

PLAN 64I: WATERSHED PLANNING

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Office Hours: 10:30-11:30 M + by appt. (please email to confirm availability)

Office: (During non-pandemic times) Davis Library 231B (in maze-like Odum Institute; behind Research Hub, ask for me in the lobby)

Spring 2021

9:05 – 10:20 M + W

Course website: <http://sakai.unc.edu>

Course Zoom access:

<https://go.unc.edu/plan641>

(or <https://unc.zoom.us/j/92414266761>;

password: 641zooms)

Course question site:

<https://pollev.com/bendor>

Course description. This course is a semester-long introduction to watershed planning, where we examine the functions of, threats to, and strategies for protecting watersheds and wetlands. We will focus on understanding the functions of ecosystems, the land development activities that impact such functions, and the land use management tools that can be used to create strategies for mitigating and restoring environmental damage. While urban land use change and environmental planning have many implications for ecological systems, water is becoming the key link between ecological health and quality and urban development.

The impacts of urbanization on watershed health can be dramatic and potentially harmful to human interests, and include flooding and declining water quality. As development continues and low-density urban growth converts open space into impervious surfaces, it is imperative that decision makers, planners and citizens assess, monitor, and mitigate these effects. A key theme throughout the course will be to explore how the scientific knowledge of ecological relationships can be integrated into an environmental planning framework. The fundamental goal is to assure natural ecosystem integrity is sustained over the long-term, while accommodating human use and occupancy within natural ecological limits.

Course objectives. Our mission in this course is to understand the ecological context of planning and how ecological principles – primarily concerning water – may inform planning decisions. By the end of the course, students should (1) understand key concepts in watershed planning and science relevant to planners, and (2) be able to apply watershed principles to real planning problems. Insightful solutions to ecological planning problems require that planners be able to synthesize in-depth ecological knowledge with a strong understanding of planning procedures, economic and infrastructural constraints, and social priorities. This course seeks to prepare planners to engage effectively with biologists, natural resource managers, park managers, and other professionals from the natural sciences. Students with a natural science background will benefit from reflecting on the potential and limitations of drawing on ecological knowledge to address real planning problems. This course also places an emphasis on written, visual, and oral communication, with the aim of preparing students to collaborate with other specialists such as hydrologists, civil engineers, ecologists or other relevant professionals. By the end of the course, students will have:

- 1) Developed a firm grasp of the quantitative, spatial, and qualitative techniques relevant to urban watershed planning;
- 2) Applied watershed assessment techniques to evaluate existing conditions and estimate the impacts of future development;
- 3) Evaluated how urban development impacts urban ecosystem functions;
- 4) Developed an understanding of, and appreciation for, the role that planners have in constructing technologically appropriate and environmentally sensitive solutions to water related problems;
- 5) Identified the important role of watershed planning and undertook specific tasks in preparing watershed plans;
- 6) Created environmental plans for mitigating the impacts of land development while protecting and restoring urban ecosystems; and
- 7) Formulated watershed management policies and actions that protect the natural system functions of watersheds, while mitigating the impacts of future development on watershed health.

What is this syllabus? This document is many things: it is a planning document, so you can plan your time commitment for reading and assignments; it is a roadmap through the class that aims to give you bearings for each class; it is also a contract of sorts, telling you the level of effort I intend to put into course as a teacher, as well as the level of effort I expect from you as a student.

Class format and readings. This course will meet twice per week. Class sessions will involve lectures, guest speakers, and extensive class discussion. “Virtual field trips” – in the form of guest lectures and videos – will also aid our observation of ecosystem functions and how these functions are influenced by urban development.

How can you do well in this class? To do well in this course, I expect you to 1) spend significant time and effort working with your group on the semester-long planning project, 2) spend time working through the reading material in advance of class, 2) attend class and participate. Remotely working with a group during the pandemic requires careful scheduling, planning, and division of work and responsibilities.

Time Commitment: In this course, you should expect to spend at least 3 hours outside of class for each hour you spend in class. This amounts to at least 7-8 hours per week outside of class. It is likely, however, that during some weeks, this course will require much more time, and in other weeks, it will require much less time.

What is participation? Participation means that you are actively listening and engaging in classroom discussions, as well as engaging the class with your own questions, whether you bring them in class or through the weekly poll for PLAN 641: <https://pollev.com/bendor/>. Please contact the instructor if you have any questions, problems with the readings or the course, or any other issues that you wish to discuss. Students in this class are encouraged to speak up and participate during class meetings. Because the class will represent a diversity of individual beliefs, backgrounds, and experiences, every member of this class needs to show respect for every other member.

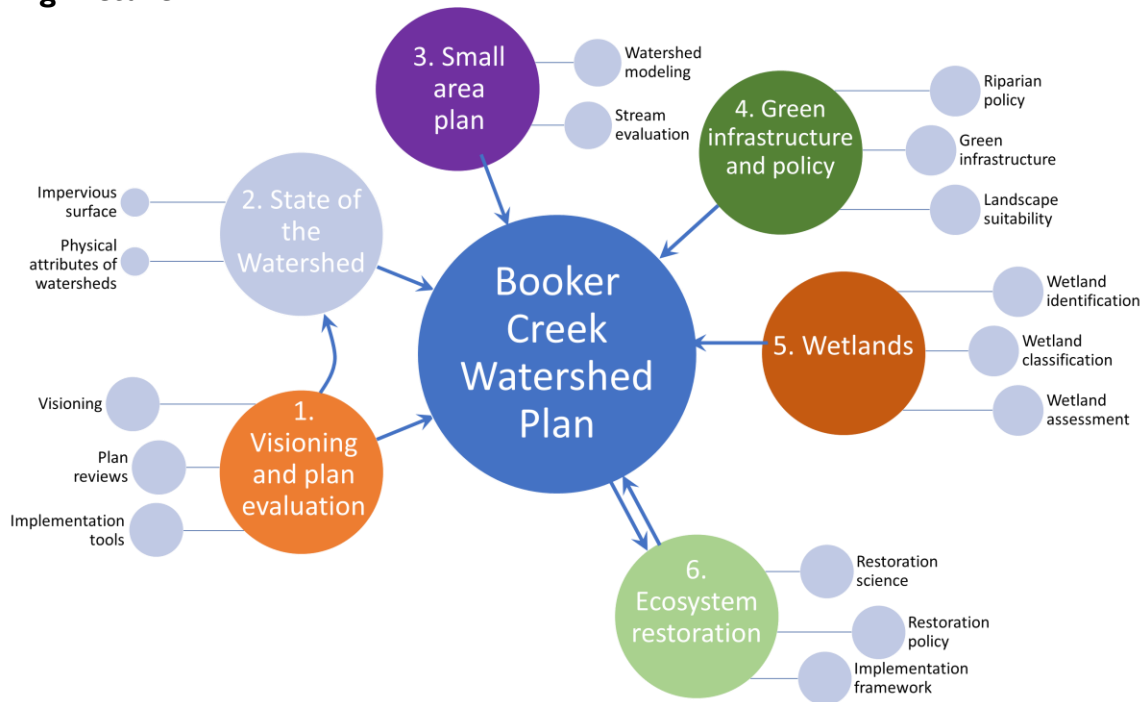
There is a lot of reading. How do I get through it all? The most important thing to do is planning your time. Some tips:

- If you don't have one, get a calendar! Put all due dates and special class activities (e.g., field trips) on your calendar.
- There are lots of resources for time management available, here is a good one: <https://students.dartmouth.edu/academic-skills/learning-resources/time-management>
- Everyone reads articles differently, you need to figure out how you can effectively read a large volume of material and come away with the main ideas and key points. “Some books should be tasted, some devoured, but only a few should be chewed and digested thoroughly.” – Sir Francis Bacon. Skimming is your friend and an important strategy to keep up with the readings, but when you see important points, slow down and digest thoroughly.
- Write down questions as you read! Submit those questions to the course's poll: <https://pollev.com/bendor/>. Asking questions is an important part of participating in your own learning process.

Why will we spend the semester creating a new plan? Bloom's Taxonomy considers educational learning based on different levels of complexity and specificity. Our goal is to climb this mountain, where the peak involves creating new knowledge, while synthesizing lots of concepts and information that you have acquired in this class. Creation is the goal.



Semester Big Picture



Assignments + course grading

0) (Individual) Linked-In Learning QGIS Module (submitted via Sakai)	5%
1) Vision statement and plan evaluation	10%
2) State of the watershed (part I)	15%
3) Sub-watershed management plan	15%
4) State of the watershed (part II) + GI plan-policy component	10%
5) Wetland management plan	15%
6) Complete (corrected) Booker Creek Watershed Management Plan (with restoration components + presentation)	20%
Course Participation	10%
Total:	100%

Grading notes: As a matter of departmental policy, and in order to be fair to your fellow students, late assignments will be docked 20% per day. Generally, an **H** (or **A**) is given for exceptional work that demonstrates a real mastery of course material. **L** or **F** (D/F) work substantially fails to meet minimum requirements, either due to incomplete coverage of required information, incorrect results, or sloppy, unprofessional reporting of results. All grades for group work will be weighted by your teammates' evaluations of your contributions and your class participation.

Summary of due dates (Homework submitted via Sakai Assignments (one per group) by 5 pm on due date)

- Feb. 10: Completion of Linked-In Learning QGIS Module (individual assignment)
- Feb. 22: Assignment 1: Booker Creek vision statement and plan review report
- Mar. 17: Assignment 2: State of the watershed report (part I)
- Mar. 24: Assignment 3: Sub-watershed field evaluations, modeling, and local area plan-policy framework
- Apr. 12: Assignment 4: State of the Watershed report (part II) + GI plan-policy component
- Apr. 21: Assignment 5: Wetland policies and actions component
- May. 5: Student presentations of Booker Creek Watershed Management Plan
- May. 7: Assignment 6: Full Booker Creek Watershed Management Plan, including ecosystem restoration actions

Virtual field trips and guest speakers

- Jan. 27: *Virtual field trip to booker creek watershed*, Led by Allison Weakley (Chapel Hill Stormwater Analyst)
- Feb. 24, Mar. 1: *Geographic information systems with QGIS*, Led by Philip McDaniel (UNC GIS Librarian).
- Mar. 29: *UNC green infrastructure virtual field trip*, Led by Sally Hoyt (UNC stormwater engineer)
- Mar. 31: *Riparian zones and urbanization*, Led by Prof. Danielle Spurlock (UNC City and Regional Planning)
- Apr. 14: *Wetland virtual field trip*, More Info TBA.
- Apr. 26: *Ecosystem restoration virtual field trip – Battle Grove Restoration Site*, Led by Sally Hoyt
- Apr. 28: *Ecosystem restoration practice and policy*. Led by Adam Riggsbee (Co-Founder/CEO, RiverBank Conservation)

IF YOU HAVE A MEDICAL EMERGENCY, PLEASE INFORM THE INSTRUCTOR AS SOON AS POSSIBLE. Grades of incomplete may be given in the event of a medical or another emergency. In these cases, a written application for an incomplete on any assignment must state the reasons for the request and propose a new deadline.

Resources: My purpose as a professor is to help you to excel in this learning environment. Should you need further assistance beyond the help of the professor, please consult the following on-campus resources:

- The Writing Center: <http://writingcenter.unc.edu>
- The Learning Center: <http://learningcenter.unc.edu>
- The Learning Center resources for students with learning disabilities (LD) and/or attention-deficit/hyperactivity disorder (ADHD): <https://learningcenter.unc.edu/services/ldadhd-services/>
- The Center for Student Success and Academic Counseling: <http://cssac.unc.edu>
- Counseling and Wellness Services: <http://campushealth.unc.edu>

The University's Honor Code is in effect. The University of North Carolina at Chapel Hill has had a student-administered honor systems and judicial system for over 100 years. The Honor Code represents UNC-Chapel Hill students' commitment to maintain an environment in which all students respect one another and are able to attain their educational goals. As a student at Carolina, you are entering a community in which integrity matters – integrity in the work you submit, and integrity in the manner in which you treat your fellow Carolina community members. Because academic honesty and trustworthiness are important to professional planning, this is a significant University and Departmental tradition. Your attention is called to the Instrument of Student Judicial Governance for policies and procedures pertaining to the honor system. We are committed to treating Honor Code violations seriously and urge all students to become familiar with its terms set out at <https://studentconduct.unc.edu/>. If you have questions it is your responsibility to ask the professor about the Code's application. Please consult with the instructor if you are uncertain about your responsibilities under that code with respect to this course.

The University of North Carolina – Chapel Hill facilitates the implementation of reasonable accommodations, including resources and services, for students with disabilities, chronic medical conditions, a temporary disability or pregnancy complications resulting in difficulties with accessing learning opportunities. All accommodations are coordinated through the Accessibility Resources and Service Office. Any student who feels s/he may need an accommodation based on the impact of a disability should contact me privately early in the semester to discuss your specific needs. Students with documented disabilities should contact the Department of Disability Services at 919-962-8300 (SASB North, Suite 2126; <https://ars.unc.edu/>) to coordinate reasonable accommodations.

Course outline

For each course topic, required readings are provided. A special effort has been made to select relevant, timely and well-written readings. Additional resources are listed that can be examined in detail, depending upon your interest in the subject. The source and style of each reading varies considerably. I recommend downloading all of the materials as they may serve you as useful references during future classes or in your career.

*** Reading comprehension and time management are skills. PLEASE READ ASSIGNED MATERIAL BEFORE EACH CLASS***

The professor reserves the right to make changes to the syllabus, including project due dates, when unforeseen circumstances occur. These changes will be announced as early as possible so that students can adjust their schedules.

Please arrive on time, activate your video on Zoom and remember to mute yourself if you are not speaking. Fun and/or hilarious (tasteful) virtual backgrounds are encouraged

I will start our Zoom 15 minutes before class and keep it going for 10 minutes after class to build in some informal time.

Recommended reference readings:

- Isobel W. Heathcote, John Richard Edwards, Hugh Greener, and Hugh M. Coombs. 1998. Integrated watershed management: principles and practice. Taylor & Francis: New York, NY
- John Randolph. 2004. Environmental land use planning and management. Island Press: Washington, D.C.

Assignment 0: On your own, please complete the Linked-In Learning course, “Learning QGIS” (Gordon Luckett; dated October 2019) at <http://linkedin.unc.edu/>. This course augments the GIS overview sessions of PLAN 641 and consists of 12 modules scheduled to take approximately 3 hours. At the end of the course, you will receive a PDF certificate, which you can submit via Sakai Assignments feature (due: Feb 10th). Please come to class with any questions you have about GIS or QGIS. If you have already completed this certificate, then you are not required to re-do it (although it may help to refresh).

Additionally, if you have not had previous GIS training (e.g. PLAN 491/591), you are required to enroll in the Linked-In Learning course “ArcGis Essential Training,” which consists of 13 modules scheduled to take approximately 5.5 hours. If you need more basic training (i.e., you have never been exposed to GIS at all), you should also complete the course, “Learning ArcGIS” (3.25 hours) prior to the “ArcGis Essential Training” course.

PART I: Creating a vision and evaluating plans

- Objectives:
- 1) Learn about the structure and requirements of the course
 - 2) Elicit and formulate watershed issues and opportunities
 - 3) Formulate a comprehensive watershed vision
 - 4) Evaluate watershed plans to understand their content, structure, and quality

Jan. 20: Course introduction

Required:

USEPA. 1996. Why Watersheds? (EPA800-F-96-001). US Environmental Protection Agency: Washington, D.C.

- Asks the question, “Why manage watersheds?” and answers with discussion of the benefits of management

Robert B. Jackson, Stephen R. Carpenter, Clifford N. Dahm, Diane M. McKnight, Robert J. Naiman, Sandra L. Postel, and Steven W. Running. 2001. Water in a Changing World. *Issues in Ecology*, Issue 9. Ecological Society of America: Washington, D.C.

- Global overview of water problems
- Justifications for urban water management

Jan. 25: *Introduction to environmental planning*

Required:

- Tom Daniels and Katherine Daniels. 2003. "Ch. 1: Taking Stock of the Local Environment and Creating an Environmental Action Plan," in *The Environmental Planning Handbook for Sustainable Communities and Regions*. APA Planners Press: Chicago: pp. 11-36.
- Robert Costanza, et al. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387 (6630): 253-260.

Recommended:

- USEPA. 2018. Watershed Funding: EPA Funding-Related Topics and Resources. US Environmental Protection Agency: Washington, D.C. [Online]: <https://www.epa.gov/nps/funding-resources-watershed-protection-and-restoration>
- Skim to get a sense of funding sources for watershed plans
- Carl Zimmer. 2014. Putting a Price Tag on Nature's Defenses. NY Times Article.

Jan. 27: *Booker Creek watershed virtual field trip (please view video before class, with questions during class), led by Allison Weakley, Chapel Hill Stormwater Analyst*

Note: Today you will be assigned to a group to review the plan-policy framework of an example plan for the following week.

Required:

- Town of Chapel Hill. 2019. Data Book and Community Indicators. Town of Chapel Hill: Chapel Hill, NC. [Online]: <https://www.townofchapelhill.org/government/departments-services/planning/data-and-resources>
- Gives a better understanding of Town's capabilities, planning, data, etc.
- Town of Chapel Hill. 2020. Watershed assessments & plans. [Online]: <https://www.townofchapelhill.org/government/departments-services/public-works/stormwater-management/know-your-watersheds/watershed-assessments-plans>
- Offers lots of information on local watershed management and planning activities.
- Tetra Tech, Inc. 2004. Morgan Creek Local Watershed Plan: Targeting of Management Report. North Carolina Ecosystem Enhancement Program: Raleigh, NC. [on Sakai; skim]
- Jess Stanford. 2019. How we created a full demographic analysis for the Chapel Hill-Carrboro region. Carolina Demography (UNC Chapel Hill): Chapel Hill, NC. [Online] <https://www.ncdemography.org/2019/09/18/how-we-worked-with-the-chapel-hill-carrboro-chamber-to-create-a-comprehensive-demographic-look-at-their-region/>
- Lots of details on Town's demographics.
- K. Alsharif. (2010). Construction and stormwater pollution: policy, violations, and penalties. *Land Use Policy* 27(2): 612-616.
- Niko Letunic. 2007. Beyond Plain English: Ten Best Practices for Creating Citizen Friendly Planning Documents. *Planning Magazine*, October, pp. 40-43.
- A good guide for making group reports easily read by a diverse group

**Required for plan review and discussion (next time):*

- Ward Lyles and Mark Stevens. 2014. Plan Quality Evaluation 1994–2012: Growth and Contributions, Limitations, and New Directions. *Journal of Planning Education and Research* 34 (4): 433–50.
- William Baer. 1997. General Plan Evaluation Criteria: An Approach to Making Better Plans. *Journal of the American Planning Association* 63(3): 329-344.
- Philip Berke, David Godschalk, and Edward Kaiser with Daniel Rodriguez. 2006. *Plan Quality Protocol* in Ch. 3: Making a Good Plan, in *Urban Land Use Planning* (5th Edition). University of Illinois Press: Chicago.

Feb. 1: *Visioning and scenario building; formulating a policy framework*

Required:

- Robert Shipley. 2002. Visioning in planning: is the practice based on sound theory? *Environment and Planning A* 34: 7-22.

- USEPA. 2013. A Quick Guide to Developing Watershed Plans to Restore and Protect Our Waters (EPA 841-R-13-003). US Environmental Protection Agency: Washington, D.C.
- Philip Berke, David Godschalk, Ed Kaiser and Daniel Rodriguez. 2006. Ch. 9: State of Community Report: Scenarios and Visions, pp. 1-26; Ch. 10: Direction Setting, pp. 1-10," In *Urban Land Use Planning* (5th Edition), University of Illinois Press: Chicago.
- NC Division of Water Resources and Triangle J Council of Governments. 2014. A simplified guide to writing watershed restoration plans in North Carolina. TJCOCG: Durham, NC

Recommended:

Berit Junker, Mattias Buchecker, and Ulrike Mueller-Boker. 2007. Objectives of public participation: Which actors should be involved in the decision making for river restorations? *Water Resources Research* 43: W10438.

Feb. 3: *Plan implementation tools*

Required:

John Randolph. 2003. "Ch. 6: Design with Nature for People: Sustainable, Livable, and Smart Land Use Development," "Ch. 7: Local Government Smart Growth Management," in *Environmental Land Use Planning and Management*. Washington, D.C.: Island Press, pp. 106-140, 141-168.

- Great reference text on development tools.
- See compilation of plan implementation tools from PLAN 744: Development and Environmental Management in Assignments directory on Sakai.

USEPA. 2014. 8 Tools of Watershed Protection in Developing Areas. US Environmental Protection Agency: Washington, D.C.

Recommended:

Tom Schueler. 2000. The Economics of Watershed Protection. *Watershed Protection Techniques*. 2(4): 469-481. [Center for Watershed Protection]

USEPA. 2004. Protecting Water Resources with Smart Growth (EPA 231-R-04-002). US Environmental Protection Agency: Washington, D.C.

- Longer document, but very valuable to skim.
- Review headings to get a good sense of diverse tools available to planners and policy-makers at different levels of government.

Recommended:

See APA Efforts to certify comprehensive plans: <https://www.planning.org/sustainingplaces/compplanstandards/>

Feb. 8: *Student plan reviews and discussion*. Reviews of illustrative vision statements, goals and objectives, policies, and other components of policy frameworks in a sample of environmental plans

Feb. 10: *Simulated visioning exercise*: "What do we want for the future of our watershed?"

Recommended:

Charlie MacPherson and Barry Topping. *Getting in Step: A Guide to Effective Outreach in your Watershed*. US Environmental Protection Agency: Washington, D.C.

DUE: Completion of Linked-In Learning QGIS Module (as individual; turn in completion certificate (or approved exemption note) by 5 PM via Sakai Assignments

Part II: Understanding the state of the watershed

- Objectives:
- 1) Learn about Geographic Information Systems (GIS) and mapping techniques with QGIS
 - 2) Map a watershed, identify drainage networks, and compute watershed slopes and area.
 - 3) Identify and evaluate land use management tools for impact mitigation and restoration and to formulate comprehensive ecosystem protection strategies.
 - 4) Evaluate land development impacts on upland and riparian zones of watersheds.
 - 5) Create a state of the watershed report and vision for the future.

Feb. 15: UNC Wellness Day (NO CLASS MEETING)

Feb. 17, 22: Physical attributes of watersheds

ASSIGNMENT 1 DUE: A) Booker Creek vision statement + B) plan review write-up (February 22, 5 PM via Sakai Assignments)

Required:

- Ann L. Riley. 1998, "Ch. 1: The Basics," in *Restoring Streams in Cities: A Guide for Planners, Policymakers, and Citizens*, Washington, D.C.: Island Press, pp. 1-13, 27-33.
- Christopher J. Walsh, Allison H. Roy, Jack W. Feminella, Peter D. Cottingham, And Peter M. Groffman. 2005. The Urban Stream Syndrome: Current Knowledge and the Search for a Cure. *Journal of the North American Benthological Society* 24(3): 706–723
- Christopher A. Frissell, William J. Liss, Charles E. Warren, and Michael D. Hurley. 1986. A Hierarchical Framework for Stream Habitat Classification: Viewing Streams in a Watershed Context. *Environmental Management* 10(2): 199-214
- William Marsh. 1991. Chapter 4: Topography, Slopes and Land Use Planning, Chapter 9: Watersheds, Drainage Nets, and Land Use, in *Landscape Planning: Environmental Applications*, John Wiley and Sons: New York. pp. 54-59, 132-135.
- Michael J. Paul and Judy L. Meyer. 2001. Streams in the Urban Landscape. *Annual Review of Ecological Systems* 32: 333–65
- Overview of chemical and geomorphic characteristics of urban streams

Recommended:

- Karen Cappiella and Lisa Fraley-McNeal. 2007. *The Importance of Protecting Vulnerable Streams and Wetlands at the Local Level*. Center for Watershed Protection and US Environmental Protection Agency: Ellicott City, MD and Washington, D.C.
- Great information source on headwater streams and definitions of intermittent streams
- Natural Resources Conservation Service. 2007. *National Engineering Handbook: Part 630 Hydrology*. Hydrologic Soil Groups (Chapter 7) (10–VI–NEH). USDA: Washington, D.C.

Feb. 24, Mar. 1, 3: *Geographic Information Systems with QGIS (Sessions 1-2 led by Philip McDaniel, UNC GIS Librarian)*. Session 3: how to make better maps

Jonathan Campbell and Michael Shin. 2011. *Essentials of Geographic Information Systems*. Minneapolis, MN: Center for Open Education. [Online] Available: <https://open.umn.edu/opentextbooks/textbooks/essentials-of-geographic-information-systems>. Please complete Chapters 1, 3-7.

Additional resources:

- QuantumGIS (QGIS) Tutorials: [Online]: <http://www.qgistutorials.com/en/docs/introduction.html>
 - This is a tutorial created for QGIS, a free and open-source alternative to ESRI's ArcGIS hegemony. Great worksheets and information on GIS concepts
- Harvard Map Collection. 2020. GIS Tutorials and Exercises: Introduction to Geographic Information Systems (GIS) Tutorial. Harvard University: Cambridge, MA. [Online]: <https://gis.harvard.edu/tutorials>
- Many books exist on GIS – including ArcGIS and ArcGIS Pro – I recommend a review (in the library):

- Michael Law and Amy Collins. 2018. *Getting to Know ArcGIS Desktop [Fifth Edition]*. ESRI Press: Redlands, CA.
- Michael Law and Amy Collins 2019. *Getting to Know ArcGIS Pro [2nd edition]*. ESRI Press: Redlands, CA.
- Juliana Maantay and John Ziegler. 2006. Map projections and coordinate systems, Chapter 2 – Spatial Data and Basic Mapping Concepts, pgs. 39-53 and Chapter 6 – Sources of Urban Data, pgs. 157-177 in *GIS for the Urban Environment*. Redlands, CA: ESRI Press.
- Agustin Rodriguez-Bachiller with John Glasson. 2004. GIS and Impact Assessment (Chapter 3), pgs. 52-80 in *Expert Systems and Geographic Information Systems for Impact Assessment*. London: Taylor and Francis.
- Robert B. Kent and Richard E. Klosterman. 2000. GIS and Mapping: Pitfalls for Planners. *Journal of the American Planning Association* 66(20): 189-198
- Another good overview of basic GIS material: Kang-tsung Chang. 2002. Chapter 1 – Introduction, pgs. 1-10, Chapter 3 – Vector Data Model, pgs. 31-49, and Chapter 6 – Attribute Data Input and Management, pgs. 100-113, in *Introduction to Geographic Information Systems*, Boston: McGraw-Hill.

Mar. 8, 10: *Impervious cover*

Required:

Thomas Schueler. 2003. Chapter 2: Hydrologic Impacts of Increased Impervious Cover. In: *Impacts of Impervious Cover on Aquatic Systems: Watershed Protection Research Monograph No. 1*. Center for Watershed Protection: Ellicott City, MD.

- An authoritative volume on urban hydrology
- Focus on Chapter 2.

Chester Arnold and C. James Gibbons. 1996. Impervious Surface Coverage: The Emergence of a Key Indicator. *Journal of the American Planning Association* 62: 243-258.

- Lends a historical perspective to the emergence of impervious surface as a driver of environmentally-related planning thought

Recommended:

Carol R. Jacobson. 2011. Identification and quantification of the hydrological impacts of imperviousness in urban catchments: A review. *Journal of Environmental Management* 92: 1438-1448.

Linda R. Exum, Sandra L. Bird, James Harrison, and Christine A. Perkins. 2005. Estimating and Projecting Impervious Cover in the Southeastern United States (EPA/600/R-05/061).

- Skim, lots of interesting information.

Mary Battiata. 2005. Silent Streams. *Washington Post*: Sunday, November 27, 2005. [Online]:

<http://www.washingtonpost.com/wp-dyn/content/article/2005/11/22/AR200511220165.html>

- Washington Post magazine article describing how impervious cover associated with sprawl is threatening streams nationwide)

David N. Lerner and Bob Harris. 2009. The relationship between land use and groundwater resources and quality. *Land Use Policy* 26S: S265–S273

Part III: Watershed field evaluation and modeling

- Objectives:
- 1) *Apply quantitative modeling to watershed hydrology and water quality*
 - 2) *Perform field evaluations of stream health and understand alternative methods*
 - 3) *Create a small area (sub-watershed) plan-policy framework*

Mar. 15: *Modeling watershed dynamics*

Required:

V. M. Jayasooriya, A. W. M. Ng. 2014. Tools for Modeling of Stormwater Management and Economics of Green Infrastructure Practices: a Review. *Water, Air, & Soil Pollution* 225:2055.

A.H. Elliott and S.A. Trowsdale. 2007. A review of models for low impact urban stormwater drainage. *Environmental Modelling & Software* 22:394-405

Recommended:

Keith E. Schilling and Calvin F. Wolter. 2009. Modeling Nitrate-Nitrogen Load Reduction Strategies for the Des Moines River, Iowa Using SWAT. *Environmental Management* 44:671–682.

Mar. 17: *Sub-watershed and stream evaluation*

ASSIGNMENT 2 DUE: *Statement of the Watershed report (Part I) (5 PM via Sakai Assignments)*

Required:

T. Schueler, A. Kitchell. 2005. Desktop Analysis: Comparative Sub-watershed Analysis. In: *Urban Subwatershed Restoration Manual No. 2: Methods to Develop Restoration Plans for Small Urban Watersheds (Version 2.0)*. Center for Watershed Protection.: Ellicott City, MD.

Eric A. Davidson, Mark B. David, James N. Galloway, Christine L. Goodale, Richard Haeuber, John A. Harrison, Robert W. Howarth, Dan B. Jaynes, R. Richard Lowrance, B. Thomas Nolan, Jennifer L. Peel, Robert W. Pinder, Ellen Porter, Clifford S. Snyder, Alan R. Townsend, and Mary H. Ward. 2012. Excess Nitrogen in the U.S. *Issues in Ecology: Report 15*. Ecological Society of America: Washington, DC.

Recommended:

WV DEP. 2006. West Virginia Nonpoint Source Program: Natural Stream Channel Design & Riparian Improvement Project Monitoring Protocol. WV Dept. of Environmental Protection Nonpoint Source Program: Charleston, WV

A. Kitchell, T. Schueler. 2005. Manual 10: Unified Stream Assessment: A User's Manual. *Urban Subwatershed Restoration Manual Series*. Center for Watershed Protection, Ellicott City, MD.

Ronald Bjorkland, Catherine M. Pringle And Bruce Newton. 2001. A Stream Visual Assessment Protocol (SVAP) For Riparian Landowners. *Environmental Monitoring and Assessment* 68: 99–125.

Part IV: Green infrastructure and policy solutions

- Objectives:
- 1) Understand the role of riparian buffers and their policy structure
 - 2) Understand the role of green stormwater infrastructure in improving urban hydrology and water =
 - 3) Create a green infrastructure-focused plan-policy framework

Mar. 22: *Land suitability analysis*

Required:

Malczewski, J. (2004). GIS-based land-use suitability analysis: A critical overview. *Progress in Planning* 62(1): 3-65.

Berke, Philip, David Godschalk, and Edward Kaiser, 2006, "Analyzing Environmental Information," in *Urban Land Use Planning*, 5th edition, Chicago: University of Illinois Press, pp. 33-41.

M. G. Collins, Steiner, F. R., & Rushman, M. J. (2001). Land-use suitability analysis in the United States: Historical development and promising technological achievements. *Environmental Management* 28(5): 611-621.

Mar. 24: *Green stormwater infrastructure and best management practices*

ASSIGNMENT 3 DUE: *Sub-watershed field evaluations, modeling, and local area plan-policy framework (5 PM via Sakai Assignments)*

Required:

Michael E. Dietz. 2007. Low Impact Development Practices: A Review of Current Research and Recommendations for Future Directions. *Water Air and Soil Pollution* 186:351–363

Stacey Berahzer. 2015. Crosswalking between Gray and Green Infrastructure – Considerations for Budget Officers. Center for Watershed Protection: Baltimore, MD

C. Girling and R. Kellert. 2002. Comparing Stormwater Impacts and Costs on Three Neighborhood Plan Types. *Landscape Journal* 21: 100-109.

Recommended:

D. E. Line, Brown, R. A., Hunt, W. F., & Lord, W. G. 2011. Effectiveness of LID for commercial development in North Carolina. *Journal of Environmental Engineering* 138(6), 680-688.

Thomas E. Low. 2010. *Light Imprint Handbook: Integrating Sustainability and Community Design*. New Urban Press: Charlotte. [Online]: <http://lightimprint.org/>.

- Snippets of the book are available online – copied onto Sakai.
- Light Imprint is the New Urbanism push for new stormwater techniques
- Contains matrix of stormwater BMPs, with information on which transect they're suitable for, their cost, and their maintenance requirements

P. Hamel, Daly, E., & Fletcher, T. D. 2013. Source-control stormwater management for mitigating the impacts of urbanisation on baseflow: A review. *Journal of Hydrology* 485: 201-211.

City of Portland. 2010. *Portland's Green Infrastructure: Quantifying the Health, Energy and Community Livability Benefits* [Specifically Sections 1 & 2]. City of Portland Environmental Services: Portland, OR. [Online]: <https://www.portlandoregon.gov/bes/article/298042>

Mar. 29: [VIRTUAL FIELD TRIP] *UNC green infrastructure field trip* (Guest speaker: Sally Hoyt, UNC Stormwater Engineer)

Required:

Jennifer Zielinski. 2001. The Benefits of Better Site Design in Residential Subdivisions. *Watershed Protection Techniques* 3(2), pp. 633-646.

Peter T. Weiss, John S. Gulliver, and Andrew J. Erickson. 2007. Cost and Pollutant Removal of Storm-Water Treatment Practices. *Journal of Water Resources Planning and Management* 133(3): 218-229.

See the NC Department of Environmental Quality Stormwater Control Measures (SCM) Design Manual: <https://deq.nc.gov/sw-bmp-manual>

- Review Sections A-1 (Runoff Treatment and Volume Match), A-7 (Guidance on SCM Selection), and C-0 (Minimum Design Criteria for all SCM)

Mar. 31: *Riparian zones and urbanization*. (Guest Speaker: Prof. Danielle Spurlock, UNC City and Regional Planning)

Required:

Peter M. Groffman, Daniel J. Bain, Lawrence E. Band, Kenneth T. Belt, Grace S. Brush, J. Morgan Grove, Richard V. Pouyat, Ian C. Yesilonis, and Wayne C. Zipperer. 2003. Down by the Riverside: Urban Riparian Ecology. *Frontiers in Ecology and the Environment* 1(6): 315-321

Leslie L. Orzetti, R. Christian Jones, and Robert F. Murphy. 2010. Stream Condition in Piedmont Streams with Restored Riparian Buffers in the Chesapeake Bay Watershed. *Journal of the American Water Resources Association* 46(3):473-485

Apr. 5: *UNC Wellness Day (NO CLASS MEETING)*

Part V: Wetland evaluation and mitigation

- Objectives:
- 1) To identify the scientific and political issues involving wetland delineation;
 - 2) To identify how land development threatens wetland functions;
 - 3) To apply a field method to evaluate the functions of wetlands and rate their value;
 - 4) To create a wetland protection strategy.

Apr. 7: *Identification and classification of wetlands and impacts of urbanization*

Required:

Richard Whisnant. 1999. *Wetlands in North Carolina*. Environmental and Conservation Law, Issue 6: 1-9. The University of North Carolina at Chapel Hill, Institute of Government: Chapel Hill, NC.

Tiffany Wright, Jennifer Tomlinson, Tom Schueler, Karen Cappiella, Anne Kitchell, and Dave Hirschman. 2006. *Direct and Indirect Impacts of Urbanization on Wetland Quality*. U.S. Environmental Protection Agency: Washington, D.C.

- See Pages 13-56.

Meiyin Wu, Dennis Kalma, and Carol Treadwell-Steitz. 2014. Differential Assessment of Designations of Wetland Status Using Two Delineation Methods. *Environmental Management* 54: 23-29.

Recommended:

Stacy Small-Lorenz. 2014. Wetlands Do Triple Duty in a Changing Climate. *Water Currents: Blog of the National Geographic Society*.

- Interesting popular writing piece on wetlands and climate mediation.

ACOE. 1987. Corps of Engineers Wetlands Delineation Manual (Technical Report Y-87-1). US Army Corp of Engineers: Washington, D.C.

- Skim, goes into more detail than in-class PowerPoint.

ACOE. 2012. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Eastern Mountains and Piedmont Region (Version 2.0) ERDC/EL TR-12-9. U.S. Army Corps of Engineers: Washington, D.C.

D. Dvoretz, Bidwell, J., Davis, C., and DuBois, C. 2012. Developing a hydrogeomorphic wetland inventory: reclassifying national wetlands inventory polygons in geographic information systems. *Wetlands* 32(1): 83-93.

Apr. 12: *Assessment of wetland functions*

ASSIGNMENT 4 DUE: State of the Watershed report (part II) + GI plan-policy component (5 PM via Sakai Assignments)

Required:

NC Wetland Assessment Method (NCWAM): <http://www.conservation.nc.gov/web/wq/swp/ws/pdu/ncwam-manual>

USEPA. 2013. Wetlands Supplement: Incorporating Wetlands into Watershed Planning. US Environmental Protection Agency (Region 5): Chicago, IL.

- Focus on Pages 1-40.

M. Acreman and J. Holden. 2013. How Wetlands Affect Floods. *Wetlands* 33:773–786.

Recommended:

M. Siobhan Fennessy, Amy D. Jacobs, and Mary E. Kentula. 2004. *Review of rapid methods for assessing wetland condition (EPA/620/R-04/009)*. US Environmental Protection Agency: Washington, DC.

Martha A. Sutula, Eric D. Stein, Joshua N. Collins, A. Elizabeth Fetscher, and Ross Clark. 2006. A practical guide for the development of a wetland assessment method: the California experience. *Journal of the American Water Resources Association* 42(1): 157-175.

Tiffany Wright, Jennifer Tomlinson, Tom Schueler, Karen Cappiella, Anne Kitchell, and Dave Hirschman. 2006. *Direct and Indirect Impacts of Urbanization on Wetland Quality*. U.S. Environmental Protection Agency: Washington, D.C.

- See Pages 1-12

Apr. 14: [VIRTUAL FIELD TRIP] *Wetland field trip* (Guest speaker: TBA, UNC Stormwater Engineer)

Required:

Center for Watershed Protection. 2000. Crafting Better Watershed Protection Plans. *Watershed Protection Techniques* 2(2): 329-337]

Kate A. Brauman, Gretchen C. Daily, T. Ka'eo Duarte, and Harold A. Mooney. 2007. The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrologic Services. *Annual Review of Environmental Resources* 32:67–98

Recommended:

Government of Western Australia. 2007. Guidelines checklist for preparing a wetland management plan. Western Australia Department of Environment and Conservation: Perth, Australia.

- Useful for preparing your wetland plans.

Becky Ward. 2008. Mason Farm Wetland/Floodplain Restoration & Stream/buffer Enhancement Chapel Hill, Orange & Durham Counties, North Carolina: Restoration Plan. NC Ecosystem Enhancement Program: Raleigh, NC

Part VI: Ecosystem restoration and restoration planning

- Objectives:
- 1) Understand the mitigation and restoration process;
 - 2) To understand the legal frameworks supporting restoration;
 - 3) To create an ecological restoration strategy.

Apr. 19, 21: Watershed mitigation and restoration

ASSIGNMENT 5 DUE: Wetland policies and actions component (April 8; 5 PM via Sakai Assignments)

Required:

- Todd K. BenDor and M.W. Doyle. 2010. Planning for Ecosystem Service Markets. *Journal of the American Planning Association* 76 (1): 59–72.
- Palmer Hough and Morgan Robertson. 2009. Mitigation under Section 404 of the Clean Water Act: where it comes from, what it means. *Wetlands Ecology and Management* 17:15–33.

Recommended:

- Kevin L. Erwin. 2009. Wetlands and global climate change: the role of wetland restoration in a changing world. *Wetlands Ecology and management* 17(1): 71-84.
- Young D. Choi. 2004. Theories for ecological restoration in changing environment: Toward 'futuristic' restoration. *Ecological Research* 19: 75–81.
- C. D. Rubec and Hanson, A. R. 2009. Wetland mitigation and compensation: Canadian experience. *Wetlands Ecology and Management* 17(1), 3-14.

Apr. 26: [VIRTUAL FIELD TRIP] *Ecosystem restoration – Battle Grove restoration site* (Guest Speaker: Sally Hoyt, UNC Stormwater Engineer)

Required:

- D. Egan, Hjerpe, E. E., & Abrams, J. 2011. Why people matter in ecological restoration. In: *Human Dimensions of Ecological Restoration* (pp. 1-19). Island Press/Center for Resource Economics: Washington, DC.

Recommended:

- M. Scholz. 2011. Chapter 2: Wetland Case Studies. In: *Wetland Systems*. Pgs. 19-126. Springer: New York.

Apr. 28: *Ecosystem restoration practice and policy*. (Guest Speaker: Adam Riggsbee, Co-Founder/CEO, RiverBank Conservation)

Required (skim):

- Interagency Workgroup on Wetland Restoration. 2003. An Introduction and User's Guide to Wetland Restoration, Creation, and Enhancement. National Oceanic and Atmospheric Administration, US Environmental Protection Agency, US Army Corps of Engineers, US Fish and Wildlife Service, and Natural Resources Conservation Service: Washington, D.C.

- Focus specifically on Pages 4-34, although the entire document is useful.

May 3: Student work day

May 5: Student presentations of Booker Creek Watershed Management Plan

ASSIGNMENT 6 DUE: Full Booker Creek Watershed Management Plan, including ecosystem restoration actions (Friday, May 7th, 5 PM via Sakai Assignments)