Global Vegetation Project
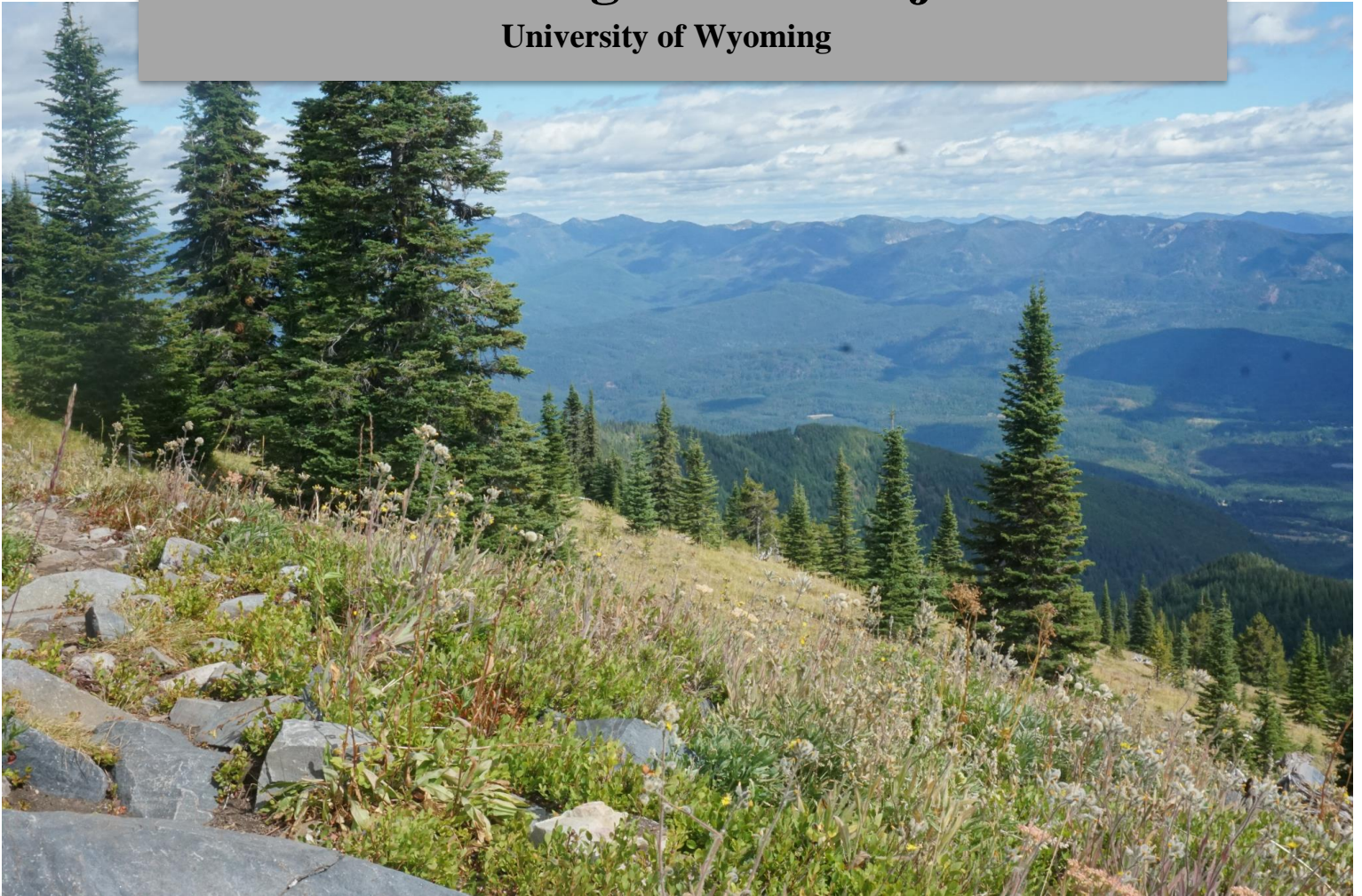
University of Wyoming

USER GUIDE:

For Educators and Community Scientists
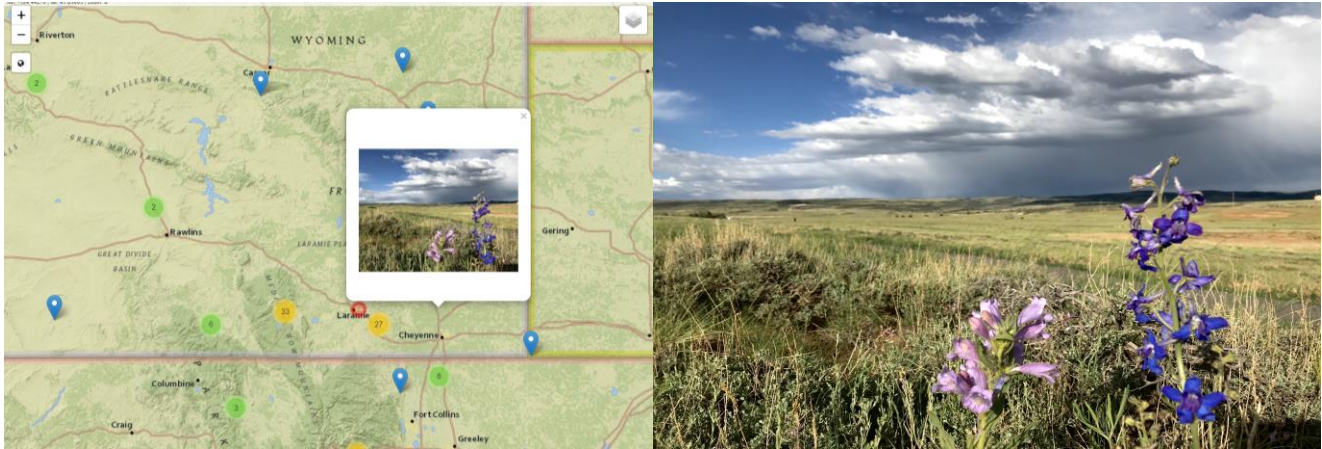
October 2021

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Global Vegetation Project User Guide

The Global Vegetation Project map displaying a photo point of a mixed grass prairie from the project's home base of Laramie, WY.

Our Mission and Vision

The mission of the Global Vegetation Project is to inspire and empower people of all ages to learn about the diversity of vegetation on our planet and to provide educators with a resource for teaching online. With the help of user submitted photos, location information, and vegetation information, we have developed an interactive biogeographical map where "travelers" can virtually navigate to points to explore vegetation types and the associated climate. Users can also filter photo points by temperature, precipitation, elevation, or biome, which expands the ways that phenomena can be observed and analyzed.

The User Interface

Our website has four navigation tabs:
- **Home:** Here you can learn more about our mission and vision and watch a short video about the interactive map. We also share articles about the project here.
- **About:** Dig deeper into the project goals and meet our staff and partners.
- **Photo Submission:** Contribute your own photos to the GVeg map. You will need a vegetation photo, the vegetation type, the photographer's name, photo coordinates, and a short list of dominant species. Bulk upload forms available upon request, email global.vegetation@gmail.com.
- **Explore Vegetation:** Open the interactive map of community-sourced vegetation photos with interactive layers, climate diagrams, and search filters.

Exploring Vegetation

It is recommended that you open the interactive application before continuing on. There is a visual guide for the map interface located at the end of this section.

1. Navigation
    a. The Explore vegetation tab opens up the interactive map of community-sourced vegetation photos.
    b. You can click and drag the map to navigate, zoom with the mouse/touchpad or +/- buttons in the upper left hand corner, and click the globe icon in the upper left hand corner to zoom out to the full map extent.
    c. Clusters of vegetation photo points are displayed across the map. The numbers displayed indicate the number of photos in the regional cluster. Zoom in to view individual photos.
2. Map Layers
    a. Click the layer icon in the upper right hand corner of the map to open layer options. Check the layers you want to toggle or turn on.
    b. Layer options:
        i. **Aerial:** Change the map to satellite imagery
        ii. **Map:** Change the map to the National Geographic style map
        iii. **Temperature:** display a colored map of yearly average temperatures (°C)
        iv. **Precipitation:** display a colored map of yearly average precipitation (mm)
        v. **Elevation:** display a shaded relief map of elevation (m)
        vi. **Aridity:** display a shaded map of aridity indices (mean annual precip/potential evapotranspiration) where lower values indicate higher aridity (0-10 scale)
        vii. **Biomes:** displays biome ranges as defined by Ellis et al. 2010
        viii. **Ecoregions:** displays ecoregion ranges as defined by Dinerstein et al. 2017
3. Tab: Photo
    a. Clicking on a blue photo point opens a photo pop-up and loads associated information into the photo tab on the right side of the application.
    b. The bold name at the top of the photo tab is the user classified vegetation type. Below is the biome as defined by Ellis et al. 2010.
    c. Associated information fields:
        i. **Photographer name** and **submission date** below the photo
        ii. Link to larger **high resolution photo** (will open in a new window)
        iii. **Location:** photo location

iv. **Ecoregion:** ecoregion as defined by [Dinerstein et al. 2017](#)

v. **Dominant species:** photographer submitted list of dominant species at the location, links connect to the iNaturalist page for each species

vi. **Comments:** photographer submitted comments about the location

vii. **Naturalness:** photographer defined level of naturalness (anthropogenic, natural, or semi-natural)

viii. **Vegetation classification system:** the system used to determine the vegetation type at the location

ix. **Articles:** photographer submitted information on journal articles, websites, or other publications associated with the photo

x. **URL to this photo:** A unique URL that can be extracted to link directly to the individual photo point. Useful for educators looking to establish examples of phenomena.

4. Tab: Climate Diagrams
   a. This tab opens up climate information associated with each selected point.
   b. **Walter and Lieth diagram:** summarize average climatic conditions for a location over a specific period of time. Users can select "Historic" or "Recent" to change the time period displayed. See "Interpreting Walter and Lieth Climate Diagrams" for more information. All units are displayed in metric values.
   c. **Whittaker biome diagram:** place photo points onto a graph of Whittaker's biome classifications based on average regional temperature and precipitation. Biome names are displayed upon hover.

5. Tab: Filters
   a. This tab opens up several filter options which constrain the points displayed on the map based on one or more parameters.
   b. Sliding filters: move sliders from either end to constrain the minimum and maximum range of values for each parameter. Users can constrain some or all parameters at once.
      i. **Mean Annual Precipitation (mm/yr)**
      ii. **Mean Annual Temperature (°C)**
      iii. **Elevation (m)**
   c. **Biome drop-down:** select any number of biomes for which points should be displayed. Select all or deselect all can be used to speed the process.

6. Extracting Data
   a. There are multiple ways that users can extract both qualitative and quantitative data to support teaching and learning. Here are a few suggestions.
   b. Qualitative Data:

i. **Openness:** portion of the canopy (top layer of vegetation, e.g. tree tops) not obscured by vegetation
ii. **Cover:** portion of the ground covered by all vegetation or vegetation of certain types such as functional groups
iii. **Functional groups:** sets of species with similar environmental adaptations and ecosystem roles; including but not limited to shrubs, cacti/succulents, grasses, non-woody flowering plants (forbs), deciduous trees, and coniferous trees
iv. **Biomes and ecoregions:** determine the local biome and ecoregion from the associated photo data, Whittaker biome diagram, and map layers

c. Quantitative Data:
   i. **Historic and recent average monthly and yearly temperature:** extract from Walter and Lieth diagrams, precipitation and temperature layers
   ii. **Historic and recent average monthly and yearly precipitation:** extract from Walter and Lieth diagrams, precipitation and temperature layers
   iii. **Regional and local elevation:** extract from Walter and Lieth diagrams, elevation layer
   iv. **Regional and local aridity:** extract from aridity layer

User Interface Visual Guide

Photo Submission

1. Requirements
    a. Users are encouraged to submit their own photos to grow the interactive map. The most useful contributions will include a high quality photo of vegetation with no people or domestic animals pictured. Photos should be landscape (i.e. not a close up shot of individual species) with as many clear and distinguishable plants as possible.
    b. Bulk upload forms available upon request, email global.vegetation@gmail.com.
    c. All of the following required fields must be filled for submission.
    d. **Images:** browse computer files to upload JPEG, PNG, or RAW image files
    e. **Full Name:** photographer credit
    f. **Latitude and Longitude:** enter coordinates as accurately as possible. Users can drop a pin on the map display (satellite or general reference) to automatically fill these fields.
    g. **Species list:** Manually enter the botanical Latin name of species found at the site or select from the list. At least one dominant species must be listed but more are encouraged if known. Listed species will be linked to iNaturalist pages.
2. Optional Fields
    a. **Observation date:** date the photo was taken
    b. **Email address:** remains confidential, allows Gveg admin to contact if there are questions about the submission
    c. **Associated publication DOI:** link to share research associated with the photo
    d. **Place name:** location the photo was taken, helps viewers to better understand the geography of the area
    e. **Landscape naturalness:** user defined category representing the level of human disturbance at the site
    f. **Vegetation type:** user defined vegetation classification using any system, highly increases the value of the photo to scientific and educational exploration of the map
    g. **Vegetation classification system:** classification system selected by the user to determine vegetation type

3. Licensing and Data Storage
   a. By submitting your photos, you agree to 1) provide the Global Vegetation Project/Biodiversity Institute/UWyo a CC-BY-NC-SA 4.0 license and 2) your images will be 'sub-licensed' by us to end-users (educators) under the same license. Please do not submit any content that could be considered irrelevant, illegal, or harmful.
   b. Each user submission (image and image attributes) is stored within a Microsoft SQL Server relational database and our associated cloud file storage server for at least 15 days. Validated submissions are stored at the Advanced Research Computing Center (ARCC) at the University of Wyoming.
4. Data Sources and Software References
   a. Data Sources:
      i. Dinerstein, E., D. Olson, A. Joshi, C. Vynne, N. D. Burgess, E. Wikramanayake, N. Hahn, S. Palminteri, P. Hedao, R. Noss, M. Hansen, H. Locke, E. C. Ellis, B. Jones, C. V. Barber, R. Hayes, C. Kormos, V. Martin, E. Crist, W. Sechrest, L. Price, J. E. M. Baillie, D. Weeden, K. Suckling, C. Davis, N. Sizer, R. Moore, D. Thau, T. Birch, P. Potapov, S. Turubanova, A. Tyukavina, N. de Souza, L. Pintea, J. C. Brito, O. A. Llewellyn, A. G. Miller, A. Patzelt, S. A. Ghazanfar, J. Timberlake, H. Klöser, Y. Shennan-Farpón, R. Kindt, J.-P. B. Lillesø, P. van Breugel, L. Graudal, M. Voge, K. F. Al-Shammari, and M. Saleem. 2017. An Ecoregion-Based Approach to Protecting Half the Terrestrial Realm. BioScience 67:534–545.
      ii. Fick, S.E. and R.J. Hijmans. 2017. WorldClim 2: new 1km spatial resolution climate surfaces for global land areas. International Journal of Climatology 37 (12): 4302-4315.
      iii. Harris, I., P.D. Jones, T.J. Osborn, and D.H. Lister. 2014. Updated high-resolution grids of monthly climatic observations - the CRU TS3.10 Dataset. International Journal of Climatology 34, 623-642.
      iv. Karger, D.N., Conrad, O., Böhner, J., Kawohl, T., Kreft, H., Soria-Auza, R.W., Zimmermann, N.E., Linder, H.P. & Kessler, M. (2017) Climatologies at high resolution for the earth's land surface areas. Scientific Data 4, 170122.
      v. Trabucco, A., and Zomer, R.J. 2018. Global Aridity Index and Potential Evapo-Transpiration (ET0) Climate Database v2. CGIAR Consortium for Spatial Information (CGIAR-CSI).
   b. Software References:
      i. Appelhans, T., F. Detsch, C. Reudenbach, and S. Woellauer. 2020. mapview: Interactive Viewing of Spatial Data in R.

ii. Bivand, R., T. Keitt, and B. Rowlingson. 2019. rgdal: Bindings for the Geospatial Data Abstraction Library.

iii. Bivand, R., and N. Lewin-Koh. 2019. maptools: Tools for Handling Spatial Objects.

iv. Chang, W., J. Cheng, J. J. Allaire, Y. Xie, and J. McPherson. 2019. shiny: Web Application Framework for R.

v. Cheng, J., B. Karambelkar, and Y. Xie. 2019. leaflet: Create Interactive Web Maps with the JavaScript Leaflet Library.

vi. Dowle, M., and A. Srinivasan. 2019. data.table: Extension of `data.frame`.

vii. Guijarro JA (2019) climatol: Climate Tools (Series Homogenization and Derived Products)

viii. Henry, L., and H. Wickham. 2019. purrr: Functional Programming Tools.

ix. Hijmans, R. J. 2019. raster: Geographic Data Analysis and Modeling.

x. Müller, K., and H. Wickham. 2019. tibble: Simple Data Frames.

xi. Ooms, J. 2020. jsonlite: A Robust, High Performance JSON Parser and Generator for R.

xii. Pebesma, E. 2019. sf: Simple Features for R.

xiii. Pebesma, E., and R. Bivand. 2018. sp: Classes and Methods for Spatial Data.

xiv. R Core Team. 2020. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

xv. Ross, N. 2018. fasterize: Fast Polygon to Raster Conversion.

xvi. Stefan, V., and S. Levin. 2017. plotbiomes: Plotting Whittaker' biomes.

xvii. Wickham, H. 2017. tidyverse: Easily Install and Load the Tidyverse.

xviii. Wickham, H. 2019a. forcats: Tools for Working with Categorical Variables (Factors).

xix. Wickham, H. 2019b. httr: Tools for Working with URLs and HTTP.

xx. Wickham, H. 2019c. stringr: Simple, Consistent Wrappers for Common String Operations.

xxi. Wickham, H., W. Chang, L. Henry, T. L. Pedersen, K. Takahashi, C. Wilke, K. Woo, and H. Yutani. 2019a. ggplot2: Create Elegant Data Visualisations Using the Grammar of Graphics.

xxii. Wickham, H., R. François, L. Henry, and K. Müller. 2019b. dplyr: A Grammar of Data Manipulation.

xxiii. Wickham, H., and L. Henry. 2019. tidyr: Tidy Messy Data.

xxiv. Wickham, H., J. Hester, and R. Francois. 2018. readr: Read Rectangular Text Data.

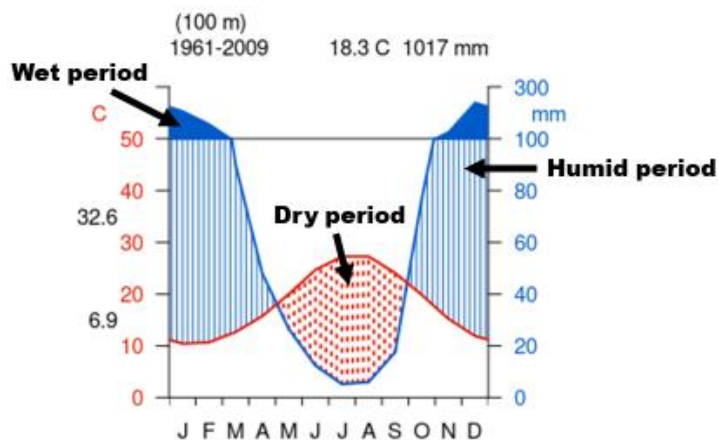## Interpreting Walter and Lieth Climate Diagrams

You can generate a Walter and Lieth climate diagram for each vegetation photo point by clicking the point and then selecting the "**Climate Diagrams**" tab in the user interface. These climate diagrams summarize average and seasonal climatic conditions for a specified region over a historic (1961-2009) or recent (2010-2018) time period. You can toggle between time periods by clicking the desired option displayed above the diagram. Temperature trends are displayed as a **red line** and precipitation trends are displayed as a **blue line**.

Anatomy of a Climate Diagram
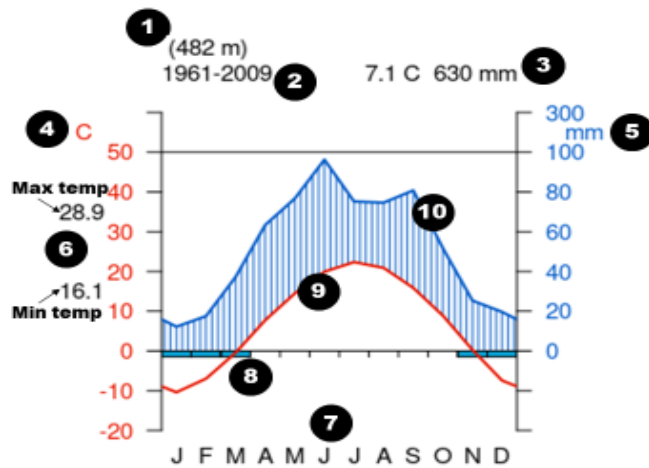
1	Site Elevation
2	Period of observation (historic is the pictured selection)
3	Average annual temperature & precipitation
4	**Temperature axis (°Celsius)**
5	**Precipitation axis (mm), reduced scale > 100mm**
6	Max temp (warmest month) & min temp (coldest month)
7	Months of the year
8	Months with frost likely (**blue bars**)
9	Average monthly **temperature curve**
10	Average monthly **precipitation curve**

Interpreting Climatic Trends

- When the **blue line** is above the **red line**, conditions are humid

- When the **red line** is above the **blue line**, conditions are dry

- When the **blue line** is above **100 mm**, conditions are wet

Interpreting Whittaker Biome Diagrams

You can generate a Whittaker biome diagram for each vegetation photo point by clicking the point and then selecting the "**Climate Diagrams**" tab in the user interface. These biome diagrams display where a point fits into Whittaker's terrestrial biome classification system which explains major global patterns of vegetation based on regional annual averages for temperature and precipitation. There are 9 possible biomes shown in the diagram.

Educational Resources on Whittaker's system:
Geography and You Biome Classification Article
BioNinja Ecosystem Analysis Notes
University of Miami Biome Lecture Notes

Anatomy of a Biome Diagram