Geog/Geol 455/655 Introduction to Remote Sensing/Remote Sensing Principles
2015

Instructor: Dr. Tim Warner

Lecture:	Tuesdays and Thursdays, 1:00-2:15, G25 Brooks					
Laboratory:	Tuesdays (Section 3) or Thursdays (Section 2), 4:00-7:00, Room 420 Brooks Hall					
Office:	341 Brooks Hall	**Telephone:**	304-293-4725	**Email:**	*tim.warner@mail.wvu.edu*	
Office Hours:	Tuesdays: 11:30 -12:30, Thursdays: 8:45 – 9:45, *or by appointment*					
WVU Science Librarian:	Linda Blake	**Telephone:**	304-293-0328	**Email:**	*Linda.Blake@mail.wvu.edu*	
Teaching Assistant:	Aaron Ferrari			**Email:**	*aferrari@mix.wvu.edu*	

Week	**Date**		**Subject**	**Text - pages**	**Assignments**	**Laboratory Exercise**
1	Aug	18	Introduction, What is RS?	1-3, 30-39, 49-52		*No lab*
		20	Information Literacy I (Blake)			
2		25	Library Database Searching I (***Rm104 Library***)			Land use/ Geology Interp
		27	Information Literacy II (Warner)			
3	Sept	1	Library Database Searching II (***Rm 104 Library***)		**1st paper**	Google Earth Interpretation
		3	History of remote sensing	Wickstead & Barber		
4		8	RS System, color theory, EM radiation	12-16, 45-49, 68-72	**2nd paper**	Internet image search
		10	Atmospheric spectral properties	9-12, 23-25		
5		15	Spectral reflectance of earth features	16-25	**3rd paper**	*No lab*
		17	Photography programs ***(+ Quiz 1)***		*Quiz 1*	
6		22	Aerial photography, films & digital cameras	85-136	**4th paper**	Image map creation (ArcMap)
		24	Photogrammetry	146-207		
7		29	Photo-interpretation	59-84	**5th paper**	Intro to Imagine
	Oct	1	***Exam 1 – meet in the computer labs***		*Exam 1*	
8		6	Optical mechanical sensors and digital images	218-242		Import and enhance data
		8	Contrast enhance. *& Brian Raber (Merrick & Co.)*	503-506	**Term paper topic**	
9		13	**Fall Break – No class**			*No lab*
		15	Image georeferencing	495-499	**Plag. tutorial**	
10		20	Satellite-borne sensors	295-384		Image geo-referencing
		22	Lidar	471-484		
11		27	Introduction to classification	537-556		Unsupervised Classification
		29	Classification methods	556-562	**Term paper outline**	
12	Nov	3	Error evaluation ***(+ Quiz 2***)	575-582	*Quiz 2*	Supervised Classification
		5	Image ratios	5173-522		
13		10	RS policy and privacy			Error evaluation
		12	Thermal imagery	4-10, 243-270		
14		17	RS and aesthetics (***WVU Art museum***)			Image ratios
		19	Student Presentations		**Term paper**	
		24	**Thanksgiving break**			(Thanksgiving)
		26	**Thanksgiving break**			
15	Dec	1	Student Presentations			Thermal imagery Chernobyl
		3	Student Presentations			
16		8	Student Presentations			*No lab*
		15	Final exam (Take-home, comprehensive) Due: 5 pm Tuesday, Dec 15			

Method of instruction:

1. Lectures (2 per week)
2. Laboratory exercise (1 per week)
   Students sign up for a **lecture** section and a **lab** section.
   However, only **one grade** is assigned for the course as a whole.
3. Extended written work, including revisions of 5 paper reviews (500 words each) and a major paper (3000 words).

Expected Learning Outcomes:

After completing this course, the student will be expected to be able to:

1. **(Remote sensing skills) Understand the theory of remote sensing and apply those theories to infer information about the earth's surface form remotely sensed data. This requires the student to be able to:**
   a. Use the concept of the remote sensing system to explain the process by which remote sensing approaches can be used to gain information about the earth.
   b. Describe the spectral reflectance properties of major land cover types (vegetation, rocks, soils, snow and clouds), and use this information in image interpretation and analysis.
   c. List the major sources of remote sensing data, and describe their spatial, temporal, spectral and radiometric characteristics.
   d. Describe typical steps and procedures for enhancing, analyzing and classifying images.
   e. Use remote sensing software to undertake basic image enhancement and analysis.
2. **(Information literacy) Understand the context of information resources, use information research tools to obtain information, and summarize scientific concepts and research findings. This requires the student to be able to:**
   a. Understand the process of scholarly information production and the structure of a typical scholarly work.
   b. Use the Web and other multidisciplinary resources to explore the shape and context of a topic.
   c. Develop a manageable thesis statement and formulate questions based on the information need.
   d. Review information retrieval tools used and expand the range of tools to include others as needed.
   e. Follow the conventions for ethical and legal citation of the ideas and works of others.
   f. Use the conventions for reporting scientific and technical material.
   g. Summarize scientific knowledge in written and verbal form in a coherent and structured manner.
   h. Apply critical thinking in reading and writing about scientific concepts.

Internet access: **https://ecampus.wvu.edu/**

Note that the material on this site might not always be available, and should not be your primary source of class information.

Recommended Text: Lillesand, T. W., R. W. Kiefer, and J. W. Chipman, 2015. *Remote Sensing and Image Interpretation*, 7th Edition. John Wiley and Sons, New York, 720pp. (**The fifth or sixth edition is also fine**).

Computer Policies: Please respect our computer labs: ***no food, drink or animals*** in the computer labs.

General Policies:

1. **Class attendance is required**. You should immediately drop this class if you cannot make all class and laboratory sessions.
2. **You must send me an email, call, or give me a written note to let me know for *every* class and/or laboratory exercise you miss. Please also inform the GTA if you miss a lab.**
3. **For every absence or late assignment there is a 1% penalty on your participation/attendance/timeliness of work grade (which is worth a total of 5%).** However, if you let me know in a timely manner about your absence (see #2, above), and you are up to date in all your work, up to 3 absences may be forgiven without penalty.
4. All assignments are due at the start of class unless otherwise stated.
5. All lab assignments are due at the end of the same lab period that the work was done.
6. You should keep current with assigned readings from the text.
7. **For each day that material is late there will be a 25% penalty for that grade**.

8. If you cannot make class, lab, quiz or exam, or turn in homework, contact me in advance of the deadline. If you do miss an exam or quiz without warning, contact me **as soon as possible afterwards**.
9. To pass this class you must complete all assignments. This applies even if the material is so late that no credit is given (see item 4, above).
10. ***Mountaineers do not cheat.*** **WVU has strict policies on cheating. Plagiarism is cheating. See additional information below.**

Academic Integrity Statement

The integrity of the classes offered by any academic institution solidifies the foundation of its mission and cannot be sacrificed to expediency, ignorance, or blatant fraud. Therefore, I will enforce rigorous standards of academic integrity in all aspects and assignments of this course. For the detailed policy of West Virginia University regarding the definitions of acts considered to fall under academic dishonesty and possible ensuing sanctions, please see the *Student Conduct Code* at http://studentlife.wvu.edu/office_of_student_conduct/student_conduct_code. Should you have any questions about possibly improper research citations or references, or any other activity that may be interpreted as an attempt at academic dishonesty, please see me before the assignment is due to discuss the matter.

[adopted by the WVU Faculty Senate: 2-11-08]

Grading Scale:

A: ≥90%+
B: 80-89%
C: 70-79%
D: 60-69%
F: <60%

Grading:

Course component		**%**	**%**
Laboratory exercises			**20**
Exams and quizzes	Exam 1	20	
	Exam 2	20	
	Quiz 1	5	
	Quiz 2	5	
Subtotal – Exams and quizzes			**50**
Paper reviews (5)	Paper reviews	5	
Term paper	Term paper topic & description	1	
	1-page outline	2	
	In-class presentation	2	
	Paper	15	
Subtotal – Reviews and term paper			**25**
Participation/attendance/ timeliness of work			**5**
Total			***100***

Note: Within each grading categories the points awarded are summed, and then scaled to the appropriate percentage.

Grading Rubrics

1. Paper Reviews (10 points maximum)

Grade	Citation	Description of article	Personal evaluation section of report	Grammar, Spelling & Style
10	Follows correct format. Has all information required. Punctuation correct.	Comprehensive summary, excellent paraphrasing of ideas, all key points described, shows insight and depth of understanding.	Student has grappled with article, and made connections to other material (in the course or outside).	Correct, with excellent, *technical English style.* No typographical mistakes (i.e. was proof-read carefully). Style shows strong command of appropriate rhetorical strategies
9	Follows correct format.	Comprehensive summary, key points described	Comments are correct and indicate thought.	Correct grammar and spelling, only occasional mistakes. Well organized, shows evidence of clear thought and good planning
8	Does not follow correct format, has most of the information required.	Relatively comprehensive summary; some sections skipped or not discussed.	Comments are correct, and show a basic understanding	Mostly correct grammar and spelling, but minor mistakes and or colloquial language, above-average work
7	Incomplete	Brief summary; limited understanding, major sections skipped	Perfunctory or shallow comments	Satisfactory work, but , does not demonstrate strengths that indicate an above-average command of technical English, for example, routine structure, inconsistent technical language, or a number of mistakes.
6	Missing	Summary is perfunctory, no understanding shown	Weak	Major problems, for example, communication is hampered by poor language or limited structure.
5 and less	Missing	Weak or missing	Missing	Language is not understandable, incoherent structure, or other issues.

2. Term Paper (100 points maximum)

Grade	Content	Structure	Introduction	Body	Conclusion	References	Grammar & Spelling
100	Comprehensive material. Shows insight. Excellent linkages between ideas	Structure is logical; ideas developed systematically, excellent transitions.	Describes theme of paper and places in context	Develops ideas, goes well-beyond mere summary	Makes connections between papers, draws common themes	Comprehensive, extensive and timely reference list. References support thesis. References correctly formatted	Correct, with good, *technical English style.* No typographical mistakes (i.e. was proof-read carefully). Engaging style.
90	Comprehensive material, key points explained clearly	Structure is logical and well-thought out	Describes themes of paper	Develops ideas, goes well beyond mere summary	Summarizes major content, makes connections, draws contrasts	Comprehensive and extensive reference list. Follows correct format.	Correct grammar and spelling, only occasional mistakes. Above-average command of technical English.
80	Relatively comprehensive material, major points identified and explained	Structure is good	Describes themes of paper	Develops ideas, summarizes major ideas clearly	Summarizes major content	Moderate reference list, mostly follows correct format.	Mostly correct grammar and spelling, but minor mistakes and or colloquial language. Style is above-average
70	Topic is mostly covered, some material poorly developed or not covered	Structure is pedestrian, or confused in places, transitions not well developed	Introduction is limited or poorly connected to the paper's themes	Ideas poorly developed, does not capture range of the topic	Summarizes major content	Limited reference list; Inconsistent or incorrect reference format	Does not use technical language (e.g. extensive use of colloquialisms), mistakes common. Style is satisfactory or weak.
60	Summary is perfunctory, limited understanding shown	Confused structure	Introduction has limited connection to the main themes of the paper	Limited understanding of the ideas, limited development	Perfunctory, or not connected to the paper body	Missing or insufficient information to locate original article	Below-average, has major problems; for example, language is not easily understandable
50 and less	Weak content, limited or no understanding of the material.	Incoherent or no structure	Limited or confused introduction	Major themes not developed, or significant errors	Perfunctory or not connected to the paper body	Missing	Language is not understandable

Note: Any plagiarism in will result in a grade of 0. Additional penalties may apply.

Rubrics continued:

For papers which are evaluated to fall in different grade levels for different categories within the rubric, the final grade will be an average of the individual categories involved.

Inclusivity statement

The West Virginia University community is committed to creating and fostering a positive learning and working environment based on open communication, mutual respect, and inclusion.

If you are a person with a disability and anticipate needing any type of accommodation in order to participate in this class, please advise me and make appropriate arrangements with the Office of Accessibility Services (293-6700). For more information on West Virginia University's Diversity, Equity, and Inclusion initiatives, please see http://diversity.wvu.edu.

Days of Special Concern

WVU recognizes the diversity of its students and the needs of those who absent themselves from class during Days of Special Concern, which are listed in the Schedule of Courses. Students should notify the instructor **by the end of the second week of classes or prior to the first Day of Special Concern**, whichever is earlier, regarding Day of Special Concern observances that will affect their attendance. As the instructor of this course, I will make reasonable accommodation for tests or field trips that a student misses as a result of observing a Day of Special Concern, so long as I am notified in advance as specified above.

Adverse Weather Commitment

In the event of inclement or threatening weather, everyone should use his or her best judgment regarding travel to and from campus. Safety should be the main concern. If you cannot get to class because of adverse weather conditions, you should contact me as soon as possible. Similarly, if I am unable to reach our class location, I will notify you of any cancellation or change as soon as possible, using eCampus or MIX to prevent you from embarking on any unnecessary travel. If you cannot get to class because of weather conditions, I will make allowances relative to required attendance policies, as well as any scheduled tests, quizzes, or other assessments.

Course Philosophy and Overview

Remote sensing is the study of the earth using photographs and images acquired from aircraft and satellites. It is a rapidly changing field, with many different applications. In this course you will gain an overview of the subject of remote sensing, with a special emphasis on principles, limitations and possibilities. In addition, this course emphasizes information literacy, and will develop your skills in finding, evaluating, and using scholarly information.

The course has four parts: lectures, laboratory exercises, critical reviews of published papers, and a term paper. In the lectures you will learn about the interaction of electromagnetic radiation and matter, photo-interpretation and image analysis. In the laboratory exercises you will learn how to use these principles to interpret photographs and how to use a computer to rectify, enhance and classify satellite images. You will learn the power, as well as the limitations, of remote sensing through these exercises. The critical reviews and the term paper are closely linked aspects of the course. The critical reviews are designed to lead you into the term paper, and to build your information literacy skills. The reviews and the term paper emphasize critical thinking and polished, structured writing.

This class emphasizes broad principles, but you need to make the subject personally relevant through exploring a subject of direct interest to you, such as a particular application, remote sensing issue or method. As already mentioned, remote sensing is a rapidly changing field, with much of the current information only available in scientific journals. If you learn how to use library and information resources, to read critically, and learn how to synthesize what you find, you will easily be able to update your knowledge whenever you need to. Such skills will be valuable not just in your student career, but in your future professional career after you leave WVU.

Geog/Geol 455/655
Critical Reviews of Research and Scholarly Papers
Guidelines

Overview

I would like you to hand in each week, for **five weeks**, a short **(500-word),** critical evaluation of a published ***research* or *scholarly* paper** that deals primarily with *remote sensing* or *photo-interpretation*. (GIS papers are not appropriate, unless they deal with remote sensing as a *core* subject.) *Try to avoid conference papers as much as you can*.

The reviews should be geared to helping you choose, and explore, your term paper topic (see the description of the **Term paper**).

Each review must have the follow components:

1. **A *correct* bibliographic citation at the top of the page, which must follow the format of Author, (year). Title, journal (underline the name or use italics), volume and page numbers, *in that order*. If there is a journal issue, it should be in parenthesis after the volume. This is an example:**

Hook, S. J., Gabell, A. R., Green, A. A. and Kealy, P. S., (1992). A comparison of techniques for extracting emissivity information from thermal infrared data for geologic studies. *Remote Sensing of Environment,* **42**(2), 123 - 135.

See additional instructions on format below.
Points will be deducted for incorrect citation format!!

2. A 400-word description of the article and any key points of interest. This should be a critical analysis in which you think about the larger issues involved.
3. A 100-word personal evaluation where you explain how the paper relates to your interest, comment on the significance of the results, and any personal reaction you have to it. A comment such as “I could not understand this paper” is not acceptable - you should skim the paper before you decide to review it, to ensure that you can get the basic gist of it. I*f you cannot understand the paper you should report on a different paper and not that one.*

Your review will be graded on quality of the review and your overall presentation. I expect the work to be well-edited and polished.

How to submit the assignment

Use eCampus – and the TurnItIn tool.

Language style

Your review should use standard scientific language. Scientific language is formal, but not overly stylized or convoluted. **Avoid colloquialisms** (slang or informal speech). Check your spelling. Make sure each sentence is a complete sentence, and has a verb. Review the structure of your paragraphs – the ideas should flow logically. It is a good habit to proofread your work a day later, checking for mistakes. The main description of the article should be dispassionate.

Important: Plagiarism

Now that many journals are available on-line it is possible to actually copy directly from the paper using cut-and-paste. This is cheating. The penalties for cheating are severe. Consult the university code on cheating in the student handbook for more information. **You must use your own words throughout your review.** If you do quote, use quotation marks, followed by an appropriate citation (author, year: page number). For example:

> It has been asserted that high resolution imagery, “ s particularly useful for spatial analysis, but of limited value for spectral analysis.” (Jones, 2002: 438).

However, I would strongly urge you to try not to quote if possible – ***it is much better to use your own words. The norm in scientific scholarly papers is not to use quotations, but instead to paraphrase and summarize material.***

Be particularly careful to avoid what is called “patchwork plagiarism”, which is the building of a new sentence or paragraph from phrases taken from one or more sources.

Critical Thinking

Critical thinking is central to this course, and probably most of your upper division classes. Critical thinking is a process of intellectually engaging your subject matter. Critical thinking involves more than just questioning the information you receive, it involves relating it to your knowledge and experience. **Thus a critical review is not one in which you necessarily find fault with a paper.** In any case, because papers are peer-reviewed they generally do not contain flagrant errors.

The reason why I ask you to do a *critical review*, rather than a *summary*, is that I would like you to engage your subject matter. Ask yourself questions like "what is the general relevance of this information," "how could this information be used?" and “are there practical limitations to the remote sensing approach implicitly advocated in this paper?”

Sources

Your best source will be ***the journals in bold below*.** Don’t forget, though, that often remote sensing papers can be found in journals that have a disciplinary focus (for example, those that focus on geology, ecology, soil science, or archaeology.) **Do not review articles from the popular press**. *Aviation week, GIS World*, etc., are not scientific/scholarly journals. Also, **do not review articles that are not from journals**. If you review an article from an Internet source, be sure to check it is a copy of a journal article. It is an especially bad sign if the article has no reference list or no abstract.

Journal Name	Available Electronically*
Photogrammetric Engineering and Remote Sensing	**Yes**
Geocarto International	**Yes**
International Journal of Remote Sensing	Yes
Remote Sensing Letters	**Yes**
Remote Sensing of the Environment	**Yes**
Canadian Journal of Remote Sensing	Yes
IEEE Transactions on Geoscience and Remote Sensing	Yes
IEEE Transactions on Geoscience and Remote Sensing (Letters)	Yes
IEEE journal of selected topics in applied earth observations and remote sensing	Yes
ISPRS journal of photogrammetry and remote sensing	Yes
The Photogrammetric Record	Yes
Remote Sensing	Open access
Journal of Applied Remote Sensing	**Yes**

* To find WVU Electronic resources, go to http://www.libraries.wvu.edu/, then click on *eJournals*, and do a search on remote sensing

Citation Format
Adapted From: ***Remote Sensing of Environment***

References
References should be cited in the text by the name(s) of the author(s), followed by the year of publication in parentheses, e.g., Baret and Guyot (1991). Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Unpublished results and personal communications are not recommended in the reference list, but may be mentioned in the text. If these references are included in the reference list they should follow the standard reference style of the journal and should include a substitution of the publication date with either "Unpublished results" or "Personal communication". Citation of a reference as "in press" implies that the item has been accepted for publication and a copy of the title page of the relevant article must be submitted.

Reference management software
This journal has standard templates available in key reference management packages EndNote (http://www.endnote.com) and Reference Manager (http://www.refman.com). Using plug-ins to wordprocessing packages, authors only need to select the appropriate journal template when preparing their article and the list of references and citations to these will be formatted according to the journal style which is described below.

Reference style
Text: Citations in the text should follow the referencing style used by the **American Psychological Association**. Details concerning this referencing style can also be found at http://linguistics.byu.edu/faculty/henrichsenl/apa/apa01.html.

Reference List: references should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters "a", "b", "c", etc., placed after the year of publication.

Examples:
Journal:
Baret, F., & Guyot, G. (1991). Potentials and limits of vegetation indices for LAI and APAR assessment. *Remote Sensing of Environment*, 35, 161-173

Book:
Schott, J.R. (1997). *Remote Sensing: The Image Chain Approach*. (pp. 52-62). New York: Oxford University Press

Edited Book:
Kaufman, Y.J. (1989). The atmospheric effect on remote sensing and its corrections. In G. Asrar (Ed.), *Theory and Applications of Optical Remote Sensing* (pp. 336-428). New York: Wiley

Reports, Theses, and Other Work:
Style as a journal article with as much source information as possible.

Web references
As a minimum, the full URL should be given and the date when the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references [should be] included in the reference list.

Source: http://www.elsevier.com/wps/find/journaldescription.cws_home/505733/authorinstructions (last accessed 8/19/2010)

Available online at www.sciencedirect.com
ScienceDirect
Remote Sensing of Environment 112 (2008) 2064–2073
Remote Sensing of Environment
www.elsevier.com/locate/rse

The use of airborne lidar to assess avian species diversity, density, and occurrence in a pine/aspen forest

Rick Clawges [a,*], Kerri Vierling [b], Lee Vierling [c], Eric Rowell [d]

[a] Institute of Atmospheric Sciences, South Dakota School of Mines and Technology, 501 East Saint Joseph Street, Rapid City, SD 57701, USA
[b] University of Idaho, Department of Fish and Wildlife Resources, PO Box 441136, Moscow, ID 83844-1136, USA
[c] University of Idaho, Geospatial Laboratory for Environmental Dynamics, Department of Rangeland Ecology and Management, PO Box 441135, Moscow, ID 83844-1135, USA
[d] The National Center for Landscape Fire Analysis, 32 Campus Drive, University of Montana, Missoula, MT 59812, USA

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Abstract

Vegetation structure is an important factor that influences wildlife-habitat selection, reproduction, and survival. However, field-based measurements of vegetation structure can be time consuming, costly, and difficult to undertake in areas that are remote and/or contain rough terrain. Light detection and ranging (lidar) is an active remote sensing technology that can quantify three-dimensional vegetation structure over large areas and thus holds promise for examining wildlife-habitat relationships. We used discrete-return airborne lidar data acquired over the Black Hills Experimental Forest in South Dakota, USA in combination with field-collected vegetation and bird data to assess the utility of lidar data in quantifying vegetation structural characteristics that relate to avian diversity, density, and occurrence. Indices of foliage height diversity calculated from lidar data were positively and significantly correlated with indices of bird species diversity, with the highest correlations observed when foliage height diversity categories contained proportionally more foliage layers near the forest floor (<5 m). In addition, lidar-derived indices of vegetation volume were significantly correlated with bird density. Using lidar-derived vegetation height data in combination with multispectral IKONOS data, we delineated five general habitat types within the study area according to the presence of prominent vegetation layers at lower levels of the forest and predominant tree type (deciduous or conifer). Habitat type delineations were tested by examining the occurrence and relative density of two bird species common to the study area that prefer lower level vegetation for foraging and nesting. Dark-eyed Juncos were significantly associated with the 0.5–2.0 m high vegetation layer in pine-dominated stands, and Warbling Vireos were significantly associated with this same layer in aspen-dominated stands. These results demonstrate that discrete-return lidar can be an effective tool to remotely quantify vegetation structural attributes important to birds, and may be enhanced when used in combination with spectral data.

Keywords: Lidar; Remote sensing; Diversity; Birds; Spectral; Habitat; Avian; Vegetation structure

1. Introduction

Ecologists have long recognized the importance of vegetation structure in the assessment of wildlife habitat. However, vegetation structure indices developed and used by ecologists are necessarily based upon field vegetation surveys, which can be time consuming, costly, and difficult or dangerous to undertake in areas that are remote and/or contain challenging terrain. Therefore, remote sensing is an attractive alternative to traditional methods used to characterize wildlife habitat (e.g. Hurlbert, 2004; Turner et al., 2003). In particular, discrete-return light detection and ranging (lidar) holds great promise for use by avian ecologists because it is an active remote sensing technology producing fine scale three-dimensional data from which vegetation structural attributes can be derived across broad landscapes (e.g. Lefsky et al., 2002).

* Corresponding author. Institute of Atmospheric Sciences, South Dakota School of Mines and Technology, 501 East Saint Joseph Street, Rapid City, SD 57701, USA.
E-mail address: rclawges@gmail.com (R. Clawges).

0034-4257/$ - see front matter © 2008 Elsevier Inc. All rights reserved.
doi:10.1016/j.rse.2007.08.023

Note the clearly identified abstract above. The correct way to cite this paper is:

Clawges, R., Vierling, K. Vierling, L. and Rowell. E. (2008). The use of airborne lidar to assess avian species diversity, density, and occurrence in a pine/aspen forest. *Remote Sensing of Environment,* 112(5), 2064-2073.

Example review:

Jenny Jones
Remote Sensing 455
September 2 2008

Clawges, R., Vierling, K., Vierling, L., and Rowell, E., (2008). The use of airborne lidar to assess avian species diversity, density, and occurrence in a pine/aspen forest. *Remote Sensing of Environment,* 112(5), 2064-2073.

Clawges et al. (2008) test the ability of discrete return airborne light detection and ranging (lidar) to quantify the three-dimensional structure of pine/aspen forests in South Dakota and correlate this to field- survey based bird species diversity and abundance. They further combine lidar with multispectral IKONOS satellite data to see if the resulting habitat delineations relate to the density and occurrence of dark-eyed juncos and warbling vireos, two common bird species in the area that depend on understory vegetation. Because habitat structure is thought to be a major factor determining habitat suitability for birds and many other organisms but can be difficult or costly to obtain, lidar shows great promise in deriving this key habitat feature remotely and at large spatial scales. The addition of spectral data strengthened the lidar application by providing additional information on habitat composition (i.e. aspen vs. pine as the dominant tree species).

Ground (bare earth) laser returns were first separated from above ground (vegetation) returns in order to create a triangular irregular network (TIN), which was converted to a high resolution 0.25 meter raster representing the ground surface. Another TIN of the same resolution was created for the above ground returns. Subtracting the ground TIN from the vegetation TIN provided a profile of remotely sensed vegetation heights which were used in selecting field sites that were open or with two height classes of understory vegetation (low: 0.5-2.0 meter vs. high: 2.0-9.0 meter dominated). IKONOS imagery further stratified the understory vegetation sites as pine-dominated or aspen-dominated. This resulted in five *a-priori* habitat types within which avian and habitat structure data were collected.

Both indices of field-collected vegetation structure, tree stem density and tree vegetation density, were positively and significantly correlated (r^2=0.51 and r^2=0.68; respectively) with the lidar-derived tree vegetation index.

While correlations between lidar-derived foliage height diversity and bird species diversity were positive and generally significant, r^2 values were small indicating relatively little of the variation in bird species diversity was explained. The lidar derived shrub density index was more strongly correlated, positively and significantly, with the relative density of dark-eyed juncos and warbling vireos, however. Further analysis showed that within the pine-dominated sites dark-eyed juncos were significantly more abundant when the low understory was dominant, while warbling vireos were significantly more abundant in both pine and aspen sites dominated by the low understory.

Personal Evaluation

Lidar seems to remotely sense habitat structure effectively as indicated by the strong correlation to measures of this structure obtained directly. As the authors point out, however, many factors beyond habitat structure may determine bird distributions as evidenced by the weak but significant correlations between structure and a broad measure such as species diversity. The stronger results from the focal species approach they also employ are of greater interest to me. I know from much field experience the effort involved in assessing vegetation structure and composition, and combining the classification of habitat through imagery with the vertical structure data provided by lidar is quite exciting even if it is beyond my capacity at present.

(Note: This example is 388 words for the main part, 114 words for the personal evaluation.)

Geography 455 Term Paper
Guidelines

Term paper:

Topic: Each student should independently write a term paper on an aspect of remote sensing or photo-interpretation. The first step in the paper is to turn in **a title, a one-paragraph description describing the topic of interest, and a list of no less than 4 references** on the specified date. If you cannot think of a topic see me by **before the deadline *(do not wait until the last minute!)*** and I will help you choose one. Note that you will be responsible for finding references on the topic, although I will try to give you what help I can.

Length: The paper should be approximately 3,000 words in length. (Length excludes reference list). Do not exceed 4,500 words. The number of references will depend greatly on the nature of the paper. A typical number might be in the 7-12 range, **with 5 as an absolute minimum.**

Outline &:Complete reference list. Part of presenting an argument is to develop a coherent, logical structure. Once your topic has been approved you should develop a one-page outline *that clearly shows how you will develop your presentation*. The outline will be graded, and must be sufficiently detailed that the essence of your paper is shown. Thus a list such as: Introduction, methods and conclusion, is totally inadequate. The outline needs to be sufficiently detailed that your line of reasoning is quite clear. **You need to outline the specific ideas for each paragraph, and the journal references for those particular ideas. Remember to include a complete reference list, using the appropriate format.**

Grading: The paper will be graded based on content and presentation. You should therefore present a logical, coherent discussion. See grading rubrics earlier in this syllabus.

Plagiarism: Plagiarism is a serious offense. Cite all your sources, and be careful to use quotation marks if you use phrases or sentences that mirror those of your sources. Particularly watch out for "patchwork plagiarism." However, you can re-use material from your paper reviews.

Submission: Please submit your paper through eCampus, using the Turnitin tool. This is a plagiarism-checking program, and will give you and me feedback on the originality of your work.

References: Include a list of references, using a consistent format, such as the one for the paper reviews.

In-class presentation: During the last week of classes, each student will give a 4-minute PowerPoint presentation on the term paper. You may use at most 4 PowerPoint slides. It is essential that you practice your presentation.

Some general comments

1. Aim your paper at a fellow student who has mastered the content of this course. Thus, for example, there is no need to define standard remote sensing terms or concepts such as infrared or pixel.
2. The shortness of this assignment should not be mistaken for an indication that the work should be shallow. It means instead that you must polish your work - there is no room for waffling or vagueness. I expect a compact, in-depth discussion.
3. Don't introduce remote sensing - rather introduce the aspect of remote sensing you are discussing, and why it is important. You can assume the reader is familiar with the basics of remote sensing.
4. Please put page numbers on your pages!
5. Most papers published in journals describe successful experiments. Thus you get the impression that remote sensing can solve every problem. It can't. I expect a critical look at both the advantages and disadvantages with remote sensing as applicable to your paper.
6. You need a focus. This applies to the paper topic itself, and the content. Thus if you discuss remote sensing for urban studies, don't discuss every aspect of all the satellite-borne sensors in the text. However, you might want to discuss the aspects that are relevant to urban studies, such as spatial resolution, historical data archives, spectral response at key wavelengths such as thermal, visible and microwave. By comparison, a geological application discussion would probably focus mainly on the spectral resolution and the nature of the interaction of radiation with rocks.
7. Often there is much uncertainty as to how much depth is required. This partly depends on the topic. If you have a broad topic, such as a survey of applications (e.g. forestry) you obviously cannot achieve the same depth as you would in a paper focusing on a narrower subject, such as remote sensing of pest infestation in forests.
8. A paper topic that is a survey of some aspect of remote sensing will require you to review many papers (and possibly to consult a few texts), whereas a narrow paper topic would almost certainly require you to consult fewer references, though, as discussed above, you

would need to understand them in greater detail. Since the topic requires you to put the subject in a critical context you will need **at least 4** *scholarly or scientific* papers to work from, and preferably more.

9. Scholarly and scientific journals (e.g. *Photogrammetric Engineering and Remote Sensing*) are distinguished from trade magazines (e.g. *GIS World* and *EOM*) by having a complex system of peer-review. Generally, if an article does not have an abstract and a reference list that is a bad sign!
10. The term paper ***must have remote sensing at its core*** - not GIS or any other topic. You could, however, discuss some aspect of GIS and remote sensing (e.g. the integration of remote sensing with GIS.) Furthermore if you discuss a remote sensing application (e.g. using remote sensing to study El Nino), make sure that the bulk of the paper is not the application itself (El Nino in my example), but rather describes how one would use remote sensing to study the application (how does one measure and analyze the phenomena associated with El Nino (e.g. oceanic and atmospheric conditions) using remote sensing?)
11. **Figures and tables** can be useful ways of presenting information. All figures and tables should be numbered, should be given titles (with a reference to their source), and should be cited in the text. (Figures are titled below the figure, tables above the figure.)
12. The strongest papers present a well-thought out overview of a topic, comparing and contrasting the different papers you read. The weakest papers tend to be summaries of individual case studies, with no clear link between the studies. If you do present a number of case studies, be sure to show the links between the studies, and develop a strong concluding section drawing out common or contrasting themes.
13. **Conclusions tend to be the weakest parts of the term papers**. A strong conclusion is not simply a statement that the paper topic is an interesting or important area. You should go back to the specifics of the topics you have covered, and make two or three general comments about the topic that can be inferred from your paper.
14. **References:** Provide a reference list, using the format instructions given for the paper reviews. Be sure to review how to cite (refer to) papers in the text, given in the same instructions.
15. **Remember to check the grading rubrics earlier in this document.**
16. Your **in-class presentation** should use PowerPoint. Save your PowerPoint file to your class account.

Some previous topics

Applied

- Use of thermal infrared imagery for monitoring wildlife
- Identification of geomorphic surfaces based on digital analysis of remotely sensed data
- Remote sensing of forests (or wetlands, or agriculture, or oceans, or bird habitat, etc.)
- Remote sensing of lineaments for groundwater exploration
- Remote sensing of Pluto
- Monitoring environmental hazards using remotely sensed data
- Aerial video: Help or Hindrance to Foresters?
- Studying urban heat islands through remote sensing
- Distinguishing old-growth and mature forests with satellite imagery
- The use of remote sensing technology to assess canopy chemistry
- Remote sensing of humanitarian crises

Theoretical and image processing

- Scale and remote sensing
- Accuracy assessment in remote sensing: A comparison of error matrices and fuzzy sets
- The commercialization of remote sensing: Success or failure?
- An overview of topographic normalization algorithms
- Low cost acquisition of remotely sensed data
- Is remote sensing an invasion of your privacy? Remote sensing and legal issues.