NUTR 231  FUNDAMENTALS OF GEOGRAPHIC INFORMATION SYSTEMS

Syllabus for Fall 2018
This syllabus is subject to change. Check the course Canvas site for latest version.

Graduate course:
Class Time: Fridays, 9:00–12:00 pm
Location: Sackler Hall, Room S514 (Big Lab) Hirsh Library 5th floor

Enrollment Limit: 20

Instructor: Paul Cote CV
Email: paulbcote@gmail.com
Office Hours: Email for Appointment

Assistant Instructor: Sam Jones
Email: sjones02@tufts.edu
Office Hours: Check Canvas site for most up-to-date schedule.

Tufts Credit: 3 Semester Hour Units (3 classroom hours per week over 15 weeks)
Prerequisites: Graduate standing, or permission of the instructor.

Course Description:
Many problems in agriculture, food, and nutrition are geographic in nature. For example, livestock production is increasingly concentrated in large feeding operations, leading to new spatial patterns of water and air pollution or foodborne illness. Spatial clustering is equally important for food consumption, nutrition, and public health, as in hunger hotspots, food deserts, and disease corridors. This course will equip students with a mindset and skills needed to produce and use geographic data and maps in decision-making situations using a variety of examples from agriculture, food, and nutrition.

Course Objectives:
This course will provide opportunities for students to acquire the following capabilities:

1. Design and evaluate research projects involving geospatial processes and data.
2. Organize and manage data and research products for collaborative and on-going projects.
3. Create and evaluate maps involving categorical, quantitative, and topographic data.
4. Develop credible arguments using Vector and Raster data models.

Background and Context:
Improvements in quality and accessibility of geographically referenced data present new opportunities and expectations for management and communication concerning landscapes and their influence on food systems and health. Students in NUTR 231 will learn to create, organize and evaluate geographic data; to develop credible arguments using maps and analytical models; and to think strategically about how organizations manage and share information.
NUTR 231 provides students with a conceptual framework and technical skills for using geographic data, maps, and geographical models in research and decision-making contexts. Each week we will meet for three hours for a presentation and technical demonstrations that weave together several threads:

**Exposing the historical context of GIS and information infrastructure** provides an understanding of the problems that geographic information systems have evolved to address, and the direction that these technologies are headed; particularly in terms of research, planning and administration. At a more technical level, the historic viewpoint on GIS reveals how the two primary tool-kits for spatial analysis: Vector/Relational; and Raster/Map Algebra have evolved to simulate particular sorts of spatial processes and relationships.

**A model-based approach to describing situations** considers the ways that problems and concerns may be boiled down to conceptual models that may be partially represented with data and computing procedures. How can data be used represent things and conditions that play a role in our conceptual model? How can we simulate and explore real-world relationships and future scenarios by transforming data with GIS? The model-based viewpoint on GIS reminds us that the representing aspects of the world with data requires choosing one type of error over others within a purpose-specific assessment of accuracy and confidence. This frame of mind provides the analyst with an operational sense of the utility of a dataset or analysis and a feel for how models and simulations may most effectively be improved.

Workshops will explore the problem of geographical problem-solving from the perspective of information management. **Technical aspects of information encoding, exchange, and organization** have been the backbone of geography since its inception in 500 BCE and into the age of the World Wide Web. Students will develop and demonstrate their capacity to participate in the culture of geography as each exercise extends their well-documented, re-usable and transferrable collection of data, map documents and models.

**Weekly Exercises:** Each course meeting will feature technical demonstrations that begin with a specific question and intention, develop a conceptual model, evaluate data-sets as proxies for elements of the model, and apply procedures to create a map or analytic model. This aspect of the course will provide students with a “How to do it” capability and a credible analytic mindset that will be practiced each week as each student investigates questions that they choose for themselves.

In keeping with the Tufts standard for weekly time-commitment per credit, students should plan on spending six hours each week working on their projects for this course. Half of each exercise is about learning how to learn software. We will practice techniques in class. Tutorials provide a narrative discussion of the methods performed in the workshop and the conceptual discussion of the interpretation of your results. Tutorials mention each step that was performed in the workshop and provide links to the ArcMap on-line help for each of the operations. Our course tutorials are not the sort that describe every single button and menu that must be tweaked. To use GIS productively in the field, this way of learning from documentation is a necessary skill.

Paul Cote
Students should expect to have problems and plan to get started early so that you have time to ask questions and overcome obstacles. Each exercise builds on the techniques, concepts and data that has been covered and collected in previous weeks. Falling behind with projects is problematic. Each student is given leeway to be up to one week late with one assignment. After this, a half-point may be deducted for the second late assignment (one week) and a full point deducted per week for subsequent late exercises.

For the first six weekly exercises, students will develop a well-organized collection of data, metadata, and map documents designed to represent many aspects of place of their choosing anywhere within the state of Massachusetts. Each week will extend the collection to cover a specific aspect of geography, data, and cartography. Students will be challenged to frame their own questions about changes that might affect the people, things or conditions in the place of their choosing.

Each weekly exercise includes the following learning objectives:

1. Frame a decision-making question in terms that may be approached with the data-set of the week.
2. Gather data and organize it in your re-useable collection of data, metadata and map documents.
3. Understand data in terms of fitness for use in a specific decision-making context.
4. Apply principles of cartography to represent digest different sorts of data into graphical representations that will be interpreted in a predictable way by an audience.
5. Communicate your understanding of data and common pitfalls of map interpretation clearly and with credibility.

Our exclusive focus on Massachusetts in the first six weeks of the course will allow a high degree of freedom to explore different sorts of geographic phenomena and decision-making situations using the very consistent and well-documented data sources provided by the Massachusetts Geographic Information System (MassGIS).

The last three or four weeks of the course will explore how GIS is used to simulate decision-making situations. By developing concise conceptual models, aspects of a situation may be represented with data and procedures. The resulting data models may then be used to explore experimental “what-if” scenarios. We will demonstrate a few of these in class, featuring some rural, agriculturally themed situations and some urban food policy scenarios.

Term Project: While weekly workshops and exercises focus on general fundamentals of applying GIS in a variety of contrived situations, the term project provides an opportunity for students to explore how geographic information systems are applied within a specific area of expertise of their own choosing. The term project is has four deliverables:

Research Review: The research review is assigned in the second week of classes. Students are encouraged to explore published GIS projects and data-sets related to their own area of interest. The research review has a written component and an in-class presentation (see schedule, below)
Term Project Models and Poster: Based on their independent research, students will propose a final independent project. Students are encouraged to keep these very simple. Depth of critical understanding is valued much more than complexity in these models. For the final project for the course, each student will prepare a poster for the Tufts GIS Expo.

Prerequisites: Students must be familiar the basics of file management using the Microsoft Windows operating system and comfortable learning and using software with on-line documentation. Students will need to be able to create multiple page documents with illustrations in PDF format.

Assignments and Submission Instructions: A ten-point exercise is assigned each week and will be due before the next class meeting.

Software: Assignments will require the use of ArcGIS desktop version 10.5. This software runs on MS Windows version 7 or beyond. Students may use lab computers and may obtain a free one-year license to ArcGIS to install on their own computers.

Backups and Lost Data: Students are responsible for keeping their work backed up on two different pieces of media that they control. Students must be capable of restoring and revising any project document at any time before final grades have been distributed.

Writing and Graphic Standards: To be worthy of an excellent mark, a project should be nearly presentable in a professional setting. Clear layout and legibility are important.

Accommodation of Disabilities: Students with disabilities are entitled to academic accommodation appropriate to their needs within the limits of the contractual requirements for course instructors. If you require accommodations, please arrange for instructions to be sent by the Friedman School Assistant Dean for Student Affairs.

Academic Conduct: Each student is responsible for upholding the highest standards of academic integrity, as specified in the Friedman School’s Student Policies and Procedures Manual and Tufts University policies. It is the responsibility of each student to understand and comply with these standards, as violations will be sanctioned by penalties ranging from failure on an assignment and the course to dismissal from the school.

Individual Work: There are no group projects in this class. Each exercise and project should be the student’s own work. Proper attribution is required for all data, figures and ideas used in each project.

Office Hours and Lab Assistants: A weekly help session will be scheduled at a time that suits the schedules of as many students as possible. Please use help sessions as a means of getting clarification on assignments and specific tasks. Students are encouraged to visit the Tufts GIS Center for help finding data. The purpose of the assignments in this course is to assess your ability to solve problems independently. Therefore, the teaching assistant and the data center personnel should not be relied on to design or perform extended analyses. One-on-one meetings with the instructor may be arranged when necessary.
Assessment and Grading:
All assignments will be assessed according to guidelines that are posted for each exercise. Weekly exercises are due the night before the next class date.

- Nine weekly exercises: 90 points
- Term project in 4 installments: 50 points
- Class participation: +/- 10 points

Attendance and Participation: Ten of the 150 total points possible in the course are for attendance and participation. Points can be gained by paying attention, asking thoughtful questions and by answering questions posed to the class. Being repeatedly absent or late, sleeping in class, or preoccupation with your mobile phone can be a cause for losing participation points. Students are responsible for making up missed lectures and workshops by consulting with the on-line notes and instructions.

Rubric for Weekly Assignments
Each of the weekly assignments calls for a demonstration of the following:

1. Use data and techniques to describe specific elements and relationships involved in a hypothetical decision-making situation.

2. Evaluate the result with regard to the fitness of the data and techniques for representing the elements and relationships as they occur in places and in decision-making.

3. Communicate a useful interpretation of the analysis to a colleague, client or a member of the public. Demonstrate an understanding of cartographic principles and pitfalls.

Grading Rubric
In keeping with the Tufts standard rubric letter grades will be assigned as follows:

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Expectation</th>
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<tbody>
<tr>
<td>100 – 95</td>
<td>Work that shows exceptional merit.</td>
</tr>
<tr>
<td>90 – 95</td>
<td>Work that is worthy of presentation in public, from the standpoint of credibility and graphical sophistication. Demonstrates a mastery of each critical concept and software techniques called for in the exercise check-list and readings.</td>
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<tr>
<td>85 – 90</td>
<td>Demonstrates the critical and technical requirements; but has problems in terms of the critical discussion of data, and sloppy or misleading cartography.</td>
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<tr>
<td>80 – 85</td>
<td>Demonstrates most of the technical and critical requirements.</td>
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<tr>
<td>70 – 80</td>
<td>Disregards key elements of the instructions.</td>
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<tr>
<td>60 – 70</td>
<td>Deficient. Makes unfounded or mistaken assertions. Does not cite sources. Misunderstands fundamental principles covered in class or the readings. Sub-standard grammar or logic. Not enough time or advance planning was dedicated to the project.</td>
</tr>
</tbody>
</table>

Late Work
Each student is allowed a 1-week extension for one project. This does not apply to the mid-term presentation and possibly other projects to be determined. After that, 1.5 points will be deducted for projects that are up to a week late. No projects are accepted after more than a week.
Fall 2018 DRAFT Course Schedule:
Meetings are on Friday Mornings in Sackler Big Lab S514 except as noted in red below.

<table>
<thead>
<tr>
<th>Date</th>
<th>Weekly Topic</th>
<th>Exercise Assigned</th>
<th>Exercise Due</th>
<th>Term Project Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 7</td>
<td>Geography in Decision-making</td>
<td>Evaluate Data</td>
<td>Nothing Due</td>
<td>Introduce Term Project</td>
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<tr>
<td><strong>Sackler 207</strong></td>
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<tr>
<td>September 14</td>
<td>Organizing Data</td>
<td>Organize Data</td>
<td>Evaluate Data</td>
<td>Research Review</td>
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<td></td>
<td></td>
<td><strong>Research Review</strong></td>
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<tr>
<td></td>
<td></td>
<td><strong>Term Project Proposal</strong></td>
<td></td>
<td></td>
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<tr>
<td>September 21</td>
<td>Nuts and Bolts of Mapping</td>
<td>Nuts and Bolts of Mapping</td>
<td>Organize Data</td>
<td>The wisdom of proof-of-concept pilot studies.</td>
</tr>
<tr>
<td>September 28</td>
<td>Data Formats, RDBMS</td>
<td>Mapping Categorical Data</td>
<td>Nuts and Bolts of Mapping</td>
<td>Gathering base data.</td>
</tr>
<tr>
<td>October 5</td>
<td>Making Sense of the Census</td>
<td>Mapping Intensive</td>
<td>Mapping Categorical Data</td>
<td>Considering context</td>
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<tr>
<td></td>
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<td>Statistics</td>
<td></td>
<td></td>
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<tr>
<td>October 12</td>
<td>Rates and Raw Quantities</td>
<td>Buffer, Selection</td>
<td>Mapping Census Data</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Summary</td>
<td></td>
<td></td>
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<tr>
<td>October 19</td>
<td>Raster Data &amp; Elevation</td>
<td>Mapping Terrain</td>
<td>Buffer, Selection</td>
<td></td>
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<tr>
<td><strong>Sackler 507</strong></td>
<td></td>
<td>Summary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>October 26</td>
<td>Geoprocessing 1</td>
<td>Vector Scenario</td>
<td>Mapping Terrain</td>
<td>Reproducible analytics</td>
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<tr>
<td></td>
<td>Vector Facility Allocation</td>
<td>Comparison</td>
<td></td>
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<tr>
<td>November 2</td>
<td>Geoprocessing 2</td>
<td>Raster Location</td>
<td>Vector Scenario</td>
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<tr>
<td></td>
<td>Raster Overlay Models</td>
<td>Analysis</td>
<td>Comparison</td>
<td></td>
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<tr>
<td>November 9</td>
<td>GIS Model Demonstrations</td>
<td>No new assignment</td>
<td>Raster Location</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Analysis</td>
<td>Analysis</td>
<td></td>
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<tr>
<td>November 16</td>
<td><strong>Research Review Presentation</strong></td>
<td>No new Assignment</td>
<td><strong>Research Review</strong></td>
<td>Raster Location Analysis</td>
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<tr>
<td>Thanksgiving Recess</td>
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<tr>
<td>November 30</td>
<td>Advanced Models &amp; Mapping</td>
<td>Term Project Models</td>
<td>Term Project Proposal</td>
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<tr>
<td><strong>Sackler 507</strong></td>
<td>Demonstration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>December 7</td>
<td>Advanced Models &amp; Mapping</td>
<td>No new assignment</td>
<td>Term Project Models</td>
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<tr>
<td></td>
<td>Demonstration</td>
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<tr>
<td>December 14</td>
<td>Conclusion &amp; Poster Design</td>
<td>Term Project Poster</td>
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<tr>
<td>TBD (Reading Period)</td>
<td>Model Hospital (by appt.)</td>
<td>No Assignment</td>
<td>Nothing Due</td>
<td></td>
</tr>
<tr>
<td>December 23</td>
<td>No Meeting</td>
<td>No Assignment</td>
<td>Term Project Poster</td>
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</tbody>
</table>
Lectures, workshops and exercises will be taken from the instructor’s website:
www.gismanual.com. These pages are continually updated.

Course Topics, Learning Objectives and Assignments

Part 1: The first half of the course focuses on organizing, mapping and evaluating typical GIS datasets. These exercises will be carried out using specific datasets chosen from MassGIS. Students will choose their own area of interest within the state to study in terms of cultural and physical context, demographics, land use and terrain.

1. **Geography in the 21st Century: Infrastructure for Spatial Data and Metadata**
   - Describe a question in terms of concepts and relationships that can be instantiated with data.
   - Use metadata to evaluate available datasets in terms of utility for specific purposes.
   - Cite originating and issuing sources appropriately.

Exercise: Introduce yourself. Include a photo. Describe a research question. Describe a dataset that may be of interest with regard to your question. Identify a two square kilometer place in Massachusetts in which the issue you are describing makes a difference. Upload a single, multi-page PDF document to the course web site on the Tufts Canvas web platform.

Readings:
- [Spatial Models for Research and Decision Support](#)
- [Sources of Geographic Data](#)
- [Understanding Geographic Data](#)
- [MassGIS Web Site](#)

2. **Begin a Data Collection for On-Going Geographic Research**
   - Plan a File System for Ongoing Research and Archiving.
   - Obtain base map data.
   - Create an ArcMap document.
   - Back-up and restore a research archive collection of data.

Exercise: Begin your Data Collection; Create a Map; Back & Restore Up Your Collection. Turn in a zip file.

Readings:
- [Organizing Data for Re-Use](#)
- [ArcMap 101: Collecting GIS Data and Metadata](#)

3. **Nuts and Bolts of Cartography: Geographic Referencing Systems**
   - Choose an appropriate map projection for a map.
   - Create a three-layer graphical cartographic hierarchy.
   - Create a map that frames a purposeful discussion of a place.

Exercise: Create a reference map portraying the immediate context of your study area.

Readings:
- [Fundamentals of Geographic Referencing](#)
4. Data Encoding and Exchange Formats, Mapping Categorical Data.
   - Understand fundamental data formats.
   - Use Structured Query Language (SQL) to filter tables based on complex relationships.
   - Create layers and table views based on definition queries
   - Use SQL to control labels

   Exercise: Use queries to filter tables, create layers and control labels.

   Readings:
   - Data Formats for Geography
   - Relational Databases, Queries and Views
   - Mapping Categorical Data

5. Demographic Surveys and Mapping with Quantitative Data
   - Obtain census data for your study area
   - Properly represent intensive and raw count statistics (parts and wholes)
   - Develop credible discussions in light of the modifiable aerial unit problem

   Exercise: Create demographic maps with choropleth and proportional symbol maps.

   Readings:
   - About Census Data
   - Mapping with Quantitative Data
   - Mapping Census Data Tutorial

   - Models are repeatable sequences of procedures
   - How to create models in ArcGIS
   - Buffers and Spatial Selections

   Exercise: Describe, and model a spatial mechanism using one or more of the techniques discussed in class.

7. Topographic Surveys & Mapping Terrain, Introduction to Rasters
   - Obtain elevation models for an area of interest.
   - Properly transform elevation data for graphical display
   - Create maps with synthetic hill shading and contours.

   Exercise: Add contours and hillshade to your area of interest map. Discuss precision of raster data.

   Readings:
   - Obtaining and Transforming Elevation Data
   - Topographical Surveys and Creating Elevation Data
Part 2: Modeling Spatial Mechanisms. In this segment of the course you are welcome to define your own conceptual models and datasets. You may also choose a new study area at this time. One or more of these projects may become the subject of your term poster. Please read the brief for the term poster for guidelines.

8. Map Algebra & Weighted Overlay:
   - Create and use raster models to represent conditions that vary as a spatially continuous function.
   - Use Map Algebra to create new surfaces as functions of input surfaces.
   - Appropriately apply weighted overlay techniques for site selection.

Readings:
   - Raster GIS Tutorial
   - Geoprocessing in ArcGIS

Exercise: Prepare a locational analysis with surfaces or weighted overlay.

Exercise: Propose model for Final Project

Readings:
   - Spatial Models for Research and Decision Support
   - Sources of Geographic Data
   - Understanding Geographic Data
   - Tufts Data Center GIS Poster Collection

Exercise: Develop a conceptual model involving spatial association (e.g. food deserts.) Instantiate your model using data of your choice. Use geoprocessing tools to create a reusable model to experiment with policy alternatives. Assess the degree of confidence in your model as a decision support tool.

Readings:
   - Evolution of Vector-Relational Database Management Systems and SQL.
   - Vector-Relational Procedures in ArcMap

9. Vector-Relational Modeling: Buffering and Overlay Techniques

   - Spatial Associations
   - Spatial Joins
   - Overlay Techniques and Aerial Allocations
   - Network Analysis

Exercise: Describe, and model a spatial mechanism using one or more of the techniques discussed in class. Use a bar chart or scatterplot to explore your model results.

Readings:
   - Vector-Relational Procedures in ArcMap

10. Raster Fundamentals: Focal, Zonal, and Interpolation Techniques

   - Create Heat maps with interpolation and focal functions.
   - Use zonal functions to model accessibility and exposure

Readings:
   - Raster GIS Tutorial (continued)
Exercise: Raster interpolation and summary.

11. **Poster Design and Course conclusion**
   - Organize ideas graphically using layout, fonts and color.
   - Discuss the future of GIS in research and decisionmaking

Exercise: Create poster for final project and the [Tufts GIS Poster Expo](https://www.tufts.edu).