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Exploring vegetation virtually with the Global Vegetation Project

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The postponement and cancellation of field expeditions in response to the global pandemic have left many of us hungry for opportunities to explore our natural world. Furthermore, travel limitations have posed significant challenges for educators, especially in teaching field-based courses. It became apparent over the summer of 2020 that the vegetation science community as a whole was yearning to virtually experience diverse plant communities, as evidenced by the broad sharing of photos on Twitter for the #IAVS2020_VirtualFieldTrip. What a joy it was to see such fine landscape photography from enthusiastic scientists sharing exciting botanical and ecological information (Wagner et al. 2020)!

As we sifted through our own photos of field seasons past while daydreaming about long workdays, relevés, and students eager to learn plant ID, an idea was born. We realized that our photographs of vegetation could play a much more significant role in teaching and research. These images capture valuable information about plant diversity and geography across the globe (Fig 1). Therefore, we put out a call in April 2020 for scientists and botanically-inclined persons to collect and contribute georeferenced vegetation photos. These submissions fueled the first draft of an interactive map application which we released over the summer of 2020 for beta testing.

The Global Vegetation Project (http://gveg.wyobiodiversity.org) emerged from these experiences and realizations. Our team of spatial database, web API, server hardware, and Shiny application developers have produced an online open-access global map of vegetation, populated by user-contributed photographs that include a variety of value-added information. Types of information collected include vegetation type, dominant species, Walter-Leith climate diagrams (Breckle 2002), biome, ecoregion (Olson et al. 2001; Dinerstein et al. 2017), Whittaker biome (Whittaker 1970), and anecdotal facts about the site of general interest. Our unique synthesis of vegetation photos and supporting information opens the door to virtual exploration of real-world ecological patterns in an intuitive and exciting way. Figure 2 illustrates the user interface, where explorers navigate the map on the left to view information about photos displayed on the right, with the option to display climate diagrams and apply different filters (e.g. maximum mean annual precipitation). Since launching our application in August 2020, the database has grown from 200 to 1240 photos, thanks to contributions from more than 250 photographer-botanists.

The collaborative map is a true celebration of the diversity of vegetation on our planet, with user-submitted photo points from 64 countries and every continent! However, many areas in the world are grossly underrepresented – a far too familiar tale in the ecological sciences (Culumber et al. 2019). For example, all terrestrial biomes are represented, but tropical and tundra regions are sparse (Fig 3A). Another primary target of this project is to represent every ecoregion, but there is a deficit in spatial representation across the 847 global ecoregions (Dinerstein et al. 2017). Our map's current version includes photo points that span less than 26% of these classified areas (Fig 3B). The educational and scientific value of our interactive map will be maximized with a more complete photoset. You can read more about our project aims and development in the full Vegetation Classification and Survey report (Fleri et al. 2021).

To make our vision for this project a reality, we are asking our colleagues in vegetation science around the world to collaborate through photo submissions and application feedback. We are thankful that IAVS leader-

Figure 1. Photographs of vegetation types from around the world (Credit: Daniel Laughlin). All of these photos are available on the application as points on our interactive map.

Figure 2. The user interface for map exploration with tabs for viewing high-resolution photos, displaying climate diagrams, or filtering for photo points based on different criteria.

ship has expressed enthusiastic support for the project. Scott Franklin and others in the IAVS Vegetation Classification Working Group, Pat Comer at NatureServe and the Ecological Society of America Vegetation Classification Panel, and Jürgen Dengler have supplied us with constructive suggestions and helpful information about vegetation classification which we incorporated into our database structure. Additionally, the Editors of *Palaearctic Grasslands* of the Eurasian Dry Grassland Group (EDGG) are encouraging vegetation photos published in their journal to appear on the map and for the EDGG's widespread membership to contribute photos.

Now, we invite you to visit our website and to explore our virtual vegetation database (http://gveg.wyobiodiversity.org). Please consider supporting this global initiative by contributing your own photos through our user-friendly photo submission portal. Crowd-sourcing is the only way for us to fill the map with photo points, especially when it comes to remote and far-reaching areas of the planet. If you are willing to contribute, you can rest assured that your photos and data will be handled and stored responsibly and professionally (see details in Fleri et al. 2021).

Virtual explorations of vegetation can never replace real-world field experiences. However, the ability to investigate global plant diversity and biogeographical patterns from a computer or smartphone anywhere in the world is unique and valuable. We envision that this database and interactive map application will serve as an engaging tool for K-12 educators, university classrooms, and anyone interested in the natural world.

You can follow the Global Vegetation Project on social media at @GlobalVegProj.

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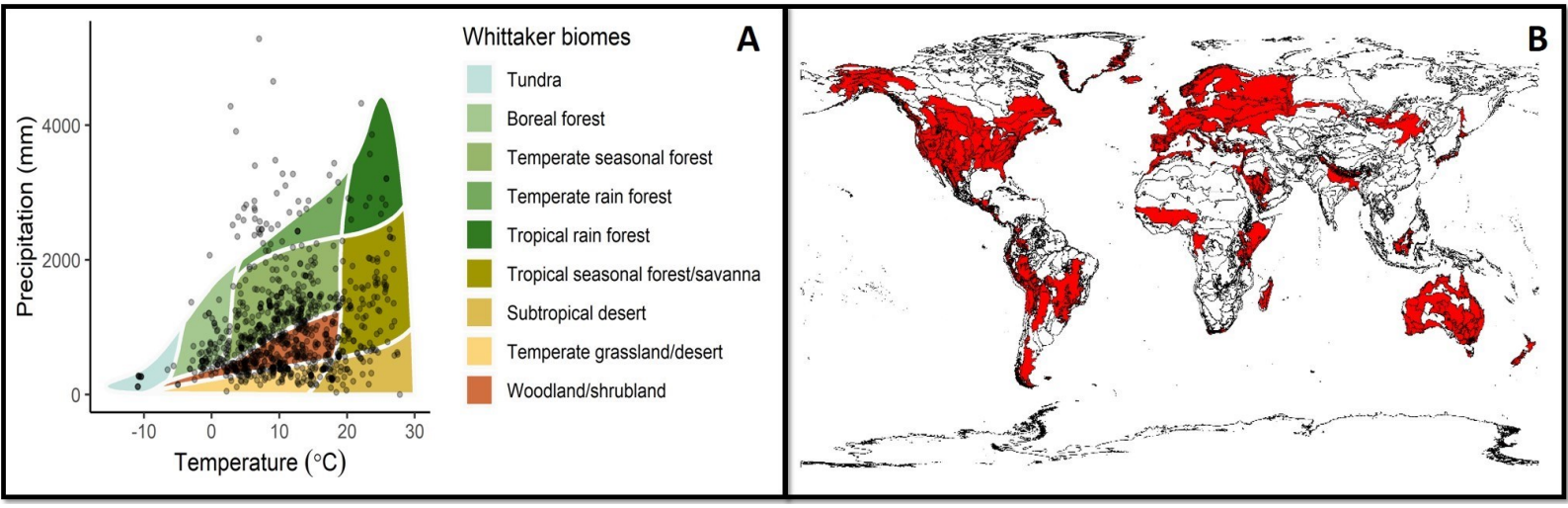

Figure 3. A. Whittaker biome diagram showing the distribution of all existing photo points. B. A map of ecoregions that displays currently represented ecoregions in red.