A DIGITIZED BIOTIC COMMUNITY MAP FOR PLOTTING AND COMPARING NORTH AMERICAN PLANT AND ANIMAL DISTRIBUTIONS

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ABSTRACT

An ecologically based classification system, when accompanied by digitized biotic community maps, has been shown to be useful for plotting and assessing plant and animal affinities in the American Southwest and northwestern Mexico. Because plant distributions are closely tied to climatic and environmental parameters, biotic community maps can be especially informative when delineating and describing vegetative communities and plant species distributions. We have therefore expanded the classification system and prepared a digitized, ecologically based color map of North America's biotic communities to assess plant distributions on continental as well as regional scales.

Key Words: ArcMap, biogeography, biotic community, GIS, habitat map, plant distribution, vegetation, vegetation map.

A DIGITIZED BIOTIC COMMUNITY MAP

Biotic communities are regional plant formations that evolved within particular climatic patterns, and are characterized by a particular suite of plant and animal species (Brown et al. 1998). As such, biotic communities are useful in describing the habitat affinities of particular plant and animal taxa, and determining the biogeographic distributions of species (e.g., Brown 1994, Brown et al.1998). The resulting maps are also useful in designing sampling strategies and assessing populations for particular species.

Incorporating the work and terminology of a broad range of ecologists and biogeographers, we developed a hierarchical classification formulated on the limiting effects of moisture and temperature minima on the structure and composition of vegetation. This effort eventually resulted in a digitized, computer-compatible classification system for the biotic communities of Arizona, the "Southwest," and North America (Lowe & Brown 1973, Brown & Lowe 1974a, Brown & Lowe 1974b,

Brown et al. 1979, Brown 1980, Brown 1982, Brown 1994, Brown et al. 1998). Attendant with these efforts was a series of maps delineating vegetation as the mapable reality of biotic community boundaries (Brown 1973 - Fig. 1, Brown & Lowe 1982 & 1994 - Fig. 2, Reichenbacher et al. 1998).

These biotic community maps have proven useful to anthropologists (e.g., Floyd et al. 2003), archeologists (e.g., Huckell 1996), climatologists (e.g., Davidowitz 2002), ecologists (e.g., Lange et al. 2000), and other scientists interested in the assessment, delineation and stratification of biotic resources along with the identification of natural areas (e.g., Martin 1979). The maps and classification system have therefore been used by the Rangelands Group of the Environmental Protection Agency's Environmental Monitoring and Assessment Program, the Arizona and New Mexico Game and Fish Departments, and other agencies charged with biotic resource inventory (e.g., Anonymous 2006). Both the classification and maps have been used by PhotoAssist, Inc. to design the biome map series of stamps issued by the U. S. Post Office, and assisted the National Geographic Society's mapping division in delineating Sonoran Desert community boundaries. Moreover, the biogeographical validity of the hierarchy's various categories are statistically testable through the use of climatic data and the "system" has been used to digitally plot numerous plant and animal distributions. A recent example of the former is the distribution maps promulgated by Brennan and Holycross (2005, 2006) and the Southwest Environmental Information Network maintained by the Vascular Plant Herbarium at Arizona State University (http://seinet.asu.edu/).

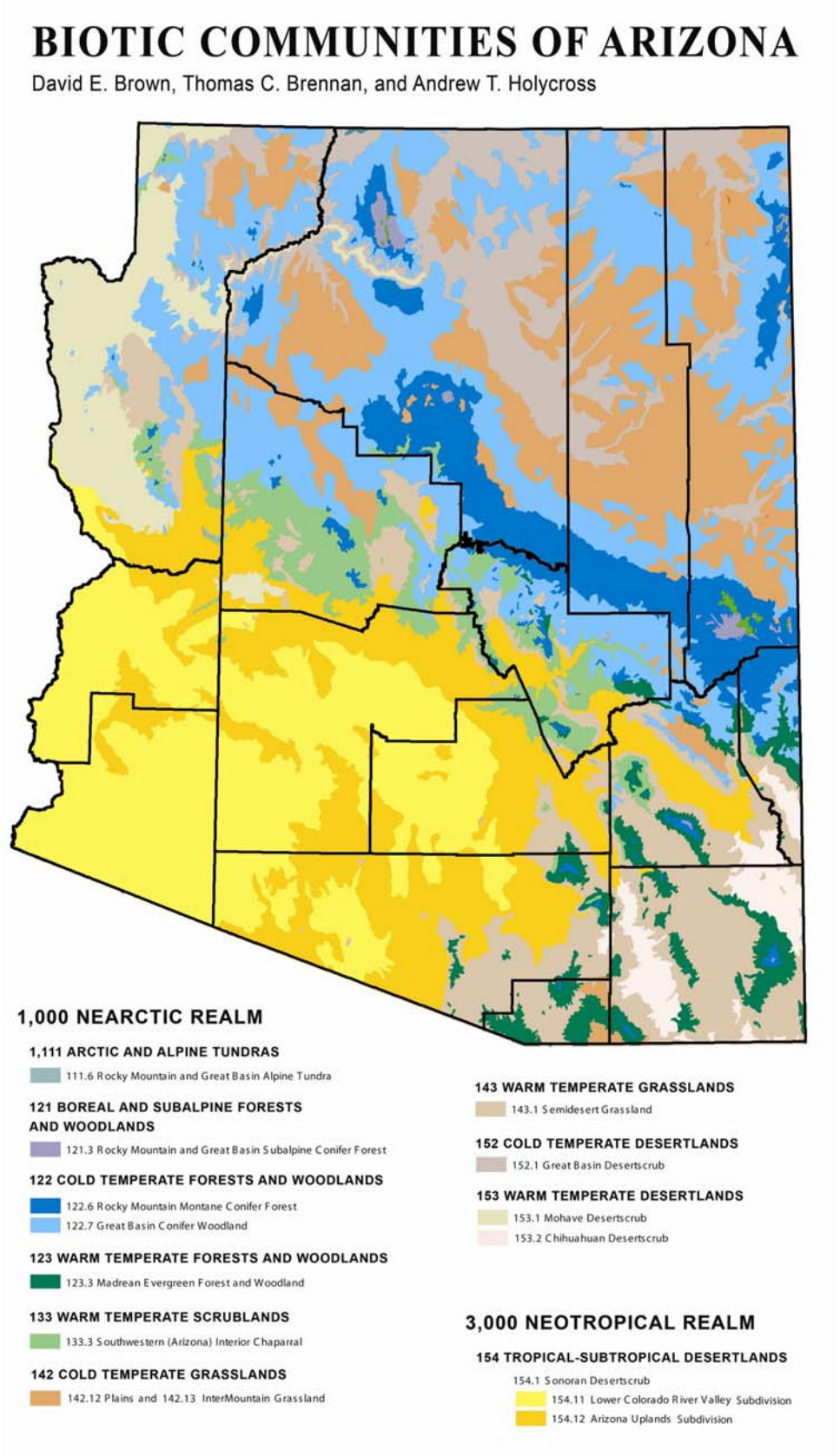
A recent "Google Scholar Search" of the scientific literature listed more than one-thousand citations for either the biotic community classification system or an accompanying map. Citations accompanied articles pertaining to general biogeographical comparisons (e.g., Floyd et al. 2000, Paysen et al. 2000, DeSilva & Medelin 2002, Coblentz & Riitters 2004, Flesch & Hahn 2005), vegetation communities and plant occurrences (e.g., Roth 2004, Laughlin et al. 2005), archeological sites (e.g., Cannon 2000), and regional climate studies (e.g., Engelthaler et al. 1999, Enscore et al. 2002, Smith & Farrell 2005) in addition to plant and animal distributions (e.g., Lanning et al. 1990, Diem 2003, Barton 2005).

Articles using these classifications and maps to describe plant distributions were noted in such publications as *American Journal of Botany* (e.g., Maschinski et al. 2004), *Annals of the Association of American Geographers* (e.g., Diem 2003), *Annals of Botany* (e.g., Martínez & López-Portrillo 2003a), *Arctic, Antarctic, and Alpine Research* (e.g., Moore & Huffman 2004), *Biodiversity and Conservation* (e.g., Richter & Stromberg 2005), *Botanical Journal of the Linnean Society* (e.g., Romero et al. 2000), *Canadian Journal of Botany* (e.g., Stutz et al. 2000), *Conservation Biology* (e.g., Floyd et al. 2003), *Freshwater Biology* (e.g., Stromberg 2001), *Ecology* (e.g., Weltzin & McPherson 2000), *Ecological Applications* (e.g., Floyd et al. 2000), *Ecological Monographs* (e.g., Weltzin & McPherson 1999), *Environmental Toxicology and Chemistry* (e.g., Gardea-Torresdey et al. 2001), *Global Ecology and Biogeography* (e.g., Drezner et al. 2001), *International Journal Plant Science* (e.g., Lange et al. 2000), *Journal of Arid Environments* (e.g., Kennedy et al. 2002), *Journal Arizona-Nevada Academy Science* (e.g., Abella 2004), *Journal of Biogeography*

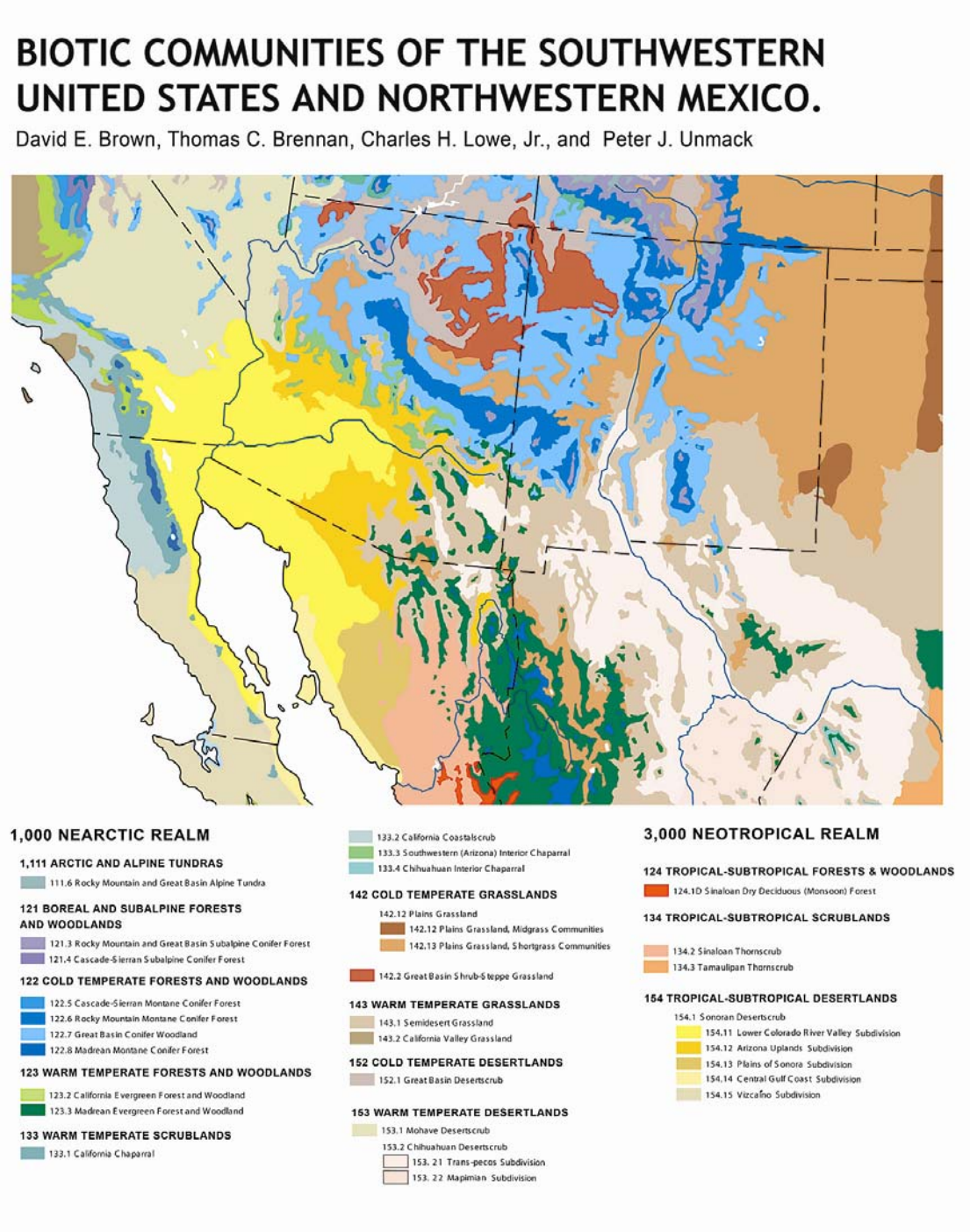
(e.g., Adams & Kolb 2005), *Journal of Ecology* (e.g., Smith et al. 2000), *Journal of Environmental Management* (e.g., Miller et al. 2003), *Journal of Vegetation Science* (e.g., Martínez & López-Portillo 2003b), *Plant Ecology* (e.g., Martinez-Yrizar et al. 1999), *Restoration Ecology* (e.g., Abella & Covington 2004), *Southwestern Naturalist* (e.g., Scott 2004, Peinado et al. 2005), and *Vegetatio* (e.g., White & Vankat 1993).

In an effort to expand the usefulness of the biotic classification system we prepared a digitized biotic communities map for North America (Figs. 3 & 4) compatible with those previously published for Arizona and the Southwest (Figs. 1 & 2). For a base chart, using the GIS software ArcInfo, we enhanced the 1:10,000,000 biotic communities map developed by Reichenbacher et al. (1998) by adding political boundaries and several large rivers. Some of the larger biotic communities were then divided into recognizable subdivisions as had been done by Shreve (1951) for the Sonoran Desert, Braun (1967) and Greller (1988) for the Northeastern Deciduous Forest, Shelford (1963) and Sims (1988) for Plains Grassland, Moravka (1977) for the Chihuahuan Desert, and West (1988) for the Great Basin Desert. We also added Balcones Woodland as described and delineated by Blair (1950) for the Edwards Plateau region in Texas.

The choice of colors was carefully considered and follow the color scheme developed by Henri Gaüssen (1953, 1955), which was later adapted by Udvardy (1975) for the world's biogeographic regions. In this ecological classification system, arid habitats are represented by light colors, the shades becoming progressively darker in the wetter communities until the most mesic entities are represented by solid, dark colors. Cold habitats are denoted by cold, dull colors - grays, dark blues, and purples. As communities become progressively warmer, the colors representing them become brighter until the brilliant warm colors of the tropics - yellows, oranges, scarlets, and magentas are used to signify the formations depicted. As a general rule, tundra communities are depicted in shades of gray, temperate grasslands in various tones of brown, conifer forests by purples and blues, temperate forests and chaparral by combinations of blues and greens, thornscrubs and savannas as yellows and oranges, tropical deciduous forests in shades of red, and tropical evergreen forests in violets and magentas. Selecting the actual color to represent a biotic community, although complex and difficult due to number of communities involved, was greatly facilitated through the use of a color wheel (Process Color System Guide, Pantone) by which more than three-thousand color shades are arranged according to the percentage sequence of four basic colors (cyan, magenta, yellow, and black). ArcMap was used to assign each community cyan, magenta, yellow, and black (CMYK) color values. For publication purposes, we exported the ArcMap file as a new, encapsulated postscript (EPS) file. Overall, the color selected for each biotic community is, therefore, a combination of colors intended to illustrate moisture and temperature gradients, formation-class, and discernability on a continental scale.

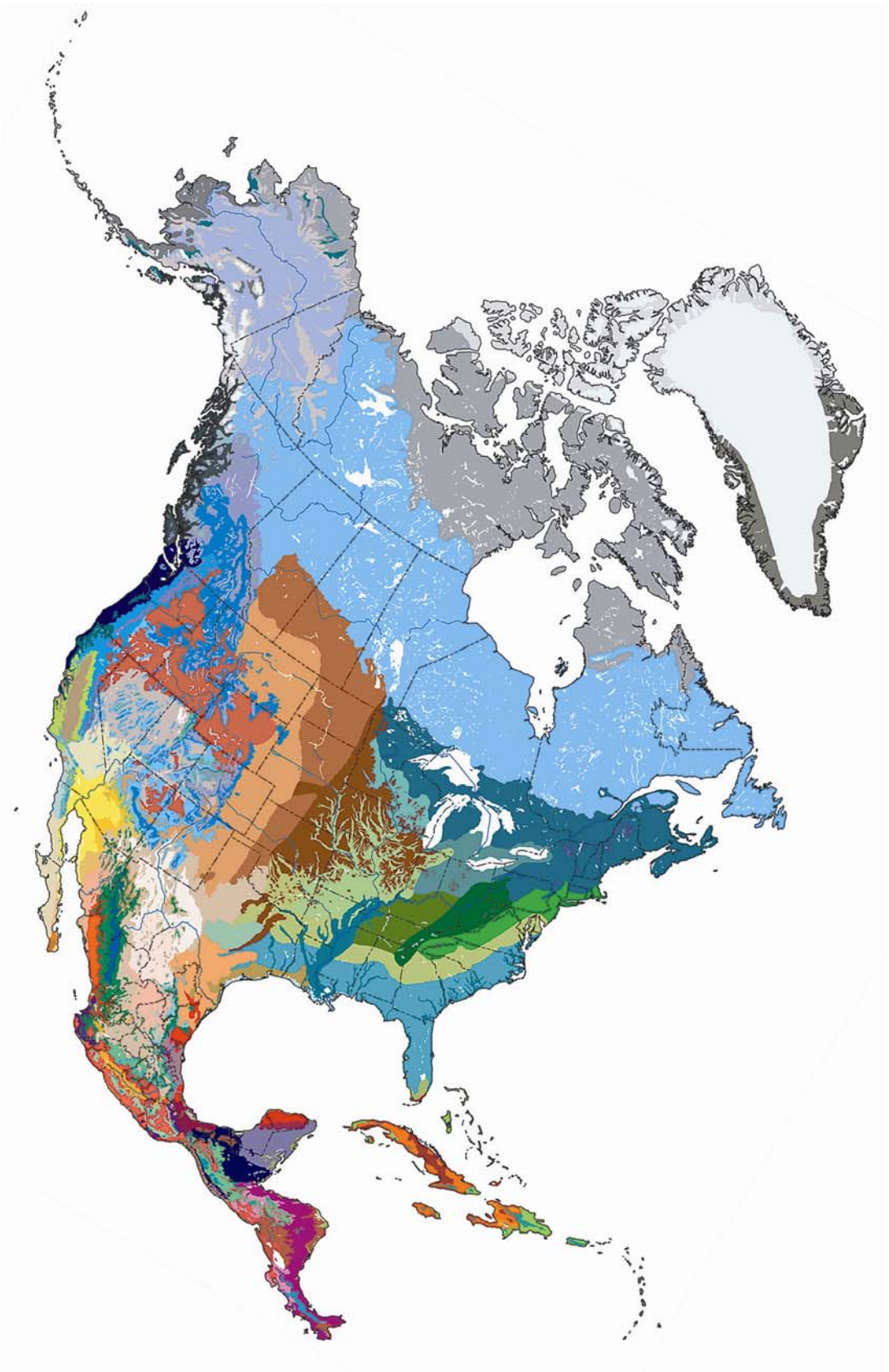


Map and Legend Figure 1. Biotic Communities of Arizona.



Map and Legend Figure 2. Biotic communities of the Southwestern United States and Northwestern Mexico.

Legend Figure 3. Digitized Biotic Community Map of North America.



Map Figure 4. Digitized Biotic Community Map of North America.

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