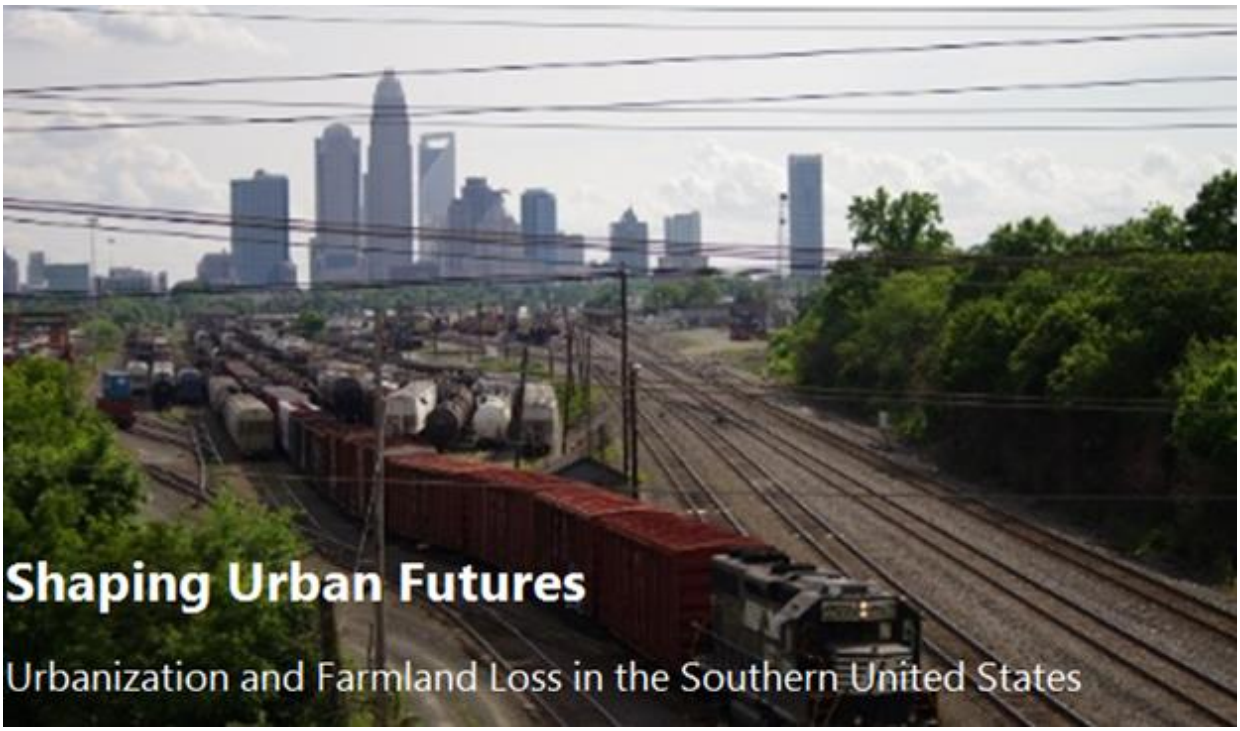

STUDENT HANDOUT

On her commute, the president of *State X's*[*] Farm Bureau comes across a news article in The Guardian that sparks her interest. The article titled "Growing mega-cities will displace vast tracts of farmland by 2030, study says" describes a global study analyzing the effects of urban expansion on farmland loss. While the study mainly focuses on hotspots of farmland loss in Africa and Asia, the Farm Bureau president is concerned about potential loss in her state, since several of the districts border the *XYZ*[*] mega-region and have experienced farmland loss caused by urban sprawl over the past decades. The following day, the Farm Bureau's president approaches the city planners of the mega-region to inquire about their plans to avoid farmland loss and learns that there is currently no strategy in place. During the Farm Bureau's next Board of Directors meeting, the issue of farmland loss is discussed, and the board hires a consulting firm to conduct a study on potential farmland loss caused urbanization in *State X*[*].

You and your group work for Shaping Futures, LLC – a consulting firm that specializes in spatially explicit land-use scenario simulations for policy support. The Farm Bureau of *State X*[*] hired your consulting firm to run simulations, to produce estimates for farmland loss in their megaregion caused by urbanization, and to help develop strategies to reduce said farmland loss. Shaping Futures has experience working on urbanization studies for which they used the FUTURES simulation model. Given the firm's expertise with this

simulation model, they decide early in the process to use FUTURES for the development of urbanization scenarios for the Farm Bureau.

Case Study Objectives:

To fulfill the needs of your customer, your team has to work through the complete process of simulation studies: research the drivers of change, collect and pre-process model inputs, develop feasible scenarios, run the simulations, and communicate the scenario findings to your customers. Make sure to document the process and to work thoroughly as your findings have a direct effect on farmland loss and livelihoods in *State X**.

*To allow for more flexibility, students can choose between different states and mega-regions in the Southern United States.

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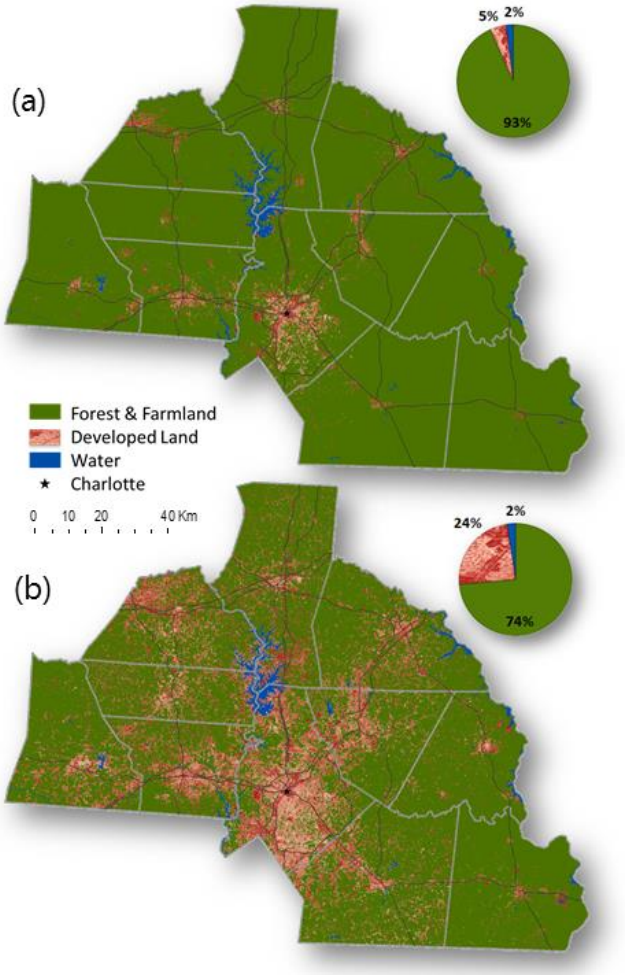

Figure 1. The Charlotte Metropolitan region, located in the Piedmont Atlantic mega-region, is an excellent example for urbanization in the Southern United States. (a) Land use/cover for the year 1986 and (b) land use/cover for the year 2006. Figure adjusted from Meentemeyer et al. (2013).

Evaluation Components:

- Concept map
- Presentation of system and preliminary findings
- FUTURES simulation results
- 2-pages technical report, 1-page policy brief

Required Software:

Following software products and add-ons are required to work on this case study:

- R (≥3.0.2), download available at: https://www.r-project.org/
- GRASS GIS 7, download available at: https://grass.osgeo.org/
- GRASS GIS add-ons:
  - r.futures.pga
  - r.futures.potential
  - r.futures.demand
  - r.futures.devpressure
  - r.sample.category

Case Study Modules:

- Module 1: Conceptualizing Urban Areas as Socio-Ecological System
- Module 2: Analyzing Historic Farmland Loss and Developing Urbanization Scenarios
- Module 3: Analyzing Alternative Urbanization Futures
- Module 4: Communicating Urbanization Findings

Assignment Sheet 1

Module 1 – Conceptualizing Urban Areas as Socio-Ecological System

Summary: This module will introduce you to the concept of mega-regions. You will conduct a literature review and internet search to learn about the factors driving urbanization in a Southern US mega-region of your choice. You will work in a group to discuss your findings and summarize your understanding of the relationships between social and ecological system components leading to urbanization in form of a concept map. In preparation for deliverables of following modules, you will document your progress and conclusions in form of short writing assignments.

Learning Objectives:

- Describe the concept of mega-regions
- Review literature on social and environmental drivers of urbanization
- Discuss the geospatial characteristics of a mega-region of your choice
- Synthesize the findings in a concept map of urbanization

Required Readings:

Before class:

1. Ostrom (2009). A general framework for analyzing sustainability of social-ecological systems. *Science* 325(5939): 419-422.
2. Meentemeyer et al. (2013). FUTURES: multilevel simulations of emerging urban–rural landscape structure using a stochastic patch-growing algorithm. *Annals of the Association of American Geographers* 103(4): 785-807.

During class:

1. "Growing mega-cities will displace vast tracts of farmland by 2030, study says," December 27, 2016, The Guardian. https://www.theguardian.com/environment/world-on-a-plate/2016/dec/28/growing-mega-cities-will-displace-vast-tracts-of-farmland-by-2030-study-says
2. "Seattle Climbs but Austin Sprawls: The Myth of the Return to Cities," May 22, 2017, New York Times. https://www.nytimes.com/2017/05/22/upshot/seattle-climbs-but-austin-sprawls-the-myth-of-the-return-to-cities.html?_r=0

Deliverables:

1. Concept map

Homework:

Read the original research article on urbanization and farmland loss (d'Amour et al. 2016).

In-Class Group Tasks:

Task 1: Urban area - urbanization and resulting farmland loss

Read the two following articles to learn about urbanization, the underlying drivers, and its effect on farmland loss:

1. New York Times:
   - Seattle Climbs but Austin Sprawls: The Myth of the Return to Cities
   - https://www.nytimes.com/2017/05/22/upshot/seattle-climbs-but-austin-sprawls-the-myth-of-the-return-to-cities.html?_r=0
2. The Guardian:
   - Growing mega-cities will displace vast tracts of farmland by 20130, study says
   - https://www.theguardian.com/environment/world-on-a-plate/2016/dec/28/growing-mega-cities-will-displace-vast-tracts-of-farmland-by-2030-study-says

Summarize the key points of each article in a paragraph (circa 150 words each). In a third paragraph, describe how the research presented in the two news articles relates to scenario studies with the FUTURES simulation model (Meentemeyer et al., 2013).

Task 2: Mega-regions – concept and selection

Explore the America 2050 webpage (http://www.america2050.org/megaregions.html) to get acquainted with the mega-region concept. Discuss how a mega-region is defined. Go to the maps section of America 2050 (http://www.america2050.org/maps/) and download two shapefiles – one with the mega-region outlines and one with counties located in mega-regions. Use the shapefiles in combination with your findings from task 1 to select one county in a mega-region located in the Southern US, which is a good fit for a FUTURES study of the impacts of urbanization. Draft a paragraph describing your county selection criteria and justifying your selection.

Task 3: Drivers of urbanization – discussion and concept mapping

To understand the context and socio-ecological setting of the county in the mega-region of your choice, conduct an internet search and quick literature review on the mega-region specific driving forces of change (i.e. which factors lead to variations in the system under study). Draft a paragraph describing the socio-environmental setting and the main factors driving urbanization in your megaregion. Include all county-specific information you can find.

Use your newly gained understanding of the processes in your study area to draft a concept map of the urban system in the county of your choice. To learn more about knowledge mapping in general and concept maps specifically, read through the following

blog entry: https://i2insights.org/2017/03/30/knowledge-mapping-technologies/. Implement your concept map making use of the MentalModeler modeling software, which is available at http://www.mentalmodeler.org/.

Scoring Rubrics:

Following scoring rubric will be used to assess the module's deliverable:

Category\Score	*Weight*	High	Medium	Low
System Components	40%	– Included components are part of the system – Key system components are included – Appropriate level of detail	– Up to two components that were included are not part of the system – Up to two key system components are missing – The concept map is too detailed	– More than two of the included components are not part of the system – More than two of the key system components are missing – The concept map does not include enough detail
Relationships	30%	– All key relationships between system components are included – No incorrect relationships between components are included – All relationships show correct directionalities	– Up to two key relationships between system components are missing – Up to two relationships are displayed for un-related system components – Up to two relationships between system components show incorrect directionality	– More than two key relationships between system components are missing – More than two relationships are displayed for un-related system components – More than two relationships between system components show incorrect directionality
Dynamic Processes	40%	– The concept map includes processes explaining both spatial and temporal dynamics of the system	– Spatial and temporal process explanations are included, but they are incorrect or lack detail	– Only spatial or only temporal process explanations are included – Included explanations are incorrect and lack detail

Assignment Sheet 2

Module 2 – Analyzing Historic Farmland Loss and Developing Urbanization Scenarios

Summary: In this module, you will use geospatial data to analyze historic farmland loss in your study area. Building on your knowledge of the driving forces of change in your selected county, you will develop a feasible scenario and start identifying corresponding FUTURES input data in preparation for simulations of future farmland loss in your study region. You will summarize and communicate your findings from modules 1 and 2 in an oral presentation targeted towards a broad, non-academic audience. Furthermore, you will continue to document your progress and conclusions in form of short writing assignments.

Learning Objectives:

- Analyze historic farmland loss in a county of your choice
- Synthesize social/ecological drivers of urbanization in form of testable scenarios
- Summarize findings and practice communicating them to a non-academic audience

Required Readings:

During class:

1. Dorning et al. (2015). Simulating urbanization scenarios reveals tradeoffs between conservation planning strategies. *Landscape and Urban Planning* 136: 28-39.
2. Environmental Scenario Analysis: http://www.peer.eu/projects/metier-training-courses/course-7-environmental-scenario-analysis/

Deliverables:

1. PowerPoint slides as visual aid for the oral presentation
2. Delivery of the 15-minutes oral presentation

Homework:

Explore different data sources to prepare the quantification of your scenarios in form of FUTURES input data.

In-Class Group Tasks:

Task 1: Install GRASS GIS – using free, open-source GIS software

Visit https://grass.osgeo.org/download/ to get to the GRASS GIS download page. FUTURES is implemented as a GRASS GIS module. Hence, install GRASS GIS to run FUTURES on your computer. Click the field that is appropriate for your computer's operating system (NOT the "… and Addons" or "Source Code" links).

Click the **download (32-bit)** or **download (64-bit)** link, based on your computer and operating system under the current stable section. Wait for the .exe file to finish downloading and double-click on the finish to initiate the installation. Select all available components to install (also the sample datasets).

Task 2: Use GRASS GIS to analyze historic farmland loss

Use GRASS GIS and the National Land Cover Database (NLCD - https://www.mrlc.gov/finddata.php) products for the years 2001 and 2011 to assess areas where farmland was present in 2001 and that are identified as urban area in the 2011 dataset.

Task 3: Development of a (FUTURES) scenario

Based on your findings on the socio-ecological system under study and your FUTURES knowledge, work on the elaboration of a scenario (besides the business-as-usual (BAU) scenario) suitable to explore urbanization in your selected county. Refer to following source to learn more about environmental scenario analysis: http://www.peer.eu/fileadmin/user_upload/opportunities/metier/course7/c7_course_book.pdf.

Revisit Meentemeyer et al. (2013) and consult the materials and methods section of Dorning et al. (2015) to learn more about the required input for FUTURES simulations. Describe, as detailed as possible, the required inputs and model parameters for your scenario. Furthermore, justify why this is an interesting scenario for your customer and the selected mega-region. Document and summarize your scenario and your justification in two paragraphs.

Task 4: Summary and communication of findings

Prepare the contents and slides for a 15-mintues oral presentation. In this presentation, summarize the findings and key points of your findings from modules 1 and 2. Make sure to present your contents in a way appropriate for a non-academic, broad audience. Give the 15-minutes oral presentation.

Scoring Rubrics:

Following scoring rubric will be used to assess the module's deliverables:

Category\Score	*Weight*	High	Medium	Low
Content	50%	– Content is accurate – Content is organized in logical order – Key points are emphasized – Questions are answered correctly	– Presented content has some errors – The general structure is clear, but some content is presented in an illogical order – Most of the key points are clear – Almost all questions are answered correctly	– Presented content has more than two error – Content order is confusing – Key points are unclear – More than two question is answered incorrectly
Visuals	10%	– Appropriate background – Limited number of fonts – Font format and size enhance readability – Graphics support explanations	– The background does not support the content, but is also not distracting – No more than two different fonts are used – Size is only just readable – The majority of the graphics supports the content explanations	– Background reduces readability of content – More than two different fonts are used – Font size is too small – Graphics are not tied to content
Audience	20%	– Presenter maintains audience interest – Content demonstrates awareness of audience interests	– Presenter maintains audience's interest during majority of the presentation – Majority of the content is adjusted to the audience's background	– Content is presented in a monotone voice – Content is not adjusted to the background knowledge of the audience
Delivery	20%	– Eye contact – No obvious use of notes	– Eye contact during the majority of the presentation – Index cards are used for notes	– No eye contact with audience – Letter format notes are used

Assignment Sheet 3

Module 3 – Analyzing Alternative Urbanization Futures

Summary: This module will guide you through the full process of running a FUTURES scenario simulation. First, you will work through the FUTURES tutorial (see below) to better understand the required input data for FUTURES urbanization simulations and to learn about the required data pre-processing steps. You will then transfer your newly acquired knowledge to prepare input data and run urbanization scenario simulations for your study area.

Learning Objectives:

- Research geospatial data in one county in a mega-region of your choice
- Install scientific software and learn how to resolve problems
- Repeat the instructions in the FUTURES GRASS-wiki tutorial
- Discover data files and formats required to run FUTURES simulations
- Identify suitable data sources and pre-process FUTURES input data
- Run FUTURES simulations making use of the input datasets

Required Readings:

During class:

1. FUTURES GRASS-wiki Tutorial: https://grasswiki.osgeo.org/wiki/FUTURES_tutorial

Deliverables:

1. FUTURES scenario input data for one county
2. FUTURES scenario simulation results for one county

Homework:

None

In-Class Group Tasks:

Task 1: Explore FUTURES input files

Visit https://grasswiki.osgeo.org/wiki/FUTURES_tutorial to get the FUTURES tutorial Wiki. **BEFORE** you start working through the tutorial in the next step, go to the "Input data used in this tutorial" section of the Wiki page. Download the sample dataset. Unzip the archive and thoroughly examine the input datasets. Use GRASS GIS to look at the different input files. If you have not worked with GRASS GIS before, look at the "Workflow" section in the FUTURES tutorial Wiki and do a quick online search on GRASS GIS resources. The tutorial lists the data sources for the different input files. Potential data sources are important information to keep in mind for step four.

Task 2: Work through the FUTURES tutorial

Visit https://grasswiki.osgeo.org/wiki/FUTURES_tutorial to get the FUTURES tutorial Wiki. Read the text carefully - not all steps are necessary, and some of the described steps are not carried out in GRASS GIS, but as Python scripts. Carry out the individual steps in GRASS GIS. While working on this, bring up a text editor and copy the GRASS GIS commands into one text file. Save the text file for future reference. This will make your life much easier when you run FUTURES with your county's input data. If you encounter error messages stating that a package is not installed, do the following on the command line:

```
>R
>install.packages("MuMIn")
>install.packages("optparse")
>install.packages("lme4")
>quit()
```

The first command starts the R software in the GRASS GIS environment. Commands two to four install different R packages on your computer. The last command closes the R software and lets you return to the GRASS GIS environment.

Task 3: Download and pre-process the FUTURES input data

In preparation for running futures for your selected county, download the datasets required for FUTURES for your study area. Use GRASS GIS to clip the datasets to the extent of your county. Load all input data into GRASS GIS in order to run FUTURES for your scenario.

Task 4: Run FUTURES scenario simulations

Under step two, you saved all the different commands to run FUTURES in a text file. Bring up that text file. Analyze, which of the statements refer to input data files required to run FUTURES. Adjust the commands to work with your newly created input files. Make sure to

use filenames that have no spaces in them. Also, consider where you stored your input files. You have to ensure that the software knows where your files are located. Once you have all commands and paths adjusted to your newly created input, run FUTURES for your county making use of those commands. After successfully running the simulation, check your output files. Where are they located? How big are they? Also, use GIS software to display the output. Is the output correct?

Scoring Rubrics:

Following scoring rubric will be used to assess the module's deliverables:

Category\Score	*Weight*	High	Medium	Low
Geoprocessing	30%	– Appropriate projection was selected – All datasets are in the same projection – All datasets have the correct format	– The projection is suitable for the larger area, but one with less distortion is available	– Not all datasets are in the same projection – Some datasets have an incorrect format resulting in errors when running the model
Completeness	35%	– Download date and source are documented – All files are organized in a logical file structure – Mnemonic file and folder names were used	– Download date and time documented for majority of data – Majority of files and folders is easy to locate	– Download date and source are not documented for all datasets – Users have difficulties locating files and folders – File and folder names do not indicate the content type
Accuracy	35%	– All datasets are for the same year – All datasets cover the same area	– Datasets cover different years because of data availability (explanation included in metadata)	– Datasets are for different years, even though all of them are available for one year – Area covered differs between datasets resulting in errors when running the model

Assignment Sheet 4

Module 4 – Communicating Urbanization Findings

Summary: In this last module, you will analyze your FUTURES scenario simulation results. You will conduct a GIS analysis to quantify the farmland loss projected under your scenario. Furthermore, you will summarize your findings in a policy brief and document your work in a technical report.

Learning Objectives:

- Carry out a spatial analysis of the FUTURES scenario simulation results
- Prepare a technical report to document the steps of the scenario analysis
- Synthesize the findings of your spatial analysis
- Communicate your findings in form of a policy brief to a non-academic audience

Required Readings:

During class:

1. How do I brief policy makers on science-related issues: http://www.scidev.net/global/communication/practical-guide/how-do-i-brief-policymakers-on-science-related-iss.html

Deliverables:

1. A 2-pages technical report documenting data source, data processing, and scenario analysis
2. A 1-page policy brief

Homework:

None

In-Class Group Tasks:

Task 1: Download farmland raster file

In order to calculate the farmland loss under different urbanization scenarios, download a farmland raster file. Derive potential candidate files from the National Land Cover Database (NLCD) or the National Agricultural Statistics Service (NASS). Both provide raster datasets for different years. Select the dataset and year that is most appropriate for your analysis. Write a paragraph summarizing the justification for your selection. Here are the links to the datasets:

- National Land Cover Database: https://www.mrlc.gov/finddata.php
- National Agricultural Statistics Service: https://www.nass.usda.gov/

Task 2: Overlay simulation output with farmland raster

Use GRASS GIS to overlay the downloaded raster file with the simulated raster files. Use a raster calculator to assess the farmland loss caused by urban expansion, i.e. areas where the map displays urbanization on cells categorized as farmland in the downloaded raster file. Calculate the total area of farmland loss in your study area, making use of GIS functionality and tools. Describe the geoprocessing steps and the results of your analysis in two paragraphs.

Task 3: Write a 2-pages technical report

Write a technical report to document the analysis process for future reference. Start by compiling the text fragments prepared in the previous steps of the case study. Fill in the details in order to provide a thorough documentation of all data source, processing steps, and important decisions carried out during the analysis. Where appropriate, also include Python (or other programming language) code fragments to support your explanations. Include the URL's to all data sources used in the analysis.

Task 4: Write a 1-page policy brief

Summarize the major findings of your analysis as well as the resulting recommendations for your customers in form of a policy brief. Read through example policy briefs, e.g. from the Intergovernmental Panel on Climate Change (Pachauri and Meyer, 2014). This will help you to understand the type of language used in this type of summaries and to understand the required level of detail. Also use following resource to learn more about writing a policy brief:

- How do I brief policy makers on science-related issues: http://www.scidev.net/global/communication/practical-guide/how-do-i-brief-policymakers-on-science-related-iss.html

Scoring Rubrics:

Following scoring rubric will be used to assess the module's deliverables:

Category\Score	*Weight*	High	Medium	Low
Content	25%	– Content of report and brief is correct, detailed, and concise – Important process steps are documented in the technical report – The technical report has all details required to repeat the analysis	– Technical and/or policy brief include some minor inaccuracies – One to two important process steps are missing from the technical report – The technical report lacks some details, but it is still possible to carry out the analysis	– There are several errors in both, the policy brief and the technical report – The documentation of the simulation process is incomplete – Technical report has insufficient detail to repeat the analysis
Accuracy	25%	– Data processing and simulation steps are correctly described – Data sources and download dates are included in the technical report	– There are up to two errors in the description of data processing and simulation – Up to two of the data sources and/or download dates are not included	– There are more than two errors in the description of data processing and simulation – More than two of the data sources and/or download dates are missing in the report
Organization	25%	– Both texts have a clear, logical structure	– One of the two texts has an unclear structure or it is difficult to follow the argument	– The structure of both texts is unclear, it is difficult to follow the argument
Audience	25%	– Policy brief avoids jargon and only highlights crucial points – Clear and simple language is used – Potential solutions are easy to identify – Technical report uses modeling and simulation terminology	– Policy brief makes use of some jargon – Most crucial points are highlighted – Up to two overly long sentences – The majority of potential solutions was clearly communicated	– Policy brief is written making extensive use of jargon and modeling and simulation terminology – Many long sentences are used – Solutions were not clearly communicated

References:

"Growing mega-cities will displace vast tracts of farmland by 2030, study says," December 27, 2016, The Guardian. https://www.theguardian.com/environment/world-on-a-plate/2016/dec/28/growing-mega-cities-will-displace-vast-tracts-of-farmland-by-2030-study-says

"Seattle Climbs but Austin Sprawls: The Myth of the Return to Cities," May 22, 2017, New York Times. https://www.nytimes.com/2017/05/22/upshot/seattle-climbs-but-austin-sprawls-the-myth-of-the-return-to-cities.html?_r=0

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Pachauri, R.K. and Meyer, L. (2014). Climate change 2014 Synthesis Report-Summary for Policymakers. http://ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf

Required Sources:

1. America 2050
   - http://www.america2050.org/megaregions.html
2. Environmental Scenario Analysis
   - http://www.peer.eu/projects/metier-training-courses/course-7-environmental-scenario-analysis/
3. GRASS GIS
   - https://grass.osgeo.org/download/
4. How do I brief policy makers on science-related issues
   - http://www.scidev.net/global/communication/practical-guide/how-do-i-brief-policymakers-on-science-related-iss.html
5. Knowledge Mapping Technologies
   - https://i2insights.org/2017/03/30/knowledge-mapping-technologies/
6. MentalModeler
   - http://www.mentalmodeler.org/
7. National Land Cover Database
   - https://www.mrlc.gov/finddata.php

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