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Using WebGIS to Develop a Spatial Bibliography for Organizing, Mapping, and Disseminating Research Information: A Case Study of Quaking Aspen

By Ryan G. Howell, Steven L. Petersen, Christopher S. Balzotti, Paul C. Rogers, Mark W. Jackson, and Anne E. Hedrich

On the Ground

- Spatial data is valuable to researchers for locating studies that occur in a particular area of interest, or one with similar attributes.
- Without a standard in publishing protocol, spatial data largely goes unreported, or is difficult to find without searching the publication.
- Assigning location data and displaying points on a public web map makes locating publications based on spatial location possible.

Keywords: aspen, spatial bibliography, webmap.
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Introduction

Spatially explicit information can provide highly valuable information for ecosystem science research and management such as species associations, distribution patterns, response to natural and anthropogenic disturbances, and ecological invasions.[1] However, when searching literature for scientific research using standard search engines (e.g., Google Scholar, Web of Science), the source is typically limited to basic locational descriptions in the text without geographic reference on a map.[2,3] The benefits of conducting research on georeferenced media is clearly outlined in the literature which includes accessibility benefits,[2,4] reduced redundancy,[2] eliminated bias towards more represented areas and ecosystems,[1] and providing solid ground on which to base meta-analysis.[5,6]

The development of a tool to geographically search scientific literature has proven challenging. Parsing documents for location data is difficult due to inconsistencies in coordinate format (Decimal degrees, Degrees/Minutes/Seconds, UTM, etc.; this is especially true of research published before GPS), character encoding (such as degree symbols), where location data is given in the text, and even if any location is specified.[3] Additionally, manually searching for articles to geocode is extremely time consuming and subject to error. Databases containing publications for a wide array of ecological subjects exist (e.g., the Western Aspen Alliance, Aspen Bibliography), but are not well known to many researchers in ecological fields, and most are not displayed spatially.

The existence of geospatially minded search tools (e.g., JournalMap, Pangaea) demonstrate the practicality of such research methods.[2,3] These tools exhibit immense potential as preferred search engines for performing research; however, they admittedly lack in content and therefore can be limited in their ability to provide a comprehensive review of the literature.[2] Specifically, these tools are limited in older references for some topics (e.g., aspen from the early 1900's) and publications not found in a scientific journal (e.g., government documents, Master's theses, and Ph.D. dissertations).

Our objective is to provide a web-based spatially explicit comprehensive citation database that focuses on a single species or natural resource-related subject. The purpose of this paper is to present the structure and application of a geospatial reference systems using a Geographic Information System (GIS) that includes peer reviewed journal articles, government reports and records, proceedings from symposia and conferences, books and book sections, Master's theses and Ph.D. dissertations, and reliable but unpublished research reports and documents. This reference system is made available using ArcGIS Online, a software that allows for user-friendly, world-wide access.

Methods

We compiled a geospatially explicit database by searching readily available online databases (e.g., Google Scholar, BYU Harold B. Lee Library, government websites) for publications and other resources (e.g., journal articles, government documents, Master's theses/Ph.D. dissertations, books and book sections) related to subjects in rangeland ecology and management. The compilation extends from the earliest periods available in the literature to present day. With each citation, we attempted to locate explicit coordinates correlating to the study area, typically in the methods section of the publication. If no coordinates were given, we located the general area using Google Earth in order to provide an estimated study location. In turn, each record was assigned one of three coordinate types: *Provided* (the coordinates were explicitly stated in the publication), *Estimated* (the coordinates of the study area were not explicitly given, but a locational description was given on which coordinates were assigned, e.g., Fishlake National Forest, Utah) or *Generalized* (no coordinates were given and the coordinates assigned cover a large, general area, e.g., Central Utah). Fields containing the publication's title, author, year, journal, volume, issue, pages, DOI, location, latitude (in decimal degrees), longitude (in decimal degrees), coordinate type, abstract, and keywords were created and populated using an Endnote database.

The Endnote database was formatted to export to a comma delimited .txt file for clean import into a Microsoft Excel document, then exported as a .csv file. We then created a heat map with the publication coordinates displayed as points to visually display hotspots, or locations with higher concentrations of ecological research. However, this method was time consuming to continuously edit and export into ArcGIS software. After the creation of the initial database using Endnote, records were stored on ArcGIS Online as a hosted web layer and edited using ArcGIS Pro (ESRI 2011), bypassing the need to continuously export an Endnote database and allowing editing access to be granted to anyone with a free account by the database managers. This allows for easier updating and editing than Endnote, which is essential for maintaining the accuracy of displayed publications. A map display has been created for subjects including Aspen Ecology and Management, Wild Horse Behavior and Habitat Use, Greater Sage-Grouse Ecology, Bristlecone Pine Forest Ecology, and Sagebrush Ecology and Management (ghal.byu.edu). These databases are at various stages of "completion" (for example, the relatively small physical range of bristlecone pine limits the research that has been done, making it more realistic to "complete" the database, while sagebrush ecosystems cover a much larger area and have an ecological impact on many species of concern, increasing the amount of research performed annually).

Aspen Case Study

Aspen (*Populus sp.*) has experienced a rich history of applied and basic science inquiry world-wide. These species are valued globally for their biodiversity, forage quality, wood products, water retention, recreational use, and aesthetics.[7–9] In North America, quaking aspen (*P. tremuloides*) is the most widespread and broadly adapted tree species. European aspen (*P. tremula*) has a similar, though even broader, ecological amplitude across Eurasia. These trees are both considered keystone species where they occur, indicating that the ecosystem as a whole would change in areas if it were removed.[10–14] Due to its ecological importance, aspen has been a focus for numerous studies in the past and the object of intensified research in recent years.[15,16]

We partnered with the Western Aspen Alliance (https://western-aspen-alliance.org/) and Utah State University's Merrill-Cazier Library to access their complete aspen publication database. We located all publications available between 1911 and 2019. Our online map can be found at https://goo.gl/hyT6QR (Figure 1). At the time of this writing, the map contains a total of 1536 publications: 488 with "Provided" coordinates, 823 with "Estimated" coordinates, and 225 with "Generalized" coordinates. The online map includes functions to filter search results by standard cataloging parameters (e.g., author, title, year) as well as geographic location. Additionally, corrections or additions can be suggested by any user through a dedicated email address or edited directly by manager-specified users.

Discussion

We developed a user-friendly, map-based, online tool for practitioners interested in researching the breadth of established aspen sciences. This cartographic platform, linked deftly to a comprehensive subject area database, allows users to geographically narrow searches with a few key strokes. Further search filters may be applied to find, for example, previous work that has been conducted on aspen stem cankers within a geographic area of interest (e.g., state, province, region).

Demonstration of this tool within a richly researched subject area has ramifications for other topic areas, particularly those with explicit spatial components. In addition to the benefits of geographically displaying the location of published material, the data extracted from the produced coordinate data can drive analysis of patterns in the locations of publications, showing locations that are perhaps too lightly or heavily researched or find completely new areas for research based on geographical characteristics of hot spots. This practice can be applied to any subject in ecology and can be compared with any geographic feature using a GIS, greatly enhancing our understanding of attributes of published literature currently unavailable using a standard search engine with a location-based query.

Development of a spatial bibliography can be time consuming and expensive due to limitations in reported coordinates and lack of documentation in the publication process. We recommend that all peer-reviewed journals and other publishers require documentation of where a study took place and its coordinates. In cases where sensitive cultural or environmental considerations are of concern, a generalized area can be given (for example, utilizing the "Estimated" or "Generalized" point types in our spatial bibliography). As suggested by Karl[6] and in practice by the Dublin Core

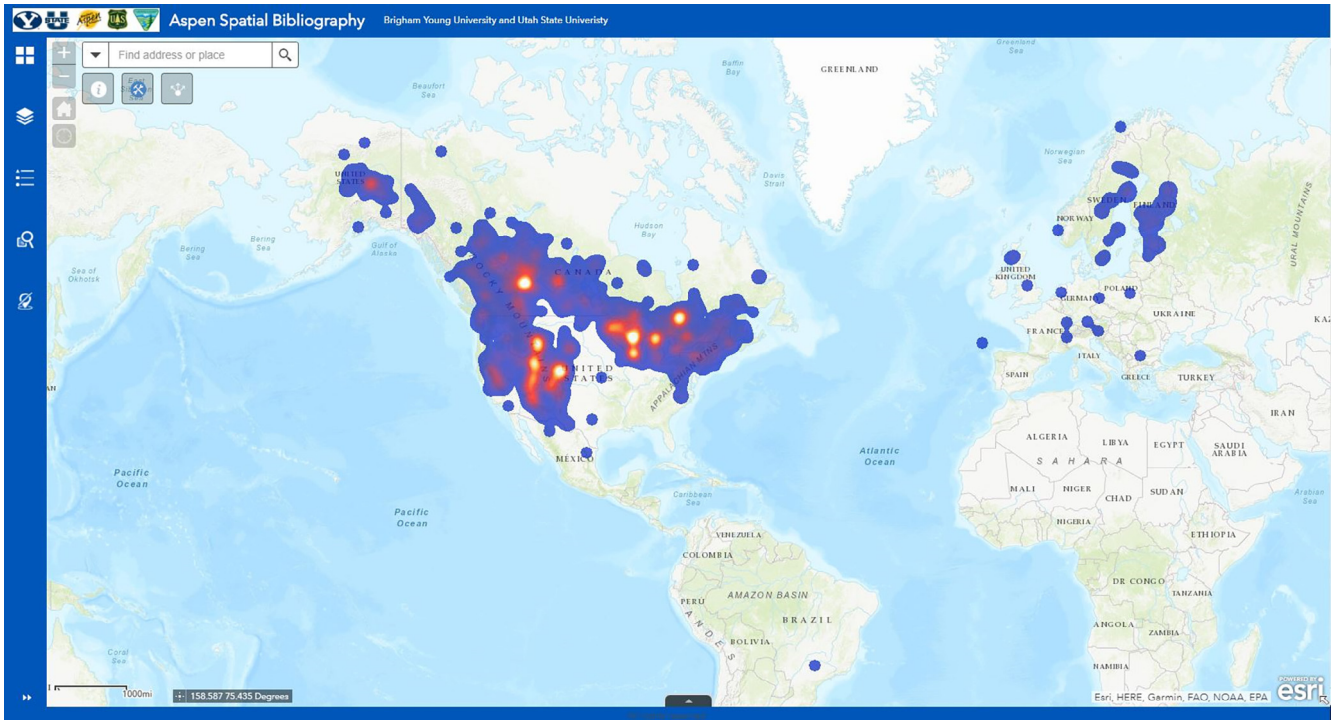

Figure 1. Screenshot of Aspen Spatial Bibliography hosted on ArcGIS online (https://goo.gl/hyT6QR). A greater number of entries in the spatial bibliography are indcated by brighter colors.

(http://dublincore.org), this information can be encoded into the article metadata (either at the publisher or database level) to facilitate automation.

The strength of our particular spatial bibliography lies in its comprehensiveness of a single topic (aspen), including all forms of publications and not only peer-reviewed journal articles dating back to the early 20th century. Additionally, pairing it with an existing database managed by a library (or interest group similar to the Western Aspen Alliance) reduces the need to rely heavily on complicated search methods and article parsing to continually find new research, although article parsing, such as outlined by Karl[6] or through available software such as the LocateXT license by ESRI, does certainly have a role in automating the identification of coordinates from newly published works to update a spatial bibliography.

Ecological topics are widely represented by interest groups and could provide a network for database population and management, crowdsourcing of geocoding publications, and quality control. We recommend that all scientific literature database managers require location data be submitted with each publication; however, until this becomes the standard, we suggest that experts and interest groups, especially those with existing publication databases in their area of study, partner to develop topical spatial bibliographies to optimize geospatial searching and meta-analysis of currently published research.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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