Geography 572

Lab #2: Terrain Representation Challenge

Lab Objectives:

- Design a visually-complex, highly-realistic reference basemap
- Demonstrate your knowledge of terrain representation
- Demonstrate your knowledge of static representations of time & procedural visual cues
- Execute a cartographic workflow across ArcMap, Photoshop, and Illustrator

Evaluation:

This lab is worth **20 points** toward the Lab Assignments evaluation item. A grading rubric is provided at the end of the lab to inform your work.

Schedule of Deliverables:

- **10/5:** Lab #2 Assigned; Route and raster processing in ArcMap
- **10/12:** Lab #2 Photoshop; Intro to Photoshop, land cover processing
- **10/19:** Lab #2 Work Period; Combine raster and vector data in Illustrator
- **10/26:** Lab #2 Due

Challenge Description

You have been hired by Union Cycliste International (UCI) to prepare a promotional map for the newly created International Championship Tour, a road cycling competition to be held every four years as the sport's main showcase. The location of the International Championship Tour will change for each event as a way to promote cycling internationally. You have been hired as both the geographic consultant and the cartographer, and therefore will be both proposing a route for the first event and providing a sample map for displaying the route. The map will serve as the primary reference for the race, and thus needs to be **information dense**. The UCI needs to begin promoting the event on **October 26**.

Notes from UCI

The tour will be completed in 21 day-long stages. The route will cover approximately 100 miles (160 kilometers) per day, varying in length with the terrain and type of course; there must be variation in terrain across the route to include flat and mountainous stages. The route can be discontinuous (see the 2015 Tour de France) and can cross international boundaries. Segments must start and end at populated places. A detailed basemap that includes **terrain, land cover, and place name labels** is required to give fans a sense of the landscape and scenery along the Tour. All waypoints must be labeled, and the map must

include an additional 50 place labels for reference. There are no size restrictions, as the map will be folded when printed and a zoomable PDF when posted online.

1. From Visual Complexity to Terrain Representation

A. Visual Complexity and Intellectual Hierarchy

Visual complexity describes the number and character of elements in the visual scene. As discussed in class, the visual complexity of a map greatly influences how we see it (e.g., Marr's stages of vision) and how we read it (e.g., Bertin's levels of organization). However, even though vision has the greatest sensory bandwidth to the brain, it is not a limitless one. From a graphic design perspective, we often discuss visual complexity in terms of ***information density***, or the number of information elements per unit area of the page.

In Cartography, we handle visual complexity differently when considering thematic mapping versus reference mapping. For thematic mapping—such as your Lab 1 visual story—visual complexity is something that we try to "overcome" through generalization. Thus, your maps and graphics were likely simplified, reduced to a series of bite-sized, immediately understandable graphics. In reference mapping, visual complexity is something that we often try to "achieve" in order to provide as information dense a representation as possible. The purpose of a reference map is to be returned to over and over again as a literal "reference", rather than be a single, clear component in a broader story or atlas. Thus, the goal of reference mapping is to jam-pack the map with information, while establishing a clear visual hierarchy within this information density for as legible of map reading as possible.

B. Realism and Terrain

There is debate in cartography on how "true to life" our reference maps should be to avoid a cognitive disagreement between map and environment. ***Realism*** describes a design approach that attempts to represent the landscape in its exact visual complexity. Realism adds illumination, shadow, and texturing that only serve the purpose of visually relating map symbols to real-world landmarks, and results in many of the most visually stunning and widely celebrated maps as works of art, but also results in many of the more clumsy and computerized visuals when care is not taken in their preparation. Importantly, even realistic maps are generalizations, as they exaggerate and enhance notable characteristics of the real world to create an impossible, yet immediately recognizable and visually complex representation (i.e., ***hyperrealism***).

Realism and hyperrealism are evoked commonly in reference mapping, particularly for ***terrain representation***, or techniques for representing changes in elevation and slope of the

Earth's surface. Numerous techniques have been developed in Cartography to represent terrain, ranging from sugar loafs and hatchures to hypsometric tints and illuminated contours. Each of these methods approaches realism differently (and some, like contours, completely abandon it), attempting to evoke the look and feel of the physical landscape. Because of the artistic skill that goes into realism, terrain representations were among the last techniques automated in modern GIS and mapping technology.

For Lab 2, you will learn how to create a ***shaded relief***, a form of terrain representation that applies an artificial light source to a digital elevation model (***DEM***, or gridded elevation data), creating illumination and shadow on the flat page to give the appearance of three-dimensional terrain features. Shaded relief often is lauded as the most beautiful examples of cartographic design, given its visual complexity, realism, and general aesthetic style. While shaded relief traditionally was hand painted—a shining example of the art in cartography—we now have digital tools that enable us to replicate much of the aesthetic quality (**Figure 1**). To enhance the realism, you also will be draping textures atop the shaded relief designed to mimic land cover.

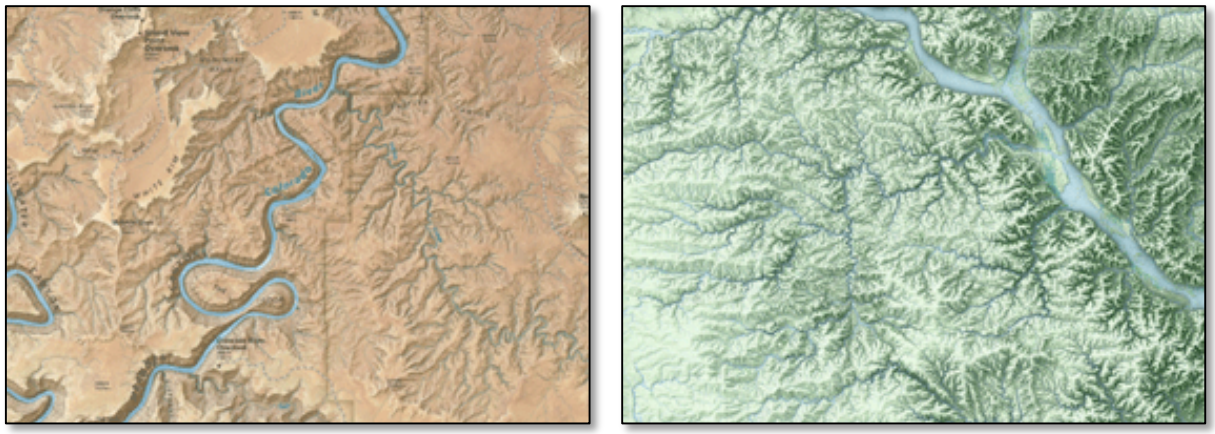

Figure 1: Digitally-provided shaded relief maps by Tom Patterson (left) and Daniel Huffman (right).

As with Lab 1, take some time to get inspired! Some of our favorites include:

- David Rumsey Map Collection: http://www.davidrumsey.com/luna/servlet/view/search/who/Raisz%252C%2BErwin?q=raisz&sort=Pub_List_No_InitialSort
- Shaded Relief: http://www.shadedrelief.com/
- Relief Shading: http://www.reliefshading.com/techniques/
- Terrain Cartography: http://terraincartography.com/
- Something About Maps: https://somethingaboutmaps.wordpress.com/2014/01/01/blender-tutorial/
- Shaded Relief Archive: http://www.shadedreliefarchive.com/

C. Representing Time

Reference maps often are used as navigational devices, and thus at times blend complexity from both realism and time. In lecture, you were introduced to a taxonomy of three static map depictions of time: (1) ***adjacent representations*** (Monmonier's *chess maps*, also described as small multiples), that show multiple time states or intervals individually on separate maps, (2) ***coincident representations*** (Monmonier's *dance maps*) that show multiple time stamps or intervals together on a single map, and (3) ***different representations*** (Monmonier's *change maps*) that show the difference between two time states on a single map. For Lab 2 scenario, you will represent the tour route as a coincident representation, with each segment representing a single time interval. Because the routes are linear map features, you essentially are making a ***network flow map*** representing time.

Network flow maps represent three things: (1) connections between locations, (2) the directionality of movement from origin place to destination place, and (3) the magnitude of flow between directions (**Figure 2**). For Lab 2, you are required to depict the **connection** and **directionality** of each stage. Thus, the temporal sequence of each stage must be represented using numbering, arrows, annotation, etc. While not required, consider how you might use size or color value—or a supplemental graphic—to represent some aspect of magnitude as well.

2. Preparing Your Terrain Representation

A. Working with Raster Data and DEMs

Unlike Lab 1, which focused primarily on vector datasets and statistical information, you will be blending both vector and raster datasets in Lab 2. ***Vector datasets*** represent objects in space, with each object bounded by a set of discrete nodes and arcs. In contrast, ***raster datasets*** represent continuous variation across space, organizing information using a field of interlocking pixels that tessellate the data coverage. Each pixel has a single ***digital number***, enabling representation in a GIS as a gradient. Rather than assigning styles to individual vector objects (e.g., changing sizes, colors, strokes), raster data are symbolized using a color gradient based on the digital numbers and enhanced with a series of filters, masks, and blends. ArcGIS handles vector and raster data equally well, while Adobe Illustrator and Photoshop are dedicated to vector versus raster respectively. Thus, developing an optimal workflow across GIS and graphic design packages is an important skill when working with raster datasets.

For Lab 2, you primarily will work with two raster datasets. First, you will make use of 15 arc minute global DEMs available in Viewfinder Panoramas (Figure 3). In the DEM, each digital number represents the average elevation for the pixel extent. The DEM will be used to create the shaded relief, providing the illumination and shadowing for your highly realistic terrain representation. If you have not worked with raster datasets in the past, it is **highly recommended** that you constrain your route to a single DEM tile from Viewfinder Panoramas to avoid issues with raster mosaics. Talk with Pete and Meghan if you would like to use a different source for your DEM.

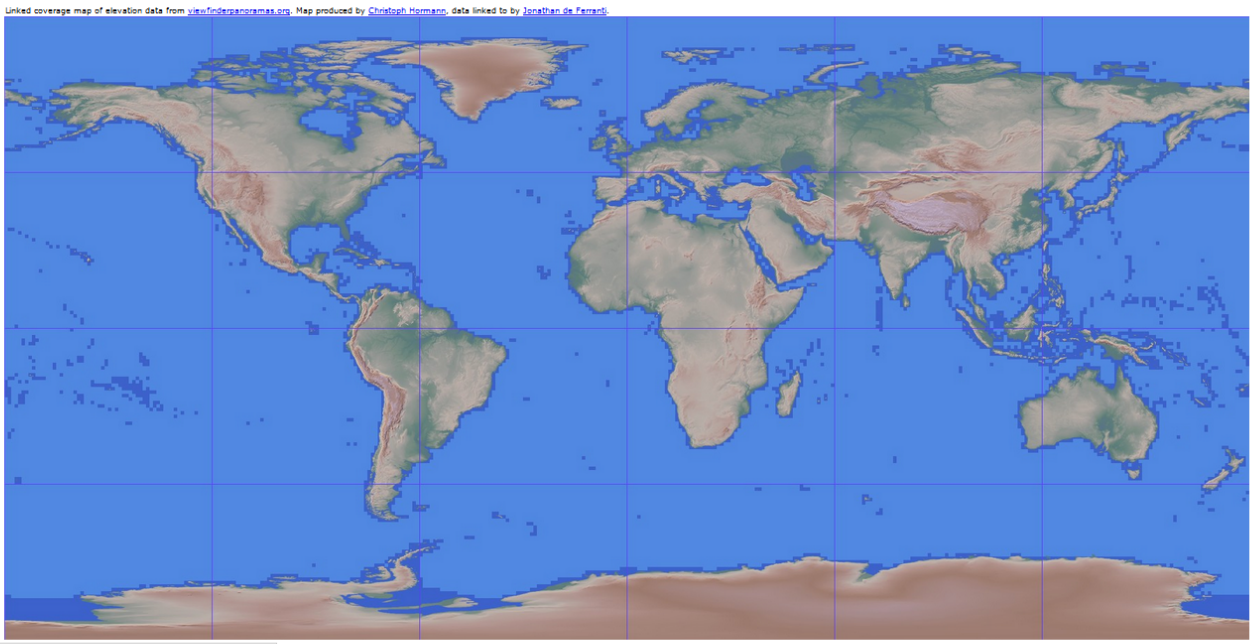

Figure 3: Download your DEM from Viewfinder Panoramas. It is highly recommended that you constrain your route to a single DEM tile from Viewfinder Panoramas to avoid issues with raster mosaics.

You then will match the geographic extent of your DEM with a GLC-Share 1km global dataset produced by the UN Food and Agriculture Organization (*Download→FAO GeoNetwork: WMS and data for download→GLC-Share→Dominant land cover type*). In a ***land cover*** dataset, each digital number represent represents the land cover type that makes up the majority of that pixel. Thus, the digital numbers are numerical, but represent categorical information. While the specific land cover categories you use in your terrain representation may vary based on your route, we recommend reclassifying the raster dataset to include the following categories:

- Artificial surfaces (Cities)
- Cropland
- Grassland + Shrubs
- Tree covered area (i.e., Forest)
- Herbaceous vegetation, aquatic or regularly flooded + Mangroves (i.e., Wetlands)
- Sparse vegetation + Bare soil
- Snow and glaciers

The land cover dataset will be used in Photoshop to bound layer styles mimicking each land cover type, providing the textural component for your highly-realistic terrain representation. Both the DEM and land cover datasets are in the common *.tiff* raster format.

Before exporting your data from ArcMap, **MAKE SURE YOU BOOKMARK YOUR SCALE!**

B. Mapping Your Route

As stated above, the most important vector overlay for Lab #2 is the route itself. While not a comprehensive cartographic or GIS tool, Google My Maps supports quick creation of navigable route of a known distance (Figure 4). It will be much easier to plan your route through the Google My Maps routing service than attempting to extract roads from OpenStreetMap or other sources.

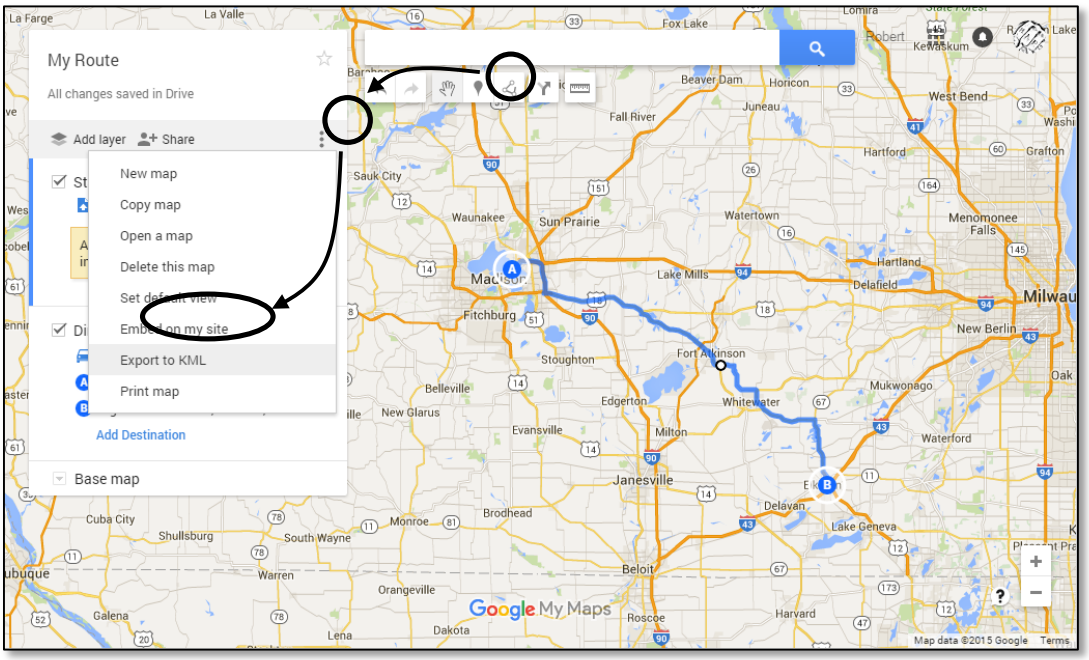

Figure 4: Creating your route in Google My Maps.

When planning your route, take into account the following considerations:

- As stated in the challenge, the tour will be completed in 21 day-long stages, with a day break every 7 stages. The route can be discontinuous, but on break days only.
- The route can cross international boundaries, but, as stated above, should be constrained to a single DEM tile from Viewfinder Panoramas.
- Your map will have a relatively small scale given that each stage will be roughly 100 miles long. Thus, small nuances in the route will not show up in the map.
- To ensure you make a compelling terrain representation, try to navigate the route across flat and mountainous areas, and across different types of land cover.
- Identify waypoints between stages that are populated places.
- A route that doubles-back on itself multiple times will be difficult to represent clearly. However, the route can begin and end at the same location.

The final temporal flow map must include information about the aspects about the route, either through symbolization or annotation:

1. The route segments.
2. The waypoint cities.
3. The sequence of route segments / waypoints.
4. The route directionality (made clear through the sequence of waypoints).
5. The distance between routes.

C. Adding Additional Vector Data

When creating shaded relief digitally, it often is necessary to clarify important features and edges by overlaying vectors. Further, shaded relief typically includes places for context, such as populated cities, political boundaries, and other aspects of the built infrastructure. Use the Natural Earth 1:10 million datasets to collect physical and cultural features to include in your basemap. At a **minimum**, your map must include:

- Relevant political boundaries (e.g., admin0 and admin1);
- Waypoint cities and relevant major cities;
- Bathymetry, lakes, and rivers;
- Major mountain ranges and peaks;
- Other prominent or substantial physical features;
- Glaciers, if within the region (use the Global Land Ice Measurements from Space project to acquire glacier information);
- At least **50 additional base labels** in addition to labels for all segments and waypoints.

D. Finishing Your Terrain Representation with Vectors

The vector layers serve a dual purpose on your map: (1) they clarify edges in the raster, enhancing the realism of the basemap (e.g., coastlines, rivers, etc.) and (2) they provide important context information for the scenario (i.e., directions along the route and sequence of segments). Spend time restyling the vector layers to reinforce the realism, explain the route, and to develop an overall coherent visual style.
The following are a few tips for styling your vectors and finishing your terrain representation:

- Play with the stroke weight until rivers look thin but not overwhelming; remember, you do not need to have rounded point sizes (e.g., 0.6pt may be better than 1pt)! Use rounded caps and corners for a more natural representation of the line.
- Taper the rivers so that they are thinner upstream. To taper the streams, first join them together using the *Join Reasonably* Illustrator script (available here) and then use

Illustrator's *Width Tool* (*Shift+W*) to create a stroke width profile that's wider on one end than the other.

- If your region borders the ocean, change the bathymetry layer colors to light blue for the shallows and dark blue for the deep areas.
- The lakes should have the same color fill as the shallowest bathymetric category.
- Add a coastline that is the same color as rivers to clarify the land-water edge. Consider adding a subtle glow around the lake and water coastlines (*Effect →Stylize*).
- Given the map focus on physical features, push political boundaries and other cultural features lower on the visual hierarchy (e.g., consider using a light stroke to make the appearance that the boundaries are burned into the basemap).
- Review label appearance and placement guidelines from Geography 370. Your label colors should be a similar hue as the features they label (slightly lighter or darker for contrast) and should be placed to promote strong graphic association between label and feature.
- Consider adding halos to labels using the *Appearance Panel* (*Window→Appearance→Add New Stroke* and drag the stroke under the fill).
- Use an opacity mask in Illustrator to hide portions of the shaded relief beneath labels to improve label legibility (*Window→Transparency→Make Mask*)
- Explore solutions for representing the cities that works well with the "Artificial surfaces" land cover class. For instance, you may want to only use symbols for the waypoints, labeling the other cities using the land cover footprint.
- Create a legend for your land cover styles and add other appropriate map elements for the intended audience.

3. Tutorials

The following tutorials can be found on Learn@UW and will help you master the technical and conceptual skills needed to produce a successful project.

1. Getting Started

1.1 Raster Data Resources

1.2 Converting KML to a Feature Class (Google My Maps to ArcMap Workflow)

2. ArcMap

2.1 Working with Raster Files in ArcMap: Stretching, Clipping, and Resampling

2.2 Generating a Hillshade with 3D Analyst

2.3 Processing Land Cover

2.4 Exporting mixed (Raster+Vector) Datasets from ArcMap

3. Photoshop

3.1 Adobe Photoshop Primer

3.2 Masking in Photoshop

3.3 Layer Styling in Photoshop

3.4 Placing a Photoshop File in Illustrator

4. Additional Tips & Tricks

4.1 Additional Tutorials (links to Lynda, youtube, blog posts, and websites)

Raster Data in Arc

Working with DEMs

Hillshades in Arc

Photoshop

Miscellaneous

Tom Patterson website

Blender Tutorial

Evaluation Rubric: Terrain Representation Challenge (25pts)

There will be a data "check in" on October 12.

You must have your raster data (DEM, hillshade, and land cover) and vector data exported from ArcMap by October 12. Raster data should be good to go in Photoshop and vector should be in Illustrator.

Terrain Representation (18)

18-20pts: The hillshade resolution and vertical exaggeration are appropriate for the map scale and scenario. The hillshade has been properly processed to accentuate both broader, regional terrain features (through generalization) and high elevation terrain features (through masking). The land cover has been properly processed to remove water and noise, as to depict a smaller number of categories. The land cover uses a color palette and texture fills that improve the realism of the basemap. The brightness and contrast of the hillshades relative to the land cover works well. The placement and position of labels results in a clear, yet information dense map. Overall, design of the hillshade, land cover, vector layers, and labels are harmonious across the map. This is professional-level cartographic design!

Additionally, the route is complete and properly responds to the challenge. The sequence of segments and waypoints is clearly presented. Required information about major roadways and distances is provided. The route is on the highest level of the visual hierarchy.

16-17pts: The hillshade resolution and vertical exaggeration are appropriate for the map scale and scenario. The hillshade can be reworked slightly to further accentuate broader, regional terrain features (through better generalization) and high elevation terrain features (through better masking). The land cover needs a bit more processing to remove noise in the categories. The land cover color palette and texture fills need to be softened to improve realism. The hillshades are a bit too stark against the land cover, resulting in dark shadows. Several labels or label groups need to be restyled and repositioned. Overall, design of the hillshade, land cover, vector layers, and labels is good, but could use a few tweaks before publishing the map.

Additionally, the route is complete, but perhaps could have responded to the challenge better with some design changes. One or several segments in the route sequence are unclear. A bit more information about major roadways and distances is needed for context. The route is on the highest level of the visual hierarchy.

14–15pts: The hillshade has several good elements, but either the resolution appears too coarse on the map or the vertical exaggeration is too extreme. The hillshade is too detailed and does not appear generalized or masked in any way. The land cover has too much noise and does not appear to be generalized in any way. The land cover palette and texture fills need to be fundamentally redesigned to promote realism. Labeling is insufficient or poorly applied. Overall, much more work is needed to develop realism and information complexity across the hillshade, land cover, vector layers, and labels.

Additionally, we need to rethink aspects of the route and temporal flow map design to better fit the scenario. The sequence of segments and waypoints is not clear from the design solution. There is minimal information about major roadways and distances between waypoints. The shaded relief competes for attention with the route in the visual hierarchy.

13pts or below: The submitted shaded relief did not meet the expectations of the assigned challenge in multiple and critical ways. Please speak with Pete and Meghan about strategies to improve the design.

The temporal flow map did not meet the expectations of the assigned challenge, or was not included in the map at all.