Climate Visualization for Natural Resources

Project Requirements and Specifications

Center for Sustaining Agriculture and Natural Resources

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I. Introduction

The Center for Sustaining Agriculture and Natural Resources (CSANR) [1] has requested a web-based tool for aiding sustainable practices of agriculture in the face of climate change. The primary user group is agricultural professionals of the United States who advise agricultural producers on crop and livestock selection, growing and rearing practices, and pest management.

In 2016, a design team delivered one feature toward development of the decision tool. During the 2017-18 academic year, a second design team is undertaking development of an additional feature.

This design project aims to build a feature that shows through data visualization how climate change impacts land used for cattle production. The feature comprises a map of the United States and a series of graphs. The map visualizes data on a large spatial scale and the graphs visualize data on a smaller, aggregated spatial scale.

The data contains values for a set of environmental factors over decades at locations across the United States. The values range over time from the past to the future, where future values have been forecast by computational models of climate. The data was curated by the US Department of Agriculture, Forest Service, and has been reported in a peer-reviewed publication [2].

The outcome of the design project is delivery of one feature for extension of a web-based decision tool. The feature, hereafter called Rangelands, visualizes climate change on lands in the United States and will be made available to the public at no cost.

This document contains four additional sections and an appendix:

Section II presents use cases, functional requirements, and nonfunctional requirements of Rangelands
Section III presents forward-looking design choices that enable Rangelands to visualize climate for years to come with minimal code modification
Section IV presents a glossary of specialized terms
Section V presents references
The *Appendix* presents mockups of screenshots of Rangelands

II. System Requirements Specification

II.1. Use Cases

Use Case Name	Seeking general information on general area
Participating Actor	Citizen
Flow of Events	1. User selects county of interest 3. User selects indicators and climate models they are concerned with or can view all 2. Software directs user to another page where they are presented with information for the selected location
Entry Condition	User must select specific area to view information.

Related Requirements	Indicators, Climate Models, Map, Module Data View Page

Use Case Name	Seeking information on specific area
Participating Actor	Agricultural Professional
Flow of Events	1. User selects data point or county that they are concerned with. 2. User may select indicators and climate models they are concerned with or view all. 3. Software directs user to another page where they are presented with desired information.
Entry Condition	User must select specific data point or county to view information.
Related Requirements	Indicators, Climate Models, Map, Module Data View Page

Use Case Name	Seeking general information on specific area
Participating Actor	Politician
Flow of Events	1. User selects county or congressional district of interest 3. User selects indicators and climate models they are concerned with or can view all. 2. Software directs user to another page where they are presented with information for the selected location.
Entry Condition	User must select specific area to view information.
Related Requirements	Indicators, Climate Models, Map, Module Data View Page

II.2. Functional Requirements

Rangelands shall orient the user to region of interest with a map on the splash page, provide data categories to query on a drop-down menu, and display responses to queries on multiple data view pages.

II.2.1. Module: Splash page

Map: The splash page shall display a centered map of the mainland United States
- Source: The client requested that Rangelands display a map of the United States. Other features display a map and the client wants consistency among features.
- Priority: Level 1. This requirement is essential.

Zoom: The map shall zoom in and zoom out
- Source: The client requested that Rangelands support zoom like other features.
- Priority: Level 2. This requirement is desirable.

Data Points: The map shall display discrete data points as pins
- Source: The client requested that Rangelands display mapped data using a similar convention as other features.
- Priority: Level 2. This requirement is desirable.

Color-coded Data: The data shall be coded by color to indicate magnitude of values

- Source: The client requested that Rangelands code mapped data values by color.
- Priority: Level 2. This requirement is desirable.

Legend: The map shall have a legend
- Source: The client requested that the map have a legend to clearly express the data color scheme.
- Priority: Level 2. This requirement is desirable.

II.2.2. Module: Drop-down menu

Indicators: The drop-down menu shall include options for the user to select climate change indicators
- Source: The client requested that Rangelands have a drop-down option for the user to select indicator.
- Priority: Level 1. This requirement is essential.

Boundaries: The drop-down menu shall include an option to show county or congressional boundaries.
- Source: The client requested that Rangelands have a drop-down option for the user to select map boundary. It is important to some of our stakeholders (politicians) to be able to get information by county or congressional district.
- Priority: Level 2. This requirement is desirable.

Overlay: The drop-down menu shall include an option to change the overlay on the map (satellite/map/hybrid).
- Source: The client requested that Rangelands have a drop-down option for the user to select map overlay. Supporting different overlays is desirable in satisfying different users. For example, an agriculture professional might want to see the satellite view while a politician might want another view.
- Priority: Level 3. This requirement is extra.

Climate Models: The drop-down menu shall include an option to select from among multiple climate models
- Source: The client requested that Rangelands have a drop-down option for the user to select climate model. There are up to four different climate models. Some users might want to view one model and others several.
- Priority: Level 1. This requirement is essential.

Time Period: The drop-down menu shall include an option to modify the time period of concern for a climate model.
- Source: The client requested that Rangelands have a drop-down option for the user to select time period. The time period of concern is a significant source of information for the stakeholders.
- Priority: Level 2. This requirement is desirable.

II.2.3. Module: Data view page

Net Primary Production: The data view page shall display information on the net primary production climate change indicator.
- Source: The client requested that Rangelands display net primary production. This climate change indicator is one of the main pieces of information that our stakeholders seek.
- Priority: Level 1. This requirement is essential.

Interannual Forage Variability: The data view page shall display information on the interannual forage variability climate change indicator.
- Source: The client requested that Rangelands display forage variability. This climate change indicator is one of the main pieces of information that our stakeholders seek.
- Priority: Level 1. This requirement is essential.

Heat Stress: The data view page shall display information on the heat stress climate change indicator.
- Source: The client requested that Rangelands display physiologic heat stress on cattle. This climate change indicator is one of the main pieces of information that our stakeholders seek.
- Priority: Level 1. This requirement is essential.

Relative Fraction of Woody vs Herbaceous Plants: The data view page shall display information on the relative fraction of woody plants as compared to herbaceous plants climate change indicator.
- Source: The client requested that Rangelands display inedible to edible forage. This climate change indicator is one of the main pieces of information that our stakeholders seek.
- Priority: Level 1. This requirement is essential.

Aggregate: The data view page shall display information on an aggregate of all the climate change indicators.
- Source: The client requested that Rangelands display an average of all indicators. While some of our stakeholders may be concerned with only one or two climate change indicators, many will be concerned with all of them. The aggregate is a great tool to get a look at all of them together and get a feel for the big picture.
- Priority: Level 1. This requirement is essential.

II.3. Non-Functional Requirements

II.3.1. Quality requirements

User help: The client requested that the design team produce a user guide in the form of a video

Browser compatibility: The client requested that Rangelands be consistent among the current updates of the three most popular web browsers: Chrome, Safari, and Internet Explorer

Scaling: The client requested that visualizations scale to screen size

Resolution: The client requested that visualizations display without pixelation at 1280 x 720 resolution

Colors and font: The client requested that color schemes and font be consistent from page to page and most closely match other features

Indicator descriptions: The client requested that descriptions of climate indicators appear on data view pages

Performance: The client requested that load times of data view pages not exceed 30 seconds

Storage: The client has acknowledged that there is a tradeoff between performance and storage and requested that storage not exceed provided data size by more than a factor of three

II.3.2. Implementation constraints

Shiny: The client requested that web application development use this open-source R package

Leaflet: The client requested that interactive maps use this open-source JavaScript library

File formats: The client requested that data files be easily converted between GeoTIFF and CSV formats

License: The client requested that Rangelands be freely used, modified, and shared

III. System Evolution

This design project aims to build the Rangelands feature as a component of a web-based tool that aids planning in agriculture. Rangelands informs and educates users on the effects of climate change on the environment. It draws on climate models to produce maps and graphs that visualize environmental variables in time and space. The models that underlie data change; so, too, does the data. Rangelands shall incorporate design choices that disassociate data and code. With minimal code modification, Rangelands shall evolve as data evolves. Rangelands shall accommodate data updates and changes to data parameters such as number of climate models, indicators, and time periods.

Rangelands aggregates data by boundary selection for graphical display of indicators. One boundary option is congressional district, which is subject to change every decade. Rangelands shall aggregate data by congressional district with the foresight that district boundaries change.

Rangelands is a web application displayed by a browser on a screen. As browsers update, Rangelands shall continue to provide a consistent user experience. As screen resolutions increase in density, Rangelands shall maintain the quality of its visualizations.

The design team shall make choices that enable Rangelands to visualize climate for years to come with minimal code modification.

IV. Glossary

Agriculture Professional - Crop consultant who advises on crop choices or university extension staff member that advises on best practices

Net Primary Productivity - The amount of carbon uptake after subtracting Plant Respiration (RES) from Gross Primary Productivity (GPP). GPP is the total rate at which the ecosystem capture and store carbon as plant biomass, for a given length of time

Interannual Variability - Value describing the interannual standard deviation in annual average forage quantity for a region

Heat Stress - Negative effects on cattle due to higher than usual temperatures

Relative Fraction of Woody vs Herbaceous Plants - Ratio of inedible to edible plants

Leaflet - Open-source JavaScript library for interactive maps

Rangeland - Open country used for grazing or hunting animals

Shiny - An open-source R package that provides an elegant and powerful web framework for building web applications using R

V. References

[1] CSANR. (2017). *Center for Sustaining Agriculture and Natural Resources* [Online]. Available: http://csanr.wsu.edu

[2] M. C. Reeves, K. E. Bagne, J. Tanaka, "Potential Climate Change Impacts on Four Biophysical Indicators of Cattle Production from Western US Rangelands," *Rangeland Ecology & Management*, vol. 70, pp.529-539.