'university-wide' ArcGIS site license concept that allows the software to be installed in any university lab or personal computer of a faculty, student or staff. UNL has adopted this model for MATLAB software and a similar model for ArcGIS and other image processing software (i.e., ENVI and ERDAS Imagine) would be of tremendous benefit across the university.

Action Items:
- o **Further discuss the specific needs for dedicated, instructional lab space, as well as research and training space** for students and faculty to interact. Such a space may come in the form of a Spatial Commons.
- o **Investigate the potential for a university-wide, site license concept for ArcGIS** including the cost, benefit and implementation of such an approach. Conduct a similar analysis for image processing software (e.g., ENVI, ERDAS Imagine, eCognition and Pix4D).

Incorporate a spatial component into the on-going computational resource discussion within IANR and other part of campus. Representation from the spatial science community is needed in these discussion to ensure very large spatial data needs are included in any campus-wide effort that may

emerge. John Gamon of CALMIT has been actively involved with both IANR leadership and HCC to discuss both the challenges and potential options for supporting the computational data needs of the campus' spatial community. These efforts to advance computational resources and capabilities in support of spatial science are likely to benefit a number of academic units within IANR and other parts of campus. Input and participation from faculty from various academic units that attended the Summit will be invited in future computational support discussions.

APPENDIX A – Summit Agenda

Spatial Science Teaching Summit

901 Hardin Hall
May 13, 2019
11 am – 1 pm

Lunch to be provided by the School of Natural Resources.

<u>Agenda</u>

1. Introduction to teaching summit – *Brian Wardlow*

2. Participant introductions

3. Review of spatial teaching survey – *John Gamon*

4. Overview of new SNR spatial science curriculum – *Yi Qi and John Gamon*

5. Roundtable discussion of other spatial courses taught and current course gaps/needs on campus

6. Current and potential spatial science-related minors and credentialing options – *Brian Wardlow*

7. Discussion of campus needs and support for spatial science teaching, students (undergraduate and graduate) and faculty – facilities, computing resources, software, professional development opportunities, etc.

8. Next steps and path forward

DISCUSSION QUESTIONS
<u>Spatial Science Credentialing</u>

1. Would a spatial science minor or other types of credentialing (e.g., certificates or badges) be of interest to UNL students?

2. What would key elements of spatial science minor include?

3. Given the breadth of spatial science, should there be different tracks in spatial science minor or other credentialing (e.g., precision ag. natural resources, cultural/social science, data science or global studies)?

4. What spatial course(s) that you teach could be included in a spatial science minor option(s)?

<u>Spatial Science Community of Practice</u>

1. Would a collaborative spatial science space for UNL in the form a Spatial Commons to support both the training and research needs of students and faculty?

2. Should UNL have shared, campus-wide software licenses for GIS (e.g., ESRI site license), remote sensing and other software to support courses and the work of faculty and students?

3. Would continuing education and training options for faculty on advanced spatial topics (e.g., Python or R), emerging technologies and new applications be of benefit?

*Hosted by the Center for Advanced Land Management Information Technologies (CALMIT) and
the School of Natural Resource (SNR)*

APPENDIX B – Participant List

Institute of Agriculture and Natural Resources (IANR)
Ron Yoder, Senior Associate Vice Chancellor of IANR*

College of Agricultural Sciences and Natural Resources (CASNR)
Tiffany Heng-Moss, Dean of CASNR

Agronomy and Horticulture
Martha Mamo, Department Head of Agronomy and Horticulture
Leah Sandall
Laura Thompson
Dirac Twidwell*
Sam Wortman

Biological Systems Engineering (BSE)
Yufeng Ge
Joe Luck
Francisco Munoz-Arriola
Christopher Neale
Yeyin Shi
Wayne Woldt

Computer Science and Engineering
Ashok Samal
Hongfeng Yu

Entomology
John Ruberson – Department Head
Matthew Smart

School of Natural Resources
John Carroll, Director of SNR*
Getachew Demisse
Trenton Franz
John Gamon
Ayse Kilic
Andrew Little
Yi Qi
Tsegaye Tadesse
Betty Walter-Shea
Brian Wardlow

Statistics
Yuzhen Zhou*

Anthropology
Heather Richards-Rissetto

Community and Regional Planning
Yunwoo Nam
 Zhenghong Tang

Geography
Clark Archer

Computer Science and Engineering
Ashok Samal
Hongfeng Yu

(*) Interested faculty that could not attend Summit because of scheduling conflicts.
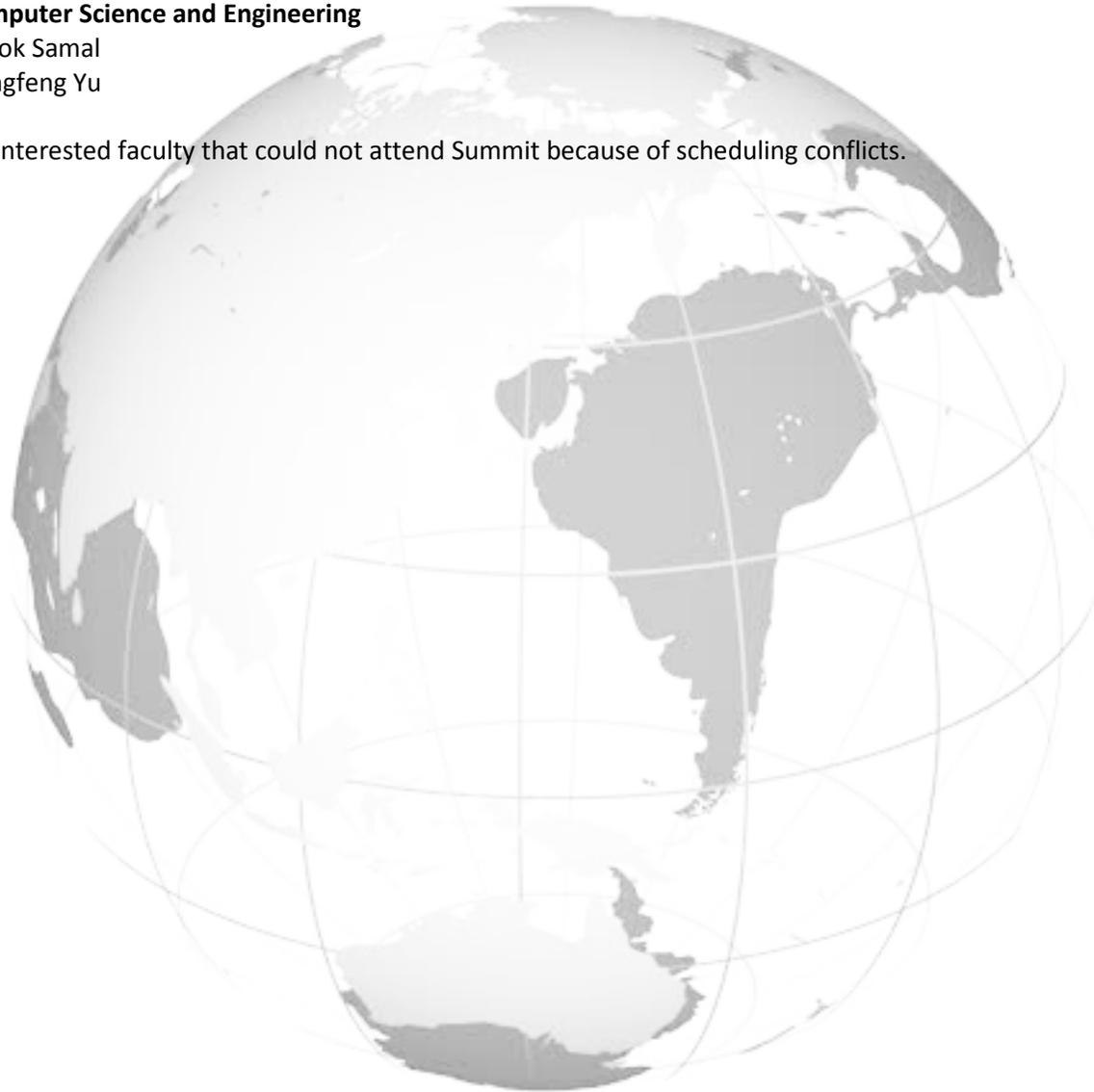
APPENDIX C – Core Spatial Science Courses and Other Relevant Courses at UNL

Core Courses	Credit	Title
NRES 312	3	Introduction to Spatial Science *Online education (start from summer 2019)
NRES 415/815	4	GIS for Agriculture and Natural Resources
NRES 418/818	4	Introduction to Remote Sensing
NRES 420/820	4	Applications of Remote Sensing in Agriculture and Natural Resources
NRES 421/821	3	Field Techniques in Remote Sensing *Open enrollment for summer 2019
NRES 427/827	3	Introduction to the Global Positioning System (GPS)
NRES 498/898	3	Special topic: Python Programming in Remote Sensing of Natural and Water Resources Special topic: Satellite-based Remote Sensing in Water Resources
NRES XXX	X	Advanced courses in spatial science (under development): GIS, Remote Sensing, spatial data science

Other Relevant Courses	Credit	Title
NRES 800	3	Sampling, Data Management and Visualization
NRES 803	4	Ecological Statistics
NRES 453/853	3	Hydrology
NRES 825	3	Geostatistics
NRES 810	3	Landscape Ecology
AGRO/NRES/RNGE 444/844	3	Ecosystems Monitoring and Assessment
STAT 432/831	3	Introduction to Spatial Statistics
BSEN 460/860	3	Instrument Controls
CRPL 432/832	3	Advanced Spatial Analysis with GIS
CRPL 433/833	3	GIS in Environmental Design and Planning
CRPL 830	3	Planning with GIS
ANTH 389	3	GIS in Archaeology
ANTH 461	3	Geospatial Approaches in Digital Humanities and Social Sciences
CSCE 411/811	3	Data Modeling for Systems Development
CSCE 320	3	Data Analysis