Review and Bibliometric Analysis of Published Literature Citing Data Produced by the Gap Analysis Program (GAP)

By Joan M. Ratz and Shannon J. Conk

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Contents

Figures

Tables

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Executive Summary

The Gap Analysis Program (GAP) of the U.S. Geological Survey (USGS) produces geospatial datasets providing information on land cover, predicted species distributions, stewardship (ownership and conservation status), and an analysis dataset which synthesizes the other three datasets. The intent in providing these datasets is to support the conservation of biodiversity. The datasets are made available at no cost. The initial datasets were created at the state level. More recent datasets have been assembled at regional and national levels.

GAP entered an agreement with the Policy Analysis and Science Assistance branch of the USGS to conduct an evaluation to describe the effect that using GAP data has on those who utilize the datasets (GAP users). The evaluation project included multiple components: a discussion regarding use of GAP data conducted with participants at a GAP conference, a literature review of publications that cited use of GAP data, and a survey of GAP users. The findings of the published literature search were used to identify topics to include on the survey.

This report summarizes the literature search, the characteristics of the resulting set of publications, the emergent themes from statements made regarding GAP data, and a bibliometric analysis of the publications. We cannot claim that this list includes all publications that have used GAP data. Given the time lapse that is common in the publishing process, more recent datasets may be cited less frequently in this list of publications. Reports or products that used GAP data may be produced but never published in print or released online. In that case, our search strategies would not have located those reports. Authors may have used GAP data but failed to cite it in such a way that the search strategies we used would have located those publications. These are common issues when using a literature search as part of an evaluation project. Although the final list of publications we identified is not comprehensive, this set of publications can be considered a sufficient sample of those citing GAP data and suitable for the descriptive analyses we conducted.

We searched Web of Science©, Scopus®, Google Scholar, CSA Illumina©, and EBSCO© for references in text to “gap analysis project,” “gap analysis program,” “‘gap analysis’ and GIS,” and “USGS and gap.” This search resulted in 2,058 unique publications after all duplicates were removed from the list. We excluded publications if the content focused on the program itself, gap analysis methods, or a specific GAP project because we were interested only in use of GAP data. We excluded all references that were published in the GAP Bulletin and all GAP Project Reports because our intention was to focus on how GAP data were used outside of the program. We included publications if the author(s) made a statement indicating they had used a dataset produced by GAP or indicated a use of a GAP dataset in a table or figure. We were unable to locate copies of 138 publications and therefore could not make a determination regarding the use of GAP data for those publications. The final list of references citing GAP data includes 646 publications.

Most authors were listed on only one publication, and only a few authors received authorship credit on more than one publication in the set. This set of references is not characterized by a small set of authors who publish repeatedly using GAP data. The authorship pool consists of many authors. The publication outlet was primarily journal articles, although there were conference presentations, student dissertations and theses, book chapters, and reports. We summarized the titles of the journals and the number of publications appearing in each journal. Publications using GAP data appeared in 161 journals. The topics addressed by the journals were quite diverse and included wildlife (Journal of Wildlife Management), conservation (Biological Conservation), weather (Weather and Forecasting), and infectious diseases (Emerging Infectious Diseases). We categorized the publications based on the year of publication with separate counts for use of state, regional, and national data. The year of publication ranged from 1994 to 2011, and state datasets were cited more frequently than regional or national datasets. This is not surprising given that the state datasets have been available for a longer period of time. Among the types of data provided by GAP, the most frequently used in the published literature was land-cover data. We analyzed the frequency with which each dataset was used based on the project developing the data (state, region, or national) and the type of data. The most frequently used dataset was land cover from the California Gap Project. We calculated the durability of data based on the earliest and most recent publication dates for publications that used GAP data from each project. The length of time that a dataset is used after it is released can be used as one indicator of the usefulness of the data. The durability of data varied, and some of the datasets had a length of use that exceeded 10 years.

The next step was to summarize the comments about GAP data from these publications. We searched the text of each publication for statements regarding GAP data. We marked the statements that referred to data or maps—ignoring those that referred to the program itself or GAP projects and not data—and pulled them into a database. We reviewed the statements and grouped them into categories based on the theme of the statement. The themes in the main categories were the following: description of data, how data were used, critiques, comparisons, commentary, and reference to GAP data.

The statements included in the description of data category were statements that described which GAP dataset was used in the publication. The category of how data were used included methodological descriptions of GAP data such as transformations made to the dataset, descriptions of how GAP data were compared to other datasets, and descriptions of how GAP data fit the purpose of the study. The statements identified as critiques addressed different issues including accuracy, error, how GAP data were lacking, limits to the data, and utility of GAP data. The statements included in the category of comparisons described conclusions drawn as to how GAP data compared to other data. GAP data were described as comparing favorably, unfavorably, favorably in some aspects yet unfavorably in others, and equivalently to other datasets. Commentary statements regarding GAP data were mostly favorable. Some of the commentary statements indicated that potential issues with GAP data were mitigated in some situations. For example, the state datasets are older which can pose a problem in some applications. However, in cases in which landscape change is the focus of study, the availability of older datasets is beneficial. In those cases, the datedness of the data is mitigated by the purpose of the study. Finally, the reference to GAP data category includes statements that describe or refer to a dataset but not specifically the use of a dataset.

We conducted a bibliometric analysis to gain additional understanding about the publications that used GAP data. The results of bibliometric analyses can be used as a component in the performance evaluation process for a research program (Campbell and others, 2010; Trochim and others, 2008; Verbeek and others, 2002) and in science policy and planning (Irvine and others, 1987). We used the journal impact factors for those publications appearing in journals, and citation counts for all publications. The journals were associated with 34 disciplines as categorized by the Web of Science Journal Citations Report®. The journals publishing articles that used GAP data had a variety of journal impact factors—which relate to the average frequency articles from that journal are cited by other publications. Forty percent of the journals were rated in the top quartile within their respective disciplines. This indicates that GAP data are used in publications that appear in journals considered to be at the top in their field.

As part of the bibliometric analysis, we researched how frequently each of the publications using GAP data was cited in other publications. We used Web of Science to determine the citation count for each publication. Older publications tend to be cited more, however, the most frequently cited publication using GAP data was published in 2004. We cross-referenced the publication citation counts with the datasets used in the publications. The datasets included in the most publications were not necessarily those in the publications with the most citations. The dataset associated with publications receiving the highest number of citations was the Utah land-cover dataset. The citation rates may indicate the degree of secondary diffusion of information regarding GAP data. The publications that used GAP data, identified their use of GAP data, and wrote about use of GAP data increased the visibility of these datasets. The citation counts for those publications provided an index of how many others were introduced to GAP data based on their citation of the publications using GAP data.

In summary, the review of published literature that cites a use of GAP data yields several conclusions. First, GAP data are being used by a wide variety of researchers. Second, the comments made in the text of the publications regarding GAP data included favorable comments as well as specific critiques. Finally, GAP data are used in publications that appear in many high-impact journals.

The results of this published literature search had several implications for the survey of GAP users. First, specific issues that emerged from the qualitative analysis of statements regarding GAP data in these publications were used to generate questions for the survey. Specifically, the survey included questions regarding the issues of accuracy, error, to what extent issues of accuracy and error are problematic to the user, what GAP data lack that would be useful, how GAP data compare to other datasets, and what transformations to GAP data are required to make the data useful to the user. Second, given the wide range of datasets used and great variety in journals and disciplines in which the publications appeared, the survey was designed as an adaptive survey so that respondents were asked only questions that pertained to the dataset with which they were most familiar. Finally, the authors of the publications were clearly individuals who have used GAP data and their names were added to the list of potential survey respondents.

Background

The Gap Analysis Program (GAP) of the U.S. Geological Survey (USGS) has been operational since 1989. GAP provides spatial data for use as a framework to make assessments regarding how well biodiversity is protected and to evaluate what aspects of biodiversity need greater protection. Among the program goals are providing “information to the public and those entities charged with land use research, policy, planning, and management,” and “build[ing] institutional cooperation in the application of this information to state and regional management activities.” To this end, GAP produces and provides the following types of datasets: land cover; predicted distributions of vertebrate species; land stewardship (ownership and conservation status); and analysis data synthesizing the three aforementioned datasets. The Gap Program does not charge a fee to download the data. The initial datasets were created at the state level; Puerto Rico was included as a state project. These datasets are archived on the GAP website. More recent datasets have been assembled at regional data levels. Specifically, regional data are available for three regions: Southwest (Arizona, Colorado, New Mexico, Nevada, Utah); Southeast (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia); and Northwest (Idaho, Montana, Oregon, Washington, Wyoming). However, not all types of data are currently available for all regions. National data for land cover and stewardship became available in 2009. Some national species distribution models and ranges are available and additional species models will be added to the website as they become available.

In Federal fiscal year 2007, the Policy Analysis and Science Assistance branch of the USGS contracted with GAP to conduct a systematic evaluation. GAP has data development programs for both terrestrial and aquatic species. At the request of GAP, we focused our evaluation on the data produced for terrestrial species. The intent of the evaluation was to assess the impacts that GAP products—the datasets it produces and distributes—have on the individuals who use the products (GAP users) and on conservation of biodiversity. The main component of such an evaluation is a data collection process using a survey (Rossi and others, 2004) designed to measure the extent to which GAP is achieving its stated goal of "keeping common species common" through the conservation of biodiversity. The results of this survey will be used by GAP administrators and staff to evaluate past performance of the program and to strategically plan changes to the current approach. Changes in the existing approach to developing and providing data may be necessary to best meet the needs of current GAP users and to expand the number of GAP users. The survey is the key piece of the evaluation project so it must be carefully designed. To support and inform survey development, we collected information from several outlets. We searched the published literature for studies making use of GAP data, reviewed the literature on use of geographic information system (GIS) data for decisionmaking and related topics, and conducted two discussion groups that included GAP users. In this report, we describe our study of the published literature using GAP data. In addition to providing direction for development of survey questions, the review of published literature makes a unique contribution by identifying how GAP is described in the public realm. We define the public realm as documents and publications that are accessible to the public in hardcopy or electronically over the internet. Information regarding the data produced by GAP that is publicly available increases awareness of the program, the data it provides, and how the data can be used. Our goal was to understand the external characterization of GAP as opposed to how it is characterized internally by GAP staff and cooperators. Focusing on the external view of GAP is more likely to result in a characterization of GAP that is independent and bias-free.

We describe the search process used to identify publications citing GAP data, the characteristics of these publications including which datasets were cited, the results of a qualitative study of comments regarding GAP data in the publications, and the results of a bibliometric analysis of these publications.

Reference Search Methods

In any study of published literature, use of multiple databases maximizes the potential of obtaining a representative set of literature (Okubo, 1997). A study of the overlap between journals covered by Web of Science© and Scopus® demonstrated that the two databases have some overlap but provide substantial unique coverage (Gavel and Iselid, 2008). The two databases overlap in their journal coverage but Scopus includes more publication outlets of other types such as conference presentations (Moed, 2009). When databases cover different ranges of publication dates, searching in multiple databases can result in a set of search results that cover a longer range of time, rather than a set of results limited by the beginning and end date of a single database. The databases searched began their collection of citations in different years; the earliest year covered was 1971.

We searched Web of Science, Scopus, Google Scholar, CSA Illumina© and EBSCO©. CSA Illumina and EBSCO enable more efficient searching because searches of multiple databases can be performed simultaneously. In CSA Illumina, we searched the following databases: Aquatic Sciences and

Fisheries Abstracts, Biological Sciences, Biology Digest, Digests of Environmental Impact Statements, Meteorological and Geoastrophysical Abstracts, NTIS, Plant Science, and Zoological Record. In EBSCO, we searched the following databases: Agricola, Biological Abstracts, CAB Abstracts, Fish and Fisheries Worldwide, GeoRef, and Wildlife Ecology. We used the search terms "gap analysis project," "gap analysis program," "'gap analysis' and GIS," and "USGS and gap." We used the first one thousand results for each of the searches in Google Scholar. Even when a search returns more than one thousand results in Google Scholar, only the first thousand can be viewed. We combined the results from all searches into a master list that included 5,507 publications. There were 2,058 unique publications after all duplicates were removed from the list.

We reviewed each entry on the list of 2,058 publications and applied a set of inclusion and exclusion criteria to create a final list of publications to include in subsequent phases of this review. We included publications if the author(s) made a statement indicating they had used a dataset produced by GAP or cited GAP data in a table or figure. We excluded publications if they met any of the following criteria:

- the content of the publication focused on the GAP program, gap analysis methods, or a specific GAP project,
- the publication outlet was the GAP Bulletin,
- the publication was a GAP project report or described a project report,
- the authors noted the GAP program as a data source but did not make use of GAP data,
- the content of the publication described using gap methodology, but not GAP data, or
- the content addressed aquatic GAP—the focus of this project is the terrestrial GAP data.

Although we intended to focus on the use of GAP data and not publications by or about the program, we did not automatically exclude publications authored by former and current GAP staff. If the content of the publication focused on the program, a GAP project, or gap analysis methods, the publication was deleted from the list. If the publications appeared to be applications of GAP data, they were included on the list.

If we could not determine if a reference should be included or excluded based on the title and abstract, we reviewed the entire text of the publication if it was accessible. We could not access the text for 138 publications and were unable to determine if those publications included use of GAP data. The final list of references citing GAP data includes 646 publications. These publications are included in the list of references and marked with an asterisk.

Limitations of Literature Search Methods

Because of the time lag in the publishing process, the more recent regional and national datasets are less likely to be used and cited in published literature. The state datasets are older and have been available for longer periods of time and therefore are more likely to have been used and cited in published research. This reality should temper conclusions regarding the quality or usefulness of the datasets. A conclusion that the regional datasets are less used and therefore less useful because they are cited in fewer publications would not be an appropriate one.

GAP produced the datasets used by the researchers who wrote these publications. There may have been uses of GAP data to create maps or documents that have not been published because they were used exclusively for management of natural areas. The use of publications citing GAP data provides what is likely to be an incomplete and conservative depiction of the actual range of GAP data use. However, these publications provide information that cannot be addressed by other methods. Publications include public statements about GAP data, and identify uses and users of GAP data that might not be identified through other means.

We cannot claim that this list includes all research publications that have cited GAP data. Compiling a complete list of publications generated by a program is a common concern when using publications as part of a program evaluation (Narin and Hamilton, 1996). It is difficult to know the completeness of the compiled list. One concern regarding constructing the bibliography for a bibliometric analysis is that the available information about publications depends on the recordkeeping practices of others. Even a database that draws from a wide range of sources is likely to omit some publication records. If the researchers used different terminology or if the publication outlet was not indexed in the databases we searched, our search strategy would not have identified all publications using GAP data. We excluded publications that seemed to primarily focus on specific GAP projects. Other readers or the publication authors may believe that these publications were examples of use of GAP data that should have been included in our final set of publications. An additional concern is the amount of time required to construct a thorough bibliography. The practical constraints of time and other resources such as funding and access to publication databases will affect the completeness of the final bibliography. We used the most thorough search strategy given the realistic constraints of time and resources. We applied our inclusion and exclusion criteria as consistently as possible. We have identified a set of publications that can be considered an adequate sample of publications citing GAP data that is suitable for the summary analyses conducted.

Data Recording Strategy

For each publication we reviewed, we created a data record that included specific information regarding the publication. The record included the citation, list of author names, the source of the publication (such as journal title, book title, conference title), the type of publication outlet (journal article, book, conference presentation, student paper, and report), year of publication, project that produced the data (state, regional, or national), type of data used (land cover, predicted species distribution, stewardship, analysis), and quotations from the publication in which GAP data are mentioned. If there was any question regarding any of what data should be recorded, we entered "unknown" into the data field. If the information was unclear, we did not assume and record data based on those assumptions. In some cases, authors did not specifically state which type of dataset from GAP was used. In other cases, authors indicated a type of data, such as land cover, but did not indicate if it came from state or regional projects.

Summary of Publication Characteristics

The set of publications citing GAP data on which we based our analyses included 646 publications. We summarized the publications based on authorship, publication outlet, year of publication, and dataset characteristics.

Authors

One of the issues addressed in the evaluation of GAP is the influence of the program. One method of assessing the breadth of the program's influence is to determine if use of GAP data can be characterized as repeated use by a limited group of users or infrequent use by a broader set of users. We used this set of publications to ascertain if evidence existed that would suggest one characterization over the other. If GAP data are used repeatedly by a limited group of users, we expect that authors will be credited on multiple publications in this sample. If GAP data are used by a broader set of users, we expect that most authors will be credited on fewer publications. In order to address this issue, we created a list of authors who received any level of authorship credit (first author, second author, etc.) in this set of publications. We counted the number of different publications on which an author received credit. There were 1,599 individuals listed as authors in this set of publications. The number of publications on which authors received credit ranged from 1 to 13. The percent of authors receiving credit on each number of publications is depicted in figure 1.

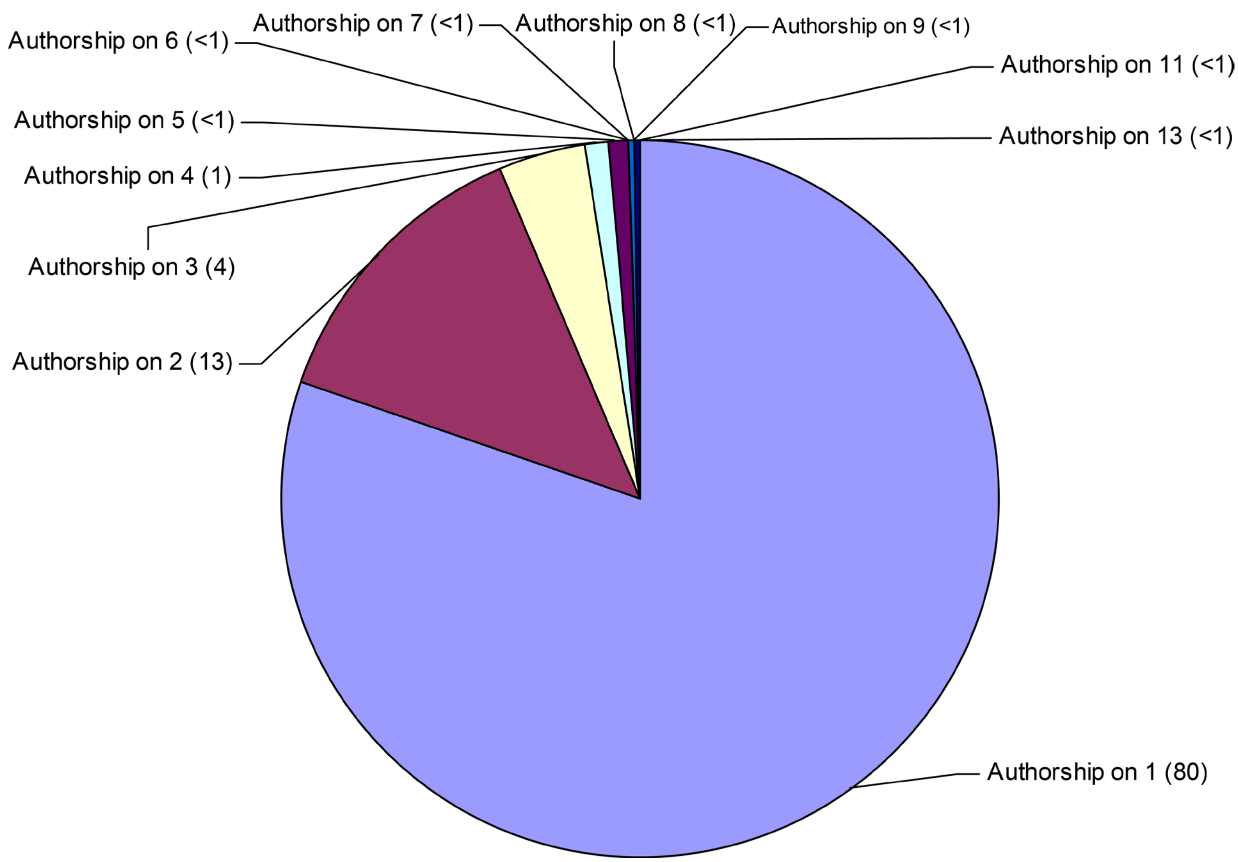


Figure 1. Proportion of authors receiving credit categorized by number of publications. Percent of authors in each category is provided in parentheses.

The majority of authors (80 percent) were credited on only one publication, which suggests GAP data are used less frequently by a wide range of users. Only 6.5 percent of authors were listed on three or more publications.

Publication Outlet

Identifying the means through which information about GAP is disseminated is another approach to understand the influence of GAP. We categorized each publication according to the type of outlet based on five categories: book, conference presentation, student paper, report, and journal article. The category labeled "book" includes chapters in edited books and conference proceedings. The reason for including conference proceedings in this category is that papers published in proceedings often undergo a more rigorous editorial process and are available in a more durable format than other types of conference presentations. The "book" category contains 117 publications. The category labeled "conference presentation" includes presentations, posters, papers identified as being presented in some way at a conference, and conference presentation abstracts. This category contains 24 publications. The category labeled "student paper" includes dissertations, theses, undergraduate honors and capstone papers, and papers written as part of required coursework. This category contains 55 publications. The category labeled "report" includes publicly available reports by federal, state, or local agencies, and nonprofit and for profit organizations. This category contains 108 publications. The majority of publications, 342, were from journals. The percent of publications from each outlet type is shown in figure 2.

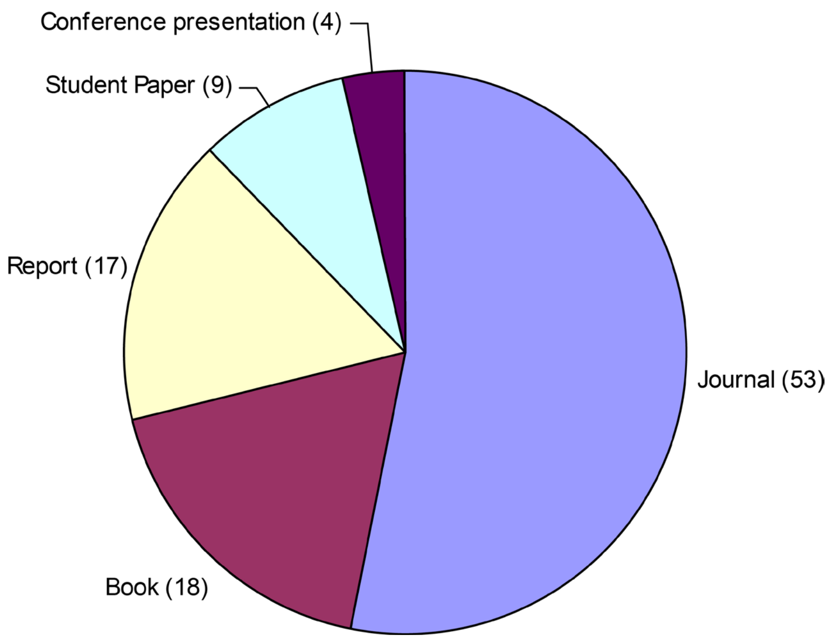


Figure 2. Percent of publications by outlet type. Percent of publications in each category is provided in parentheses.

For the publications included in the report category, we identified the type of organization producing the report. Government agencies produced 32 (30 percent) of the reports. Educational institutions produced 31 (29 percent) of the reports. Nonprofit organizations produced 27 (25 percent) of the reports. Organizations that operate for profit produced 13 (12 percent) of the reports. We could not identify the type of organization that produced five of the reports because the identifying information was limited.

We identified the type of student paper for the 55 publications in that category. The student papers included 34 Master's theses (62 percent), 10 Doctoral dissertations (18 percent), and the remaining 11 (20 percent) were other student papers.

Because so many of the publications were from journals, we examined the publications from journals more closely by conducting a bibliometric analysis. The bibliometric analyses are described in a subsequent section of this report. We provide a list of the 161 journal titles and number of articles from each of those journals as part of the description of this set of publications citing GAP data. This information is provided in table 1.

Table 1. Journal title and number of articles from each journal.

Journal Title	Number of Articles
Journal of Wildlife Management	20
Conservation Biology	17
Ecological Applications	14
Landscape Ecology	9
Photogrammetric Engineering & Remote Sensing	9
Wildlife Society Bulletin	8
Biological Conservation	7
Environmental Monitoring and Assessment	6
Natural Areas Journal	6
Environmental Management	5
Journal of Mammalogy	5
Madroño—California Botanical Society	5
Molecular Ecology	5
Remote Sensing of Environment	5
Southwestern Naturalist	5
Monthly Weather Review	4
American Journal of Tropical Medicine and Hygiene	3
American Midland Naturalist	3
Animal Conservation	3
Auk	3
Diversity and Distributions	3
Ecography	3
Environmental Modelling & Software	3
Forest Ecology and Management	3
International Journal of Remote Sensing	3
Journal of Arid Environments	3
Journal of Forestry	3
Journal of Medical Entomology	3
Journal of the American Water Resources Association	3
Landscape and Urban Planning	3
North American Journal of Fisheries Management	3
Southeastern Naturalist	3
Wetlands	3
American Fisheries Society Symposium	2
Applied Geography	2
Atmospheric Environment	2
Biodiversity and Conservation	2
Condor	2
Ecohydrology	2
Ecological Indicators	2

Table 1. Journal title and number of articles from each journal.—Continued

Journal Title	Number of Articles
Ecological Modelling	2
Ecology and Society	2
Ecosystems	2
Emerging Infectious Diseases	2
Forest Policy and Economics	2
Forest Science	2
Global Change Biology	2
Global Ecology and Biogeography	2
Journal of Coastal Research	2
Journal of Soil and Water Conservation	2
Journal of the Arkansas Academy of Science	2
Journal of Vegetation Science	2
Occasional papers, Museum of Texas Tech University	2
Oikos	2
PloS ONE	2
Professional Geographer	2
Quaternary Research	2
Soil Science Society of America Journal	2
Southern Journal of Applied Forestry	2
Studies in Avian Biology	2
Transactions of the Kansas Academy of Science	2
Ursus	2
Western Journal of Applied Forestry	2
Wildlife Biology	2
Wilson Journal of Ornithology	2
Agricultural Water Management	1
Ambio	1
American Journal of Enology and Viticulture	1
Annals of the Association of American Geographers	1
Applied Vegetation Science	1
Biological Invasions	1
Bioresource Technology	1
BioScience	1
California Agriculture	1
Canadian Journal of Fisheries and Aquatic Science	1
Climatic Change	1
Computing in Science and Engineering	1
Conservation and Society	1
Conservation Genetics	1
Digital Soil Mapping	1
Ecological Monographs	1

Table 1. Journal title and number of articles from each journal.—Continued

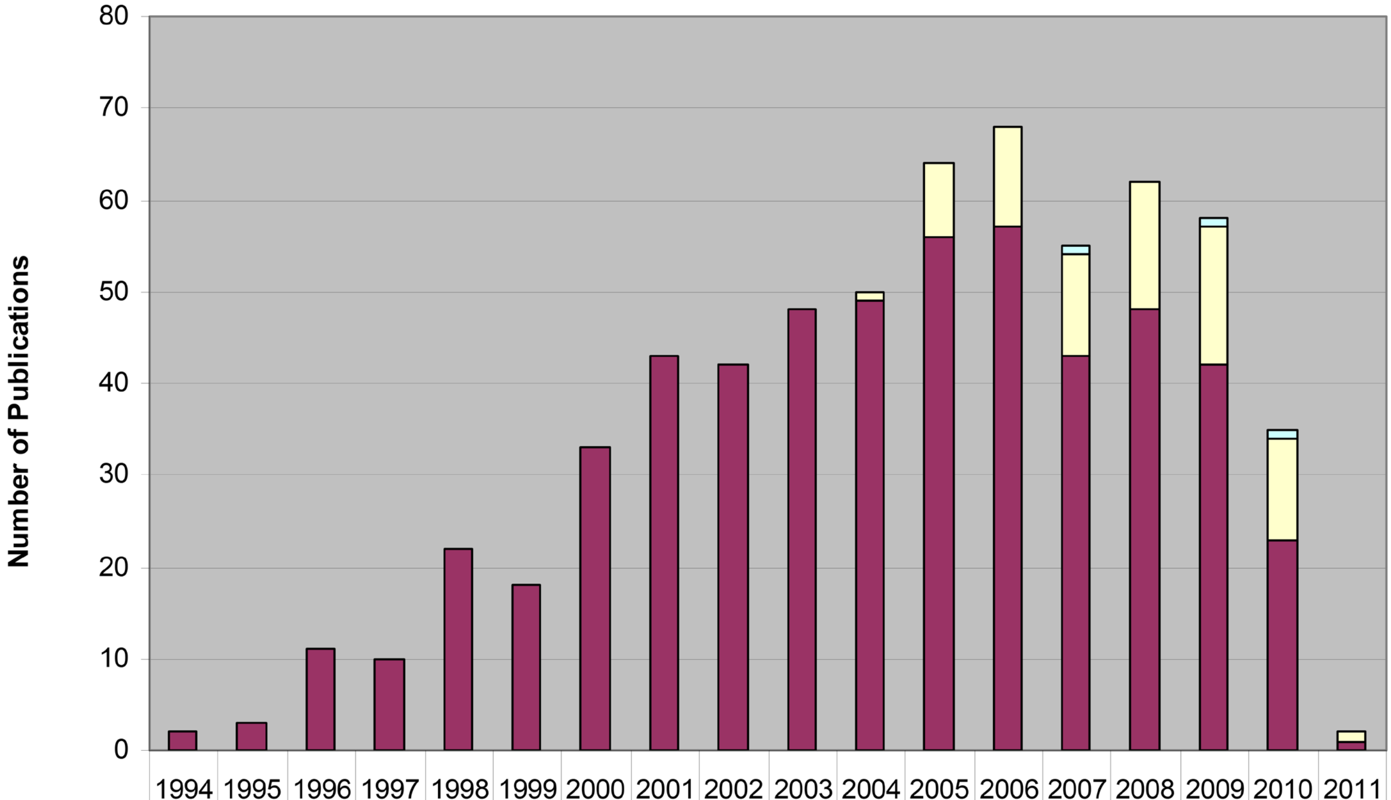
Journal Title	Number of Articles
Ecological Research	1
Ecology	1
Ecology Letters	1
Endangered Species Update	1
Energy Policy	1
Environmental Entomology	1
Environmental Geology	1
Environmental Science and Pollution Research	1
Environmetrics	1
Evolution	1
Fire Ecology	1
Forestry Chronicle	1
Freshwater Biology	1
Frontiers in Ecology and the Environment	1
Geoderma	1
Geographical Review	1
Geoscience and Remote Sensing Symposium Proceedings	1
Geospatial Health	1
GIScience and Remote Sensing	1
Great Basin Naturalist	1
Great Plains Research	1
Human and Ecological Risk Assessment	1
Human Dimensions of Wildlife	1
Human Ecology Review	1
Hydrobiologica	1
Hydrological Sciences Journal	1
Insecta Mundi	1
Integrated Environmental Assessment and Management	1
International Journal of Biodiversity and Conservation	1
International Journal of Wildland Fire	1
Invasive Plant Science and Management	1
IUCN Otter Specialist Group Bulletin	1
Journal of Applied Ecology	1
Journal of Applied Remote Sensing	1
Journal of Biogeography	1
Journal of Conservation Planning	1
Journal of Environmental Engineering	1
Journal of Environmental Planning and Management	1
Journal of Environmental Quality	1
Journal of Great Lakes Research	1
Journal of Insect Conservation	1

Table 1. Journal title and number of articles from each journal.—Continued

Journal Title	Number of Articles
Journal of Land Use Science	1
Journal of Raptor Research	1
Journal of Remote Sensing	1
Journal of the North American Benthological Society	1
Journal of the Torrey Botanical Society	1
Journal of Water Resources Planning and Management	1
Kalmiopsis	1
Lake and Reservoir Management	1
Marine Geodesy	1
Marine Pollution Bulletin	1
McNair Research Journal	1
Northeastern Naturalist	1
Northern Journal of Applied Forestry	1
Northwest Science	1
Northwestern Naturalist	1
Ocean Engineering	1
Oecologica	1
Parks	1
Peromyscus Newsletter	1
Physics and Chemistry of the Earth	1
Proceedings of the National Academy of Sciences	1
Pure and Applied Geophysics	1
Rangeland Ecology & Management	1
Sensors	1
The Bryologist	1
Transactions in GIS	1
Transactions of the American Entomological Society	1
Transactions of the American Fisheries Society	1
Transactions of the ASABE	1
Urban Ecosystems	1
Water Resources Research	1
Water, Air, and Soil Pollution	1
Waterbirds	1
Weather and Forecasting	1
Western North American Naturalist	1
Wildfowl	1
Wildlife Biology in Practice	1
Wyoming Open Spaces Bulletin	1
Yearbook of the Association of Pacific Coast Geographers	1

Year

GAP has been producing data for more than a decade. State GAP datasets predate the regional and national datasets. One concern regarding GAP data from the state projects is that the datasets are out-of-date and may no longer be as useful. Another view is that the historical perspective provided by older datasets is invaluable, and these datasets will continue to be used particularly in light of the evolution of landscapes and the threat of climate change. We categorized the publications based on the year of publication with separate counts for use of state, regional, and national data (figure 3).



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
National														1		1	1	
Region											1	8	11	11	14	15	11	1
State	2	3	11	10	22	18	33	43	42	48	49	56	57	43	48	42	23	1

Year

Figure 3. Number of publications citing state, regional, and national GAP data by year. The data for 2011 includes only the month of January.

Dataset

In addition to the distinction between state, regional, and national datasets, there are multiple datasets produced for each project: land cover, predicted species distributions, stewardship, and analysis. The analysis dataset synthesizes the land-cover, predicted species distributions, and stewardship datasets. We noted which datasets were used in each publication. Some publications used multiple datasets. There were publications in which the authors stated that data from GAP were used but did not provide sufficient detail for us to confidently determine which dataset was used.

First, we counted the number of publications using each type of data. If a publication used the land-cover datasets from two adjoining states, the publication would count as one publication using land-cover data. If a publication used a land-cover dataset and a predicted species dataset, it would count as one publication using land cover and one publication using predicted species data. The level of analysis was the publication. The number of publications using each type of dataset is depicted in figure 4. Land-cover data was used in 73 percent of the publications. Because some of the publications used more than one type of dataset, the total number of publications depicted in the pie chart in figure 4 exceeds the number of publications in the dataset.

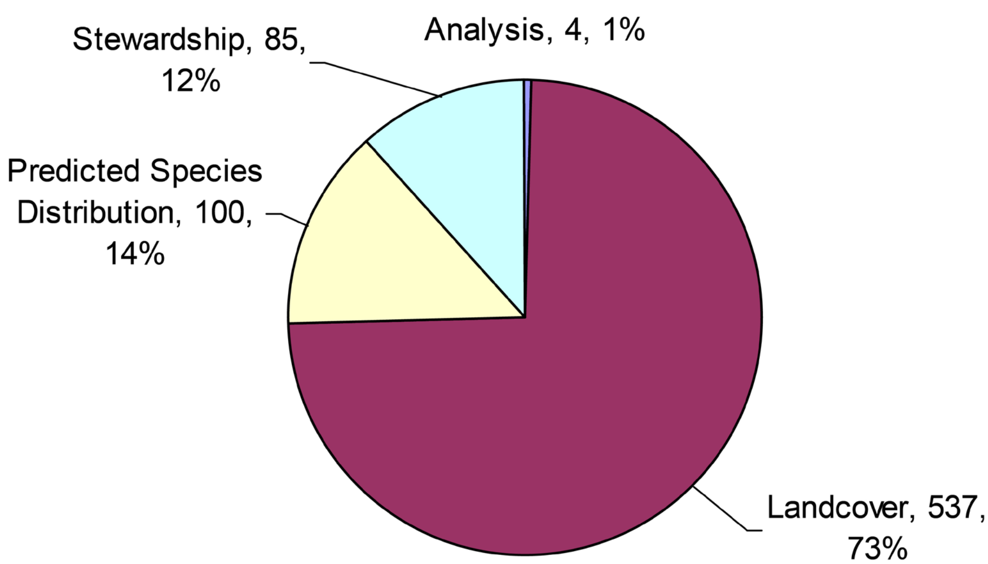
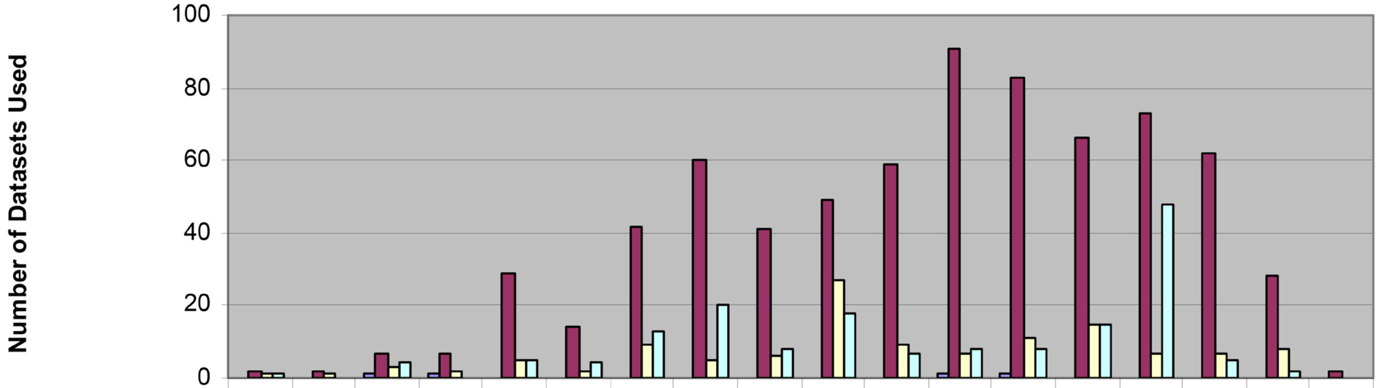


Figure 4. Number and percent of publications using each type of dataset.

Second, we counted the number and type of datasets used in each publication. For example, if a publication used the land-cover datasets from two adjoining states, that counted as two uses of land-cover datasets. The level of analysis was the dataset. Figure 5 provides the number of each type of dataset used by year of publication.



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Analysis			1	1								1	1					
Landcover	2	2	7	7	29	14	42	60	41	49	59	91	83	66	73	62	28	2
Predicted Species	1	1	3	2	5	2	9	5	6	27	9	7	11	15	7	7	8	
Stew ardship	1		4		5	4	13	20	8	18	7	8	8	15	48	5	2	

Year

Figure 5. Number of datasets used by year of publication. The data for 2011 includes only the month of January.

Each type of dataset is provided within the state, regional, and national projects. We counted the datasets used based on the state, regional, or national project as well as the type of data. To identify the project producing the data, we used the two letter abbreviation for states, PR for Puerto Rico, and the acronyms SWReGAP (Southwest regional GAP), SEGAP (Southeast GAP), and NWGAP (Northwest GAP). In figure 6, we provide the number of times each dataset was used in the group of publications used in this study. The datasets are grouped by state, region, or national level, and each type of data is depicted separately. The actual counts are provided when the number of times the dataset was used exceeds 10.

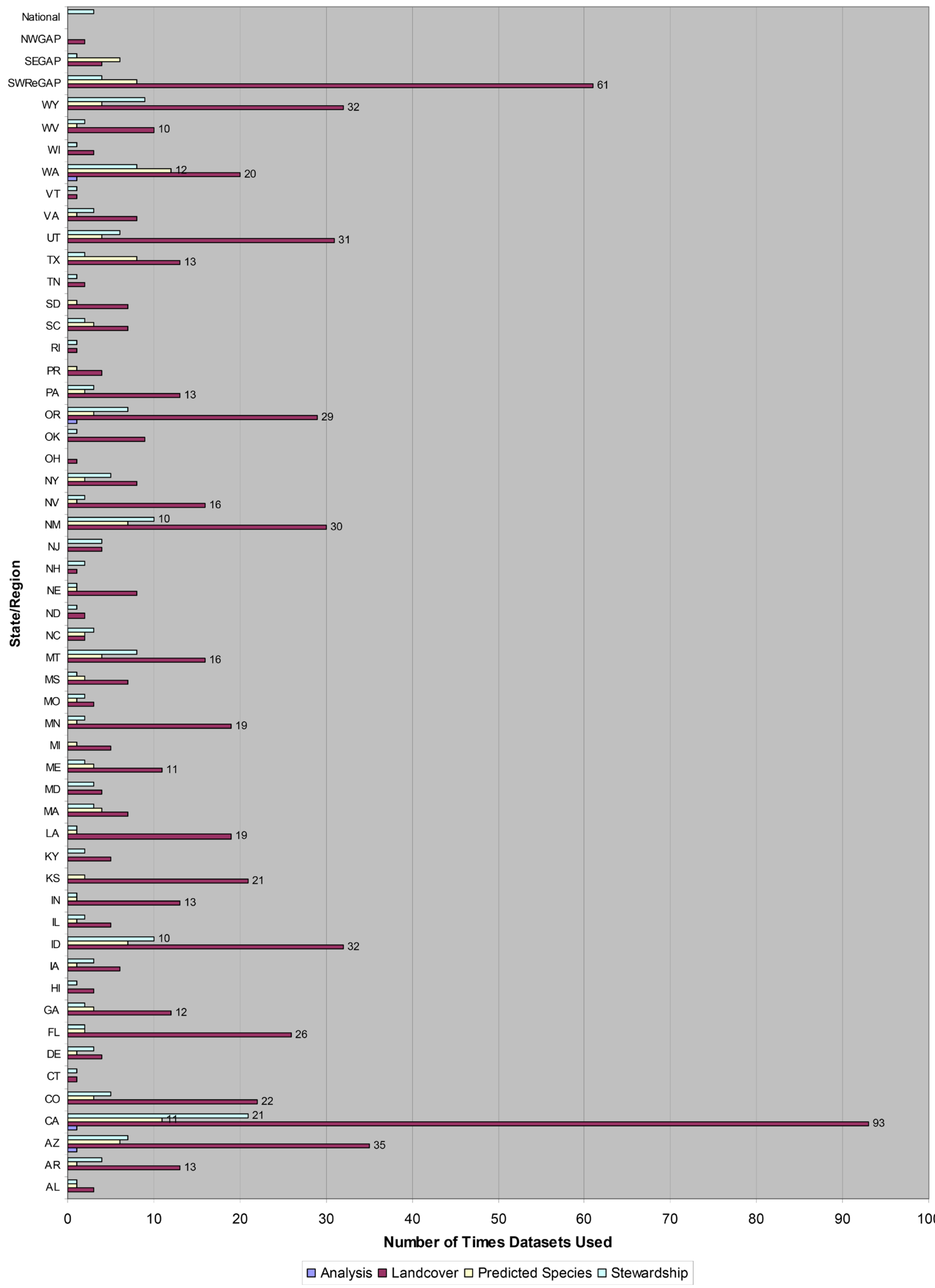


Figure 6. Frequency of use for each type of dataset, grouped by state, region, and national level.

There is evidence of use of multiple types of data from most state and all regional projects. There were no citations of use of Alaska GAP data. As seen in figure 6, there were only four state projects from which the analysis type of dataset was used: Arizona, California, Oregon, and Washington. Land cover was the only type of data used from the Ohio state project. At the national level, the stewardship type of data was used. The frequency counts demonstrate how widely the use of GAP datasets varies. There are two datasets that have been cited more frequently than many of the other datasets: land cover from the state GAP for California—cited 93 times, and the land cover from the Southwest Regional GAP—cited 61 times.

Durability of Datasets

One of the goals of the evaluation project is to understand the usefulness of GAP data. One approach is to determine how long GAP data continue to be used. The length of time that people use GAP data after the data are released can be interpreted as an indicator of the usefulness of the data. We determined the durability of the datasets from each project by comparing the early and the most recent years of publications that used data from that project. The state, regional, and national projects were finished at different times, so the datasets became available during different years. The durability of data from each project is illustrated in figure 7. We included the year that the projects were completed with the illustration of the data durability.

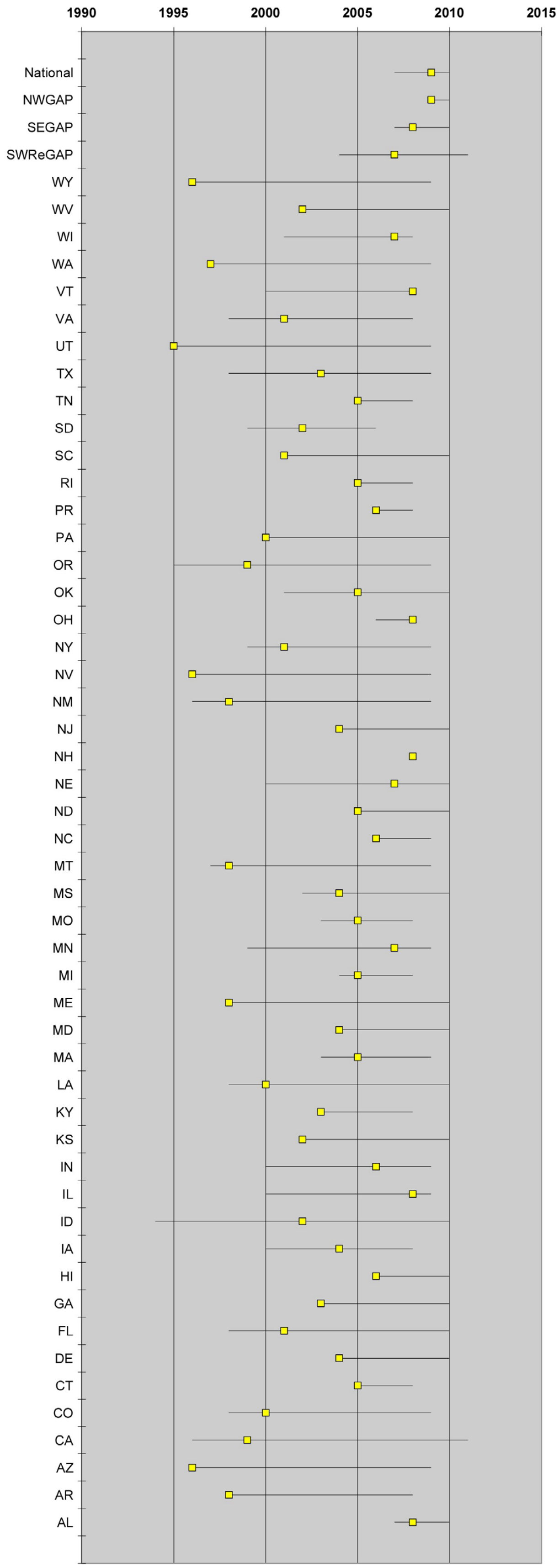


Figure 7. Durability of project datasets. The line for each project indicates the earliest and most recent years of publications included in this literature review. The official release date for the project data is indicated by a yellow point; this information was provided by the GAP office in Moscow, Idaho.

Information for projects was included in this figure if all relevant data (year of earliest publication, year of most recent publication, project release year) were available for that project. The durability of the datasets varies. The datasets from some projects (for example, Arizona, California, Idaho, Louisiana, Maine, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming) have been used for more than 10 years. In the case of the New Hampshire state project, the year of the earliest publication, the year of the most recent publication, and the year of the project completion are the same—2008.

There are some publications that used GAP data prior to the project completion dates. There are two reasons for this. For many GAP projects, land-cover data are completed and released prior to the other datasets and prior to project completion (Jocelyn Aycrigg, GAP, oral commun., 2010). Therefore, the project completion date is after the actual release of the data for some projects. Second, several authors cited the use of "pre-release" GAP data. In those instances, the publication year can be earlier than the project completion year.

Summary

The summary of this set of publications indicates that most authors were credited on one publication, which suggests that a broad group of authors have made use of GAP data. In addition to this large group of infrequent users, there is a small group of authors who use GAP data repeatedly. There may be others—those who use the data for applied purposes—who also use GAP data. The publication outlets for this set of publications were primarily journals. The dominance of journals as a publication outlet may have resulted from the search methodology—journals tend to be indexed in databases more often than book chapters or conference presentations. It may also result from the manner in which publications were excluded—applications of data may be more likely to be published in journals whereas descriptions of a program or method may be published as part of a book.

The types of journals that published articles citing GAP data were numerous and varied. The topics covered by the journals were quite diverse and included wildlife (Journal of Wildlife Management), conservation (Biological Conservation), weather (Weather and Forecasting), and infectious diseases (Emerging Infectious Diseases).

GAP data are time-sensitive in that they represent the land cover, stewardship, and predicted species distributions for a given area at a particular point in time. The state GAP datasets are based on older data than the regional GAP datasets. However, publications continue to be produced using GAP data from the state projects. This may indicate that GAP data have a longer than anticipated scientific life and that state datasets are not considered obsolete when regional or national datasets become available.

The land-cover type of data was most frequently used in publications. Used less frequently than land cover, predicted species distribution and stewardship datasets were utilized in 14 percent and 12 percent of publications respectively. The analysis data layer was rarely used.

The next step in the review of published literature was to summarize what the authors of these publications wrote regarding their use of GAP data.

Qualitative Review of Comments

We searched the text of each publication for statements regarding GAP data. We included all written language as the text of the publication. Figure and table headings and notes, acknowledgments, and reference lists were included in our review of a publication's text. We looked specifically for "gap" in the text and then determined if the statement referred to a dataset, a map, the national program, a project, or gap methodology. We marked the statements that referred to data or maps and pulled those statements into a database. When possible, we conducted this text search electronically using the search function. In the cases in which we could not obtain an electronic copy of the publication but could obtain a hard copy, we conducted the search manually. This search resulted in 1,376 statements. Each publication contributed at least one statement.

We reviewed this set of statements to identify emergent themes. Emergent themes are those that are derived from the set of statements; this is a bottom-up process. An alternative top-down approach would be to use a set of predefined categories and identify statements that belonged in each of those categories. This approach is limiting in that the categories are restricted to the predefined categories—what we would expect authors to state about GAP data. Because we were interested in comments generated by the authors rather than a select group of themes on which we expected authors to comment, we chose to use the bottom-up process of identifying emergent themes. Six broad themes emerged from these statements. The themes were description of data, how data were used, critiques, comparisons, commentary, and reference to GAP data. We describe each of these themes and provide examples. We report the number of statements in the theme and the number of publications that produced these statements, because the number of publications from which the statements are drawn provides context for understanding the number of statements. For example, accuracy of GAP data was cited as an issue in 29 statements. The context to interpret that theme is different if those statements came from 24 publications as opposed to if all 29 statements came from two publications. The latter case indicates that the accuracy issue was raised more frequently by a small number of authors.

Description of Data

The 559 statements in this category provide a description of the GAP data used by the authors. This was the largest category that emerged from the set of statements derived from the publications. All of the publications identified as citing GAP data included some statement about the use of GAP data. However, not all of them made statements that would have been included in this category. For example, if a citation of GAP data was included on the reference list only and made no other mention of GAP data in the text of the article, there would be no text that described the GAP data. The statements describing the data were from 430 of the 646 publications. In some cases, the description was concise. For example, Coops and Waring (2001a, p. 20) stated, “We obtained data on the spatial distribution of current vegetation from the Oregon Gap Analysis Program.” Some publications, such as Singleton and others (2004), referenced GAP in the body of tables or in the acknowledgments only and not in the actual text of the document.

Other publications included additional information in the statement describing GAP data. For example, Boykin, Boykin, Stovall, and Whitaker (2008, p. 213) included a reason why the GAP data was used, “Because of the varying land management occurring within the Bootheel region, the only available land cover map was from the original New Mexico Gap Analysis Project (Thompson and others 1996)." Other statements included information on how the authors obtained GAP data. For example, Mawdsley (2001a, p. 434) wrote, “Two ARC/INFO interchange files were obtained by anonymous ftp from the Arizona National Biological Information Infrastructure website (*http://usgsbrd.srnr.arizona.edu/nbii/index.html*; ftp site *ftp/srnr/arizona/edu*): a high-resolution vegetation map of Arizona (the Arizona Gap Vegetation map), and a map indicating the boundaries of federally designated wilderness areas in Arizona." Authors also provided additional detail about the GAP datasets. Karlik and others (2003, p. 316) wrote, “The GAP database developed for California (found at the website *http://www.biogeog.ucsb.edu/projects//gap/gap_home.html*) is an ARC/INFO GIS database with plant species and vegetation class attributes associated with polygons within a defined geographic region."

How Data Were Used

Statements that describe how the GAP data were used were included in this category—525 statements from 316 different publications, the second largest category of statements. The descriptions of how data were used appeared in two forms—either statements regarding how data were used as part of the method or statements regarding how GAP data were used within the context of the intent of the study. Statements that indicated GAP data were used in combination with other datasets appeared in 184 statements from 151 publications. For example, Leu and others (2008b, unpaged) wrote, “Furthermore, because the Sagestitch map did not cover the entire study area, we appended missing agricultural lands using state GAP coverages for Arizona, New Mexico, California, Oregon, and western Washington * * *. We developed a grid of forest habitat from the ‘Sagestitch’ map (http://sagemap.wr.usgs.gov), and GAP landcover data (New Mexico, Oregon, Arizona, Washington, and California) by using a crosswalk among forest types (deciduous forest, mixed deciduous/conifer forest, conifer forest) and the input data layers (Table 1).” Webb and others (2010, p. 111) supplemented GAP data with a soils dataset, “We analyzed a land cover dataset (1991–1993) provided by the GAP project of Nebraska (Henebry et al. 2005) and a hydric soils dataset provided by the Natural Resources Conservation Service to describe landscape characteristics."

One hundred ten statements from 87 publications indicated that a transformation to GAP data was necessary. Transformations were in the form of excluding portions of datasets, reclassifying data, and converting data to a different format. Hopton and Mayer (2006, p. 4480) described their transformation of GAP data, “We combined the Gap analysis data for 130 polygons in West Virginia with other data sources using ArcView 3.3 (ESRI, Redlands CA). Six of the original 136 Gap analysis polygons (#2, 14, 30, 48, 120, and 127) were excluded because none of the polygons extended into the state (Figure 1).” Hoffman and others (2008, p. 362) described how they condensed GAP data for their purposes, “Land cover data were gathered from the gap analysis program (GAP) data layer. GAP represents the highest spatial resolution, 30-m, land cover data for Nebraska. It consists of 20 different vegetation and land cover types. For this research, we condensed the GAP data into six major categories including native woodland, native grassland, wetland, cropland, water, and human inhabitance (i.e., towns and cities).” Roberson (2009, p. 21) described multiple transformations to the GAP data, “The location of all roads in the National Forest which was provided by the US Forest Service and the newest (2008) version of the South Carolina GAP land use classification dataset. First, the GAP land use classification was reclassified to a forest or non-forest dataset. Then the GAP land use classification was converted from a 30 meter cell size raster to a polygon feature class.”

GAP data were used as foundational data for some studies. In these cases, GAP data did not seem to be a primary focus or tool in the study. Rather, GAP data were used as a basis for implementing or evaluating a strategy or method. Seventy-six statements from 68 studies indicated that GAP data were used in a foundational manner. For example, GAP data were used to select sampling sites by Martin and others (2007, p. 542) who stated, “Therefore, we sorted the 2,566 available grids by the percentage of shortgrass prairie contained in the grid based on data from the Colorado Gap Analysis Program and then systematically selected every 50th grid for sampling foxes (with a random starting point between 1 and 51)." Larson and Sengupta (2004) used GAP data to test a spatial decision support system (SDSS).

Other publications included descriptions of how GAP data were compared to other data. Ninety-one statements from 63 documents were made regarding comparisons to GAP data. These statements did not include the outcomes of the comparisons, or in other words, how GAP data fared when compared to other datasets. These statements described how GAP data were used in the comparison. For example, Howell and others (2008, p. 169) stated their objectives clearly, “to build empirical hierarchical models to predict the probability of occurrence for 9 avian species throughout the state of Georgia, USA, and to compare the performance of our models to the associated Georgia GAP Analysis (GAGAP) models." Similarly, Rice and others (2008, p. 49) stated their goal “to compare the GAP LCLU layer and a derived LCLU layer developed with landsat imagery specifically for the Trans-Pecos region of Texas." Some of these comparisons were specifically conducted to test or evaluate GAP data. Karlik and others (2003, p. 317) wrote, “A subsample of polygons was selected as a test for correctness of the geographic location of a specific GAP polygon; in other words, a test of the registration of the GAP database.”

Other studies using GAP data framed their use of the data in terms of the intent or purpose of the study. Twenty-two statements from 19 publications indicated GAP data were used for studies regarding particular species. However, the predicted species distributions were not necessarily the GAP data used in these species studies. Adjemian and others (2006, p. 94) described their use of GAP data to study potential spread of plague by fleas, “Geographic information system (GIS) coverages of biological and environmental features were obtained from the California Gap Analysis Project (Santa Barbara, CA) and were used to develop the bioclimatic rules best associated with the observed locations of the fleas."

GAP data were also used in studies illustrating the use of these data for environmental planning and prediction. Eleven statements were made in eight studies that indicated this use of GAP data. For example, Crowe (1996, p. 232) wrote, “Another application of GAP and SCAG data was to prioritize planning related to at risk communities based on three criteria: amount of Protection Level III coverage, planned urban development coverage, and community size.” Additionally, 16 statements from 14 publications described the use of GAP data to identify management and protection status for land that is of potential conservation interest. Hopton and Mayer (2006, p. 4492) describe their use of GAP data as, “While Gap analysis uses assembled data to focus mainly on small groups of species with shared habitat requirements that have little to no protection, we used the data to assess whether the current patterns of protected areas cover the areas with the highest species richness. As this method illustrated, some Gap analysis polygons of high species and habitat richness are not well represented by the current network of publicly held protected areas.” Beal (2000, p. 121) concluded, “Of potential importance for conservation investment consideration, a comparison of each area with the land ownership layer in the Utah GAP (Edwards et al. 1995) indicated a large portion of both areas as privately owned.”

Finally, fifteen statements were made in eleven publications that GAP data were used in studies of change. For example, McKerrow (2007, p. 85) stated, “Specifically, we wanted to use the newly available 2001 GAP Ecological Systems map for the Onslow Bight as a base and perform backcasting to identify the pattern and types of land cover changes that had occurred between 1992 and 2001.”

Critiques

The statements that were categorized as critiques described limitations and problems with and cautions regarding the use of GAP data. There were 121 statements from 85 publications included in this category. The critiques addressed several different issues. Accuracy of GAP data and of products based on GAP data was one issue. Comments about accuracy of GAP data were part of 29 statements from 24 publications. For example, Lipow and others (2004, p. 422) stated, “The accuracy of the tree-distribution maps was lowest in southwestern Oregon, where they were based on the relatively poor-resolution Oregon GAP coverage.” Peterson (2008) suggested that the accuracy issue warranted a particular interpretation. Peterson (2008, p. 33) wrote, “Accuracy assessment on REGAP data suggests that annual grass cover is generally underestimated for sites with high cover, thus the map should be interpreted as an index of cover rather than an estimate of actual cover."

Other authors addressed errors in GAP data. There were 26 comments about error from 21 publications. Some statements were quite general. McCarthy (1998, p. 57) stated, "Like most ecological models, Arizona GAP models are subject to error for numerous reasons." Alfieri and others (2007, p. 1804) stated, "…while the GAP dataset is more accurate than the NLCD 92 data set, it still contains significant errors." Wolter and others (2006, p. 613) made a more specific statement regarding error. They wrote, "The water class of the Michigan GAP classification available at the time of this project was found to include erroneous lowland conifer classes—specifically black spruce in Landsat path 22/row 28."

Limits in the use of GAP data were noted in some statements included in the critique category. Certain information lacking from GAP data was noted 22 times in 19 publications. Other limits were noted in 26 statements in 21 publications. Enquist and Gori (2008, p. 415) noted a lack of certain information in the classification of GAP data, and stated "The GAP vegetation system, a widely-employed vegetation classification for Arizona and New Mexico, was also printed on the maps to serve as a general reference to vegetation type (Thompson et al. 1996; Halvorson et al. 2001). However, it should be noted that the developers of the GAP map did not incorporate information on the amount of shrub cover nor presence of non-native grasses as a means of classifying grassland association types." A limit related to classification was also commented on by Hurley (2001, p. 104), who wrote, "Oregon GAP neglects to separate out certain types of agriculture, namely orchards. * * * Consequently, the current analysis identifies large chunks of agriculture within areas identified by ORGAP as native forest or woodlands. The large tracts of orchard evident from air photos do not appear in the Oregon GAP map." Larson and Sengupta (2004, p. 17) describe the limitation to the use of GAP data created by data quality issues. They state, "However, the effectiveness of the results generated by the SDSS [spatial decision support system] is currently limited by the quality of the GAP data available to perform such analyses." Thompson and others (2001, p. 240) cautioned others to careful use of GAP data when they stated, "Results of our research indicate estimates based on breeding areas do not reliably coincide with areas used by non-breeding birds. If the goal of the GAP is to broadly represent biodiversity, including migrant birds is essential. However, keeping migrant species distributions and richness estimates separate from breeding bird distributions and richness estimates (as currently recommended by GAP coordinators) is an acceptable way to present this information as long as it is recognized that breeding birds are probably not suitable surrogates for all birds when attempting to locate areas of significant use. * * * we stress the importance of carefully framing the questions investigated with GAP data sets."

Finally, 18 critiques addressed the limits to the utility or usefulness of GAP data. These statements came from 15 publications. Peterson (2005, p. 232–233) wrote, "The difference seems to be a result of uneven methods in the Kansas Gap program for establishing likely presence of a particular species in a particular land use or land cover type, making for unstable predictions using the Gap method." Weathers and others (2009, p. 147–148) made this comment about the use of GAP data, "GAP land cover data were used as the primary source for habitat type. However, because of (1) availability of higher resolution data (i.e., DOQQ [digital orthophoto quarter quadrangles] imagery and DEMs [digital elevation models), (2) incorrect land classification resulting from the coarse resolution of the data, and (3) changes in land cover realized after the GAP baseline data were captured (in 1992), this data set was not solely relied on for habitat classification."

Comparisons

As described in a previous section, some use of GAP data was for the purpose of comparing GAP data to other data. The statements included in the section on how data were used included statements describing the comparisons. We categorized statements regarding the outcomes of comparisons between GAP data and other data into a separate category. There were 51 statements from 34 publications describing how GAP data fared in comparison to other data.

Nineteen statements from 15 publications indicated that the result of the comparison was unfavorable to GAP. All of the 15 publications cited use of data from state GAP projects. Eleven of the 15 publications cited the use of land-cover data; three publications used predicted species distribution data; one publication used land cover and predicted species distribution data. Thorne and others (2004, p. 359) compared GAP data to the CalVeg map and to a map created by the authors based on the Manual of California Vegetation (MCV); they concluded that "Where equal vegetation type extents were measured between GAP and MCV, MCV provides more information about the distribution." Specifically, they stated, "In a comparison with two previous digital vegetation maps for the area, the US Forest Service's CalVeg and the Gap Analysis Program's GAP maps, the MCV map had finer spatial and floristic resolution. The MCV map has 15 more vegetation types than CalVeg and 22 more vegetation types than GAP. The MCV map contains more riparian corridors and isolated wetlands, identifying 157 km^2 of these types, compared to 7 km^2 for CalVeg and a non-spatial result for GAP." (Thorne and others, 2004, p. 343).

Fifteen statements from 11 publications indicated that the result of the comparison was favorable to GAP. The publications providing these favorable statements most frequently used land cover data from state GAP projects. Eight of the 11 publications used state project land cover data. State project predicted species distribution data, and regional project land cover and predicted species data were each cited in one publication that provided favorable statements regarding the comparison of GAP data to other data. Mehaffey and others (2009) compared GAP data to other data when deciding which dataset to use in their study of air pollution on habitat. They described their conclusion as, "We used final-draft-before-release SE-GAP data. We believe the data is high quality and accurately maps potential habitat for the species groups we examined (SE-GAP 2007). * * * Qualitative comparison of the SE-GAP data compared favorably, in respect to overall distribution of habitat, to other ecological model output for the region such as the Southeast Ecological Framework (USEPA 2002) and as such we felt it was adequate for the purpose of demonstrating the toxic vulnerability methods of this study." (Mehaffey and others, 2009, p.154).

Nine statements from seven publications described mixed results from a comparison of GAP data to other data. We classified statements as mixed if the authors described the results of the comparison as being favorable to GAP in some way and unfavorable to GAP in another way. For example, Peterson and Kluza (2003, p. 49, 51) wrote, "Omission error was lower in gap models (Table 1). In 24 of 30 species, gap models had better success in predicting the 20 test presence points, whereas GARP [Genetic Algorithm for Rule-Set Prediction] models were better in only three species; the two methods tied for three species. Hence, on the omission criterion, gap models performed better than GARP models. The situation regarding commission error, however, was different. For this error component, GARP models outperformed gap models in 28 of 30 species, with substantial differences in commission error (Table 1)." In another example, Wardlow and Egbert (2003, p. 1396) stated, "NLCD [National Land Cover Data] gives a useful first-order view of general land-cover patterns at the state to regional level and GAP provides a more detailed view of localized land-cover patterns within the state." Four of the seven publications that generated these mixed statements cited use of state project land cover data. State project predicted species distribution data and regional project land cover data were each cited in one of the seven publications. One publication used state project land cover and stewardship data.

Finally, eight statements from eight publications described GAP data as equivalent to other data. Five of these eight publications used state project land cover data. One publication used land cover and stewardship data from a state project; one publication used regional predicted species distribution data; and one publication used stewardship and predicted species distribution data from a regional project. Moen, Burdett, and Niemi (2008) used GAP data and compared it to another land-cover dataset. They concluded “The LULC [Land Use Land Cover] and GAP coverages were created from different LANDSAT scenes, were classified by different organizations, and had different cover type naming conventions (MDNR, 2007a, b, p. 1512). Yet both classifications resulted in similar relationships between selected cover types and distance from the den site.”

Commentary

The theme we labeled as commentary includes statements that are favorable to GAP but that do not arise from a comparison of GAP data to other data. Thirty-nine statements from 32 publications were categorized as commentary. Twenty-six statements from 22 publications were strictly favorable to GAP. For example, Chung and Winer (1999, p. 195) stated, “Despite the discrepancies between predicted and observed plant species cover, on average the utility of the GAP database for developing BHC [biogenic hydrocarbons] emission inventories appears to be adequate.” Clark and Slusher (2000, p. 77) described the importance of GAP stewardship data to their study. “Because areas managed by ILDNR [Illinois Department of Natural Resources], IDNR [Indiana Department of Natural Resources], TNC [The Nature Conservancy], NAWMP [North American Waterfowl Management Plan], counties, and the military were important in the analysis, the Gap Analysis Stewardship data layer proved essential to Phase 1.”

Other comments indicated that a potential negative aspect of GAP was mitigated in their situation and was either not a problem or was favorable. Thirteen statements from 12 publications indicated that GAP issues were mitigated. Dumas (2005, p. 75–76) wrote, “Anyone with a working knowledge of ArcGIS™ can easily work with the GAP datasets. It is standardized and nationally accepted, easy to use with standard GIS tools and free to the public. The only drawback experienced was the dating of the data. GAP data for this project was based on LandSat imagery from the mid-1990s and a lot can change in that amount of time, however because this project was based within the Bienville National Forest, most of the landcovers have not changed in that amount of time.” Another example that indicated the datedness of GAP data was not an issue was found in Thatcher and others (2009, p. 919), who stated, “We chose a subset of the panther telemetry data for analysis that coincided with a time period within 5 years (1988–1998) of the Florida Gap Analysis Program (GAP) land-cover data (1993, see “*Landscape data*”). Although more recent landscape data were available, the majority of the radiotelemetry data coincided with the 1993 landscape data set.” Not all of the statements were about the datedness of data. Comments in the critique category previously described in this report address accuracy of GAP data as a concern. McClain and Porter (2000, p. 558) described GAP accuracy as less of a concern. They wrote, “However, in both the HSI [habitat suitability index] and PATREC [pattern recognition] models, the data obtained from the GAP classification had higher correlations with the harvest data (highest GAP $r^2 = 0.584$, highest NFLI [Northern Forest Lands Inventory] $r^2 = 0.328$). The better predictability of the GAP data suggests that GAP’s slightly lower accuracy is not as detrimental as NFLI’s 10-ha mmu [minimum mapping unit].”

Reference to GAP Data

The final theme included references to GAP data and products that were not specifically about use of GAP data. There were 81 statements from 67 publications in this category. Larson and Sengupta (2004, p. 11) made a descriptive statement about GAP data and wrote, "Most of the analysis was performed in raster mode, which is the native format of the GAP datasets released by the state agencies." Similarly, McCarthy (1998) described the products of Arizona GAP. McCarthy wrote, "Arizona's participation in GAP has resulted in a vegetation map with a greater resolution than previous editions and over 500 geo-referenced predicted vertebrate distribution maps" (p. 61).

Summary

One of the unique contributions of this publication search is that it provided a view of what statements were made and how GAP data were described in the public realm. Examination of the statements made in these publications illustrated how GAP data were depicted by those who have made use of these datasets. Authors identified GAP as their source of data and provide descriptions of varying detail regarding the datasets they used. The descriptions of how GAP data were used were also varied. Some of the statements described the tactical use of GAP data—how the data were used as a foundation for another analytical technique or to select study sites. Statements made in these publications also indicated that transformations to GAP data were necessary for some applications. These transformations could involve combining GAP with other data, excluding some data from the GAP datasets, or altering the format of the data. This suggests that a minimum level of expertise may be needed by those who use GAP data.

The statements regarding how GAP data were used suggested a range of applications. While some of the applications seem to fall in line with the goal of GAP, such as the studies of species, studies for prediction and planning, and identification of management and protection status, other publications indicated a use of GAP data for other purposes. The emergent category of change studies which primarily focused on landscape change demonstrates that GAP data have been used to study issues of increasing importance that may not be directly related to conservation of biodiversity.

The evaluative comments that were made regarding GAP data that were included in the critique, comparisons, and commentary themes present a mixed picture of GAP data. The issues raised in some publications as critiques of GAP data such as accuracy, errors, and limits based on characteristics of the data, were described in other publications as issues that did not impact the study or were otherwise mitigated. Comparisons of GAP data to other datasets yielded results that were unfavorable, favorable, and mixed towards GAP. The diversity of these comments suggests that issues with GAP data may be application specific. In other words, an issue in one study may be a nonissue in another. For example, the datedness of the state GAP datasets may create an accuracy issue in one study dependent on the goal of that study. However, the datedness may be a nonissue if there has not been much change in the characteristic mapped by the GAP dataset (such as land cover) or may actually be a benefit such as in studies of changes in landscape characteristics. For all categories of comparison outcome, the most frequently used datasets in those publications were land cover data from state GAP projects. This may reflect the overall higher levels of use of land cover data from state projects in the set of publications we identified.

These themes provided us with information to use in developing topics to include on the survey. In particular, the survey will include questions addressing the issues raised in the how data were used, critiques, commentary, and comparisons themes. Specifically the survey will include questions regarding the issues of accuracy, error, to what extent issues of accuracy and error are problematic to the user, what GAP data lack that would be useful, what transformations are necessary to make GAP data useful, and how GAP data compare to other datasets. The survey will also include questions regarding the level of GIS expertise needed to make use of GAP data.

Bibliometric Analysis

Bibliometric methods include a set of techniques for the quantitative study of publications (Gauthier, 1998; Schubert and others, 1988; Wallin, 2005). The results of bibliometric analyses have been used as components in the performance evaluation process for research programs (Campbell and others, 2010; Frame, 1983; Gauthier, 1998; Kostoff, 1995; Leydesdorff, 2005; Narin, 1987; Trochim and others, 2008; Verbeek and others, 2002) and in science policy and planning (Irvine and others, 1987). Bibliometric analyses are not recommended as stand alone methods for evaluation but are considered a useful component to use in conjunction with other methods (Melkers, 1993; Pendlebury, 2009).

The most commonly used measures in bibliometric analyses for evaluation (Martin, 1996; Narin and others, 1994) are publication and citation counts. These can be used as partial indicators of research impact (Campbell and others, 2010; Frame, 1983; Martin and Irvine, 1983; Mullins, 1987; Schubert and others, 1988). Number of publications is considered an acceptable measure of research production (Martin, 1996; Melkers, 1993; Narin and Hamilton, 1996; Shapira and others, 2003; van Raan, 1989; Verbeek and others, 2002) or research activity (Kostoff, 1995; Narin, 1987). A count of the number of publications has been used to evaluate the impact of a program providing resources to researchers (Campbell and others, 2010). For example, Campbell and others (2010) evaluated the effect of a program that provides funding to researchers. GAP is in a similar position in that it provides resources in the form of datasets. Bibliometric techniques have been used in program evaluation for federal agencies (U.S. Environmental Protection Agency, 2006; Kostoff, 1994; Kostoff, 1995; Porter and others, 2003; Porter and others, 2010; Roessner, 2002; Trochim and others, 2008). These techniques have been recommended as useful in documentation for the Government Performance and Results Act to demonstrate the results of a program (Hicks and others, 2004; Narin and Hamilton, 1996).

In the case of GAP, the results of a bibliometric analysis are an indirect evaluation of the program because GAP itself did not produce the publications in the analysis. GAP produced the datasets which were used by the authors who wrote the publications. There may have been uses of GAP data to create maps or documents that have not been published because they were used exclusively for management of natural areas. The bibliometric analysis indicated the research impact of GAP—an added benefit given that the primary objective of GAP is to promote management of land for the conservation of biodiversity. Previous evaluations of databases—instead of programs—have included bibliometric analyses (Hicks and others, 2004). Bibliometric analyses have been used to investigate the use of publications in diffusion of innovation (Genuis, 2005) and evaluation of research and development activities (Melkers, 1993). In a sense, the datasets produced by GAP are an innovation and identifying how they have been used to generate publications provides evidence regarding the level of diffusion achieved.

Based on prior use of bibliometric analysis for programs and databases and for federal programs, we concluded that this analysis was appropriate to include in the evaluation of published literature citing GAP data.

The weakness of any given indicator in bibliometric analysis can be offset by combining it with other measures (Thelwall, 2004). In the bibliometric analysis for literature citing datasets produced by GAP, we used descriptive indicators including journal impact factors, journal impact ranks, and citations. These indicators are considered evidence of the volume of scientific output related to a program and the impact of program output on the development of knowledge in a field (Campbell and others, 2010; Gauthier, 1998).

Publication Count

The set of 646 nonduplicate publications collected for the literature review was included in the bibliometric analysis. The publication dates ranged from 1994 to 2011. Fifty-three percent of the publications were journal articles. We summarize the journal impact factors and ranks for the journal publications only. We included all 646 publications in our search for citations.

Journal Impact

The journal impact factor represents the frequency of citation for an average article from a journal within a defined time period (Garfield, 1994). Although the journal impact factor is not a perfect measure of the research impact of any article published in the journal, the impact factor of the journal is often used as a proxy measure of impact of the articles included in the journal (Davis and Royle, 1996; Seglen, 1997). The journal impact factor has been demonstrated to relate to the perceived prestige of the journal (Davis and Royle, 1996). Some of the specific criticisms of use of the journal impact factor, for example that many databases are less likely to index non-U.S. publications (Rey-Rocha and others, 2001; Seglen, 1997; Verbeek and others, 2002), are not relevant to our bibliometric analysis for publications citing GAP data. The databases produced by GAP are specific to the U.S. and publications using GAP data are likely to be published in U.S.-based journals. However, our set of publications also includes journal articles published in European-based journals. We found that some of these journals are indexed in the databases we used for the bibliometric analysis making less relevant the criticism that non-U.S. publications are less likely to be indexed.

We obtained five-year journal impact factors and ranks from the Web of Science Journal Citations Report® (JCR) Science Edition 2010. These were the current journal impact factors and in some cases may differ from the journal impact factor at the publication date of individual articles. Journal impact factors do not generalize across disciplines (Gauthier, 1998; Narin and Hamilton, 1996; Seglen, 1997) and so caution must be exercised in interpreting the results for multiple disciplines. Journal ranks indicate the relative standing of a journal based on its impact factor compared to other journals within the same discipline. We report the number of articles from each journal appearing in the list of publications citing GAP data, with the impact factor, the discipline with which the journal is affiliated, the journal impact rank, and the corresponding quartile of the rank in table 2.

Table 2. Number of articles appearing in each journal, 2010 journal impact factor, discipline, and journal impact rank.

Journal Title	Number of Articles	5 yr Journal Impact	Category	Journal Rank	Quartile
Journal of Wildlife Management	20	1.977	Ecology	73/129	Q3
Conservation Biology	17	5.963	Biodiversity Conservation	2/33	Q1
Ecological Applications	14	5.067	Ecology	23/129	Q1
Landscape Ecology	9	3.648	Ecology	35/129	Q2

Table 2. Number of articles appearing in each journal, 2010 journal impact factor, discipline, and journal impact rank.—Continued

Journal Title	Number of Articles	5 yr Journal Impact	Category	Journal Rank	Quartile
Photogrammetric Engineering & Remote Sensing	9	1.566	Imaging Science & Photographic Technology	9/19	Q2
Wildlife Society Bulletin	8	N/A			
Biological Conservation	7	4.042	Biodiversity Conservation	6/33	Q1
Environmental Monitoring and Assessment	6	1.539	Environmental Sciences	106/192	Q3
Natural Areas Journal	6	0.863	Ecology	109/129	Q4
Environmental Management	5	1.895	Environmental Sciences	101/192	Q3
Journal of Mammalogy	5	2.074	Zoology	43/145	Q2
Madroño: California Botanical Society	5	N/A			
Molecular Ecology	5	6.633	Ecology	5/129	Q1
Remote Sensing of Environment	5	4.605	Environmental Sciences	16/192	Q1
Southwestern Naturalist	5	0.547	Ecology	120/129	Q4
Monthly Weather Review	4	2.649	Meteorology & Atmospheric Sciences	18/68	Q2
American Journal of Tropical Medicine and Hygiene	3	2.884	Public, Environmental, & Occupational Health	38/140	Q2
American Midland Naturalist	3	0.768	Ecology	115/129	Q4
Animal Conservation	3	3.037	Ecology	42/129	Q2
Auk	3	2.276	Ornithology	3/19	Q1
Diversity and Distributions	3	4.550	Ecology	25/129	Q1
Ecography	3	5.325	Ecology	22/129	Q1
Environmental Modelling & Software	3	2.900	Environmental Sciences	38/192	Q1
Forest Ecology and Management	3	2.507	Forestry	6/54	Q1
International Journal of Remote Sensing	3	1.551	Remote Sensing	9/23	Q2
Journal of Arid Environments	3	2.064	Environmental Sciences	99/192	Q3
Journal of Forestry	3	1.465	Forestry	23/54	Q2
Journal of Medical Entomology	3	2.257	Veterinary Sciences	17/145	Q1
Journal of the American Water Resources Association	3	1.771	Geosciences, Multidisciplinary	77/165	Q2
Landscape and Urban Planning	3	2.789	Ecology	57/129	Q2
North American Journal of Fisheries Management	3	1.439	Fisheries	20/46	Q2
Southeastern Naturalist	3	0.501	Ecology	125/129	Q4
Wetlands	3	1.810	Environmental Sciences	119/192	Q3

Table 2. Number of articles appearing in each journal, 2010 journal impact factor, discipline, and journal impact rank.—Continued

Journal Title	Number of Articles	5 yr Journal Impact	Category	Journal Rank	Quartile
American Fisheries Society Symposium	2	N/A			
Applied Geography*	2	2.320	Geography	10/65	Q1
Atmospheric Environment	2	3.435	Environmental Sciences	24/192	Q1
Biodiversity and Conservation	2	2.336	Biodiversity Conservation	12/33	Q2
Condor	2	1.775	Ornithology	5/19	Q2
Ecohydrology	2	1.873	Ecology	63/129	Q2
Ecological Indicators	2	3.058	Environmental Sciences	36/192	Q1
Ecological Modelling	2	2.438	Ecology	68/129	Q3
Ecology and Society	2	4.644	Ecology	34/129	Q2
Ecosystems	2	4.735	Ecology	26/129	Q1
Emerging Infectious Diseases	2	6.996	Immunology	14/134	Q1
Forest Policy and Economics	2	1.315	Forestry	25/54	Q2
Forest Science	2	1.590	Forestry	18/54	Q2
Global Change Biology	2	7.814	Ecology	6/129	Q1
Global Ecology and Biogeography	2	6.330	Ecology	10/129	Q1
Journal of Coastal Research	2	0.690	Environmental Sciences	168/192	Q4
Journal of Soil and Water Conservation	2	1.695	Water Resources	27/76	Q2
Journal of the Arkansas Academy of Science	2	N/A			
Journal of Vegetation Science	2	3.002	Forestry	2/54	Q1
Occasional papers, Museum of Texas Tech University	2	N/A			
Oikos	2	3.920	Ecology	33/129	Q2
PloS ONE	2	4.610	Biology	12/85	Q1
Professional Geographer*	2	1.988	Geography	18/65	Q2
Quaternary Research	2	3.310	Geosciences, Multidisciplinary	28/165	Q1
Soil Science Society of America Journal	2	2.598	Soil Science	13/32	Q2
Southern Journal of Applied Forestry	2	0.713	Forestry	40/54	Q3
Studies in Avian Biology	2	N/A			
Transactions of the Kansas Academy of Science	2	N/A			
Ursus	2	1.090	Zoology	95/145	Q3
Western Journal of Applied Forestry	2	0.660	Forestry	37/54	Q3
Wildlife Biology	2	1.137	Zoology	96/145	Q3
Wilson Journal of Ornithology	2	0.593	Ornithology	15/19	Q4

Table 2. Number of articles appearing in each journal, 2010 journal impact factor, discipline, and journal impact rank.—Continued

Journal Title	Number of Articles	5 yr Journal Impact	Category	Journal Rank	Quartile
Agricultural Water Management	1	2.391	Water Resources	17/76	Q1
Ambio	1	2.847	Environmental Sciences	86/192	Q2
American Journal of Enology and Viticulture	1	2.568	Horticulture	6/30	Q1
Annals of the Association of American Geographers*	1	2.986	Geography	11/65	Q1
Applied Vegetation Science	1	2.091	Forestry	9/54	Q1
Biological Invasions	1	3.749	Biodiversity Conservation	7/33	Q1
Bioresource Technology	1	4.901	Energy & Fuels	9/78	Q1
BioScience	1	6.335	Biology	7/85	Q1
Bryologist	1	1.039	Plant Sciences	108/187	Q3
California Agriculture**	1	0.918	Agriculture, Multidisciplinary	15/55	Q2
Canadian Journal of Fisheries and Aquatic Sciences	1	2.690	Fisheries	6/46	Q1
Climatic Change	1	4.433	Environmental Sciences	35/192	Q1
Computing in Science and Engineering	1	0.899	Computer Science, Interdisciplinary Applications	66/97	Q3
Conservation and Society	1	N/A			
Conservation Genetics	1	1.889	Biodiversity Conservation	16/33	Q2
Digital Soil Mapping	1	N/A			
Ecological Monographs	1	8.827	Ecology	8/129	Q1
Ecological Research	1	1.671	Ecology	89/129	Q3
Ecology	1	6.218	Ecology	12/129	Q1
Ecology Letters	1	14.261	Ecology	1/129	Q1
Endangered Species Update	1	N/A			
Energy Policy	1	3.020	Environmental Sciences	46/192	Q1
Environmental Entomology	1	1.702	Entomology	21/83	Q2
Environmental Geology	1	1.344	Environmental Sciences	135/192	Q3
Environmental Science and Pollution Research	1	2.733	Environmental Sciences	39/192	Q1
Environmetrics	1	0.986	Statistics & Probability	64/110	Q3
Evolution	1	6.041	Ecology	9/129	Q1
Fire Ecology	1	N/A			
Forestry Chronicle	1	0.845	Forestry	34/54	Q3
Freshwater Biology	1	3.785	Marine & Freshwater Biology	7/92	Q1
Frontiers in Ecology and the Environment	1	7.931	Environmental Sciences	2/192	Q1
Geoderma	1	2.806	Soil Science	5/32	Q1

Table 2. Number of articles appearing in each journal, 2010 journal impact factor, discipline, and journal impact rank.—Continued

Journal Title	Number of Articles	5 yr Journal Impact	Category	Journal Rank	Quartile
Geographical Review	1	0.648	Geography	50/65	Q4
Geoscience and Remote Sensing Symposium Proceedings	1	N/A			
Geospatial Health**	1	1.705	Public, Environmental, & Occupational Health	64/140	Q2
GIScience and Remote Sensing	1	N/A			
Great Basin Naturalist	1	N/A			
Great Plains Research	1	N/A			
Human and Ecological Risk Assessment	1	1.382	Environmental Sciences	103/192	Q3
Human Dimensions of Wildlife	1	N/A			
Human Ecology Review**	1	1.000	Sociology	43/129	Q2
Hydrobiologia	1	1.997	Marine & Freshwater Biology	25/92	Q2
Hydrological Sciences Journal	1	1.891	Water Resources	26/76	Q2
Insecta Mundi	1	N/A			
Integrated Environmental Assessment and Management	1	N/A			
International Journal of Biodiversity and Conservation	1	N/A			
International Journal of Wildland Fire	1	2.523	Forestry	5/54	Q1
Invasive Plant Science and Management	1	N/A			
IUCN Otter Specialist Group Bulletin	1	N/A			
Journal of Applied Ecology	1	5.715	Ecology	14/129	Q1
Journal of Applied Remote Sensing**	1	1.000	Remote Sensing	11/23	Q2
Journal of Biogeography	1	4.716	Ecology	24/129	Q1
Journal of Conservation Planning	1	N/A			
Journal of Environmental Engineering	1	1.217	Engineering, Civil	31/115	Q2
Journal of Environmental Planning and Management**	1	1.111	Environmental Studies	39/77	Q3
Journal of Environmental Quality	1	2.738	Environmental Sciences	56/192	Q2
Journal of Great Lakes Research	1	1.789	Environmental Sciences	115/192	Q3
Journal of Insect Conservation	1	1.901	Entomology	17/83	Q1
Journal of Land Use Science	1	N/A			
Journal of Raptor Research	1	0.568	Ornithology	16/19	Q4
Journal of Remote Sensing	1	N/A			

Table 2. Number of articles appearing in each journal, 2010 journal impact factor, discipline, and journal impact rank.—Continued

Journal Title	Number of Articles	5 yr Journal Impact	Category	Journal Rank	Quartile
Journal of the North American Benthological Society	1	3.920	Marine & Freshwater Biology	9/92	Q1
Journal of the Torrey Botanical Society	1	1.114	Plant Sciences	128/187	Q3
Journal of Water Resources Planning and Management	1	1.993	Engineering, Civil	25/115	Q1
Kalmiopsis	1	N/A			
Lake and Reservoir Management	1	0.742	Marine & Freshwater Biology	75/92	Q4
Marine Geodesy**	1	0.917	Oceanography	39/59	Q3
Marine Pollution Bulletin	1	2.899	Marine & Freshwater Biology	15/92	Q1
McNair Research Journal	1	N/A			
Northeastern Naturalist	1	0.567	Biodiversity Conservation	23/33	Q3
Northern Journal of Applied Forestry	1	0.741	Forestry	35/54	Q3
Northwest Science	1	0.531	Ecology	124/129	Q4
Northwestern Naturalist	1	N/A			
Ocean Engineering	1	1.038	Engineering, Civil	38/115	Q2
Oecologica	1	N/A			
Parks	1	N/A			
Peromyscus Newsletter	1	N/A			
Physics and Chemistry of the Earth	1	1.211	Water Resources	44/76	Q3
Proceedings of the National Academy of Sciences	1	10.591	Multidisciplinary Sciences	3/57	Q1
Pure and Applied Geophysics	1	1.231	Geochemistry & Geophysics	46/77	Q3
Rangeland Ecology & Management	1	1.579	Ecology	82/129	Q3
Sensors	1	1.917	Instruments & Instrumentation	14/61	Q1
Transactions in GIS	1	N/A			
Transactions of the American Entomological Society	1	0.414	Entomology	74/83	Q4
Transactions of the American Fisheries Society	1	1.959	Fisheries	13/46	Q2
Transactions of the ASABE	1	1.193	Agricultural Engineering	8/12	Q3
Urban Ecosystems	1	N/A			
Water Resources Research	1	3.081	Water Resources	2/76	Q1
Water, Air, and Soil Pollution	1	1.929	Water Resources	19/76	Q2
Waterbirds	1	0.746	Ornithology	14/19	Q3
Weather and Forecasting	1	1.980	Meteorology & Atmospheric Sciences	38/68	Q3
Western North American Naturalist	1	0.454	Ecology	121/129	Q4

Table 2. Number of articles appearing in each journal, 2010 journal impact factor, discipline, and journal impact rank.—Continued

Journal Title	Number of Articles	5 yr Journal Iimpact	Category	Journal Rank	Quartile
Wildfowl	1	N/A			
Wildlife Biology in Practice	1	N/A			
Wyoming Open Spaces Bulletin	1	N/A			
Yearbook of the Association of Pacific Coast Geographers	1	N/A			

*This journal did not appear in JCR Science Edition; the journal was included in JCR Social Science Edition 2010.

**No five-year Journal Impact Factor was available, the one-year Journal Impact Factor is substituted in this table.

N/A indicates the journal was not listed in either edition of the Journal Citation Report.

The impact factor of the journals in which articles citing GAP data were published ranged from 14.261 (Ecology Letters) to 0.414 (Transactions of the American Entomological Society). The journals were affiliated with 34 disciplines. There were 101 articles citing GAP data published in journals affiliated with the Ecology discipline that were ranked at all four quartile levels. Journals affiliated with the Environmental Sciences discipline included 40 articles citing GAP data. The Environmental Sciences journals that cited GAP data included some journals from each quartile level. In the discipline of Biodiversity Conservation, 29 articles published appeared in journals ranked at the top three quartile levels. There were 20 articles citing GAP data published in journals affiliated with the Forestry discipline that were ranked in the top three quartiles. These are the results for the four disciplines with the largest numbers of articles within the set of publications citing GAP data. It is apparent that articles citing GAP data are published in multiple disciplines in journals of varying degrees of impact as defined by the journal impact factor.

The total number of articles and relative percent published in journals in each quartile within their respective disciplines is depicted in figure 8. This is based on the 289 publications for which this information was available. The purpose of this figure is to summarize to what extent GAP data appeared in publications at each level of relative prestige and impact based on quartile ranking.

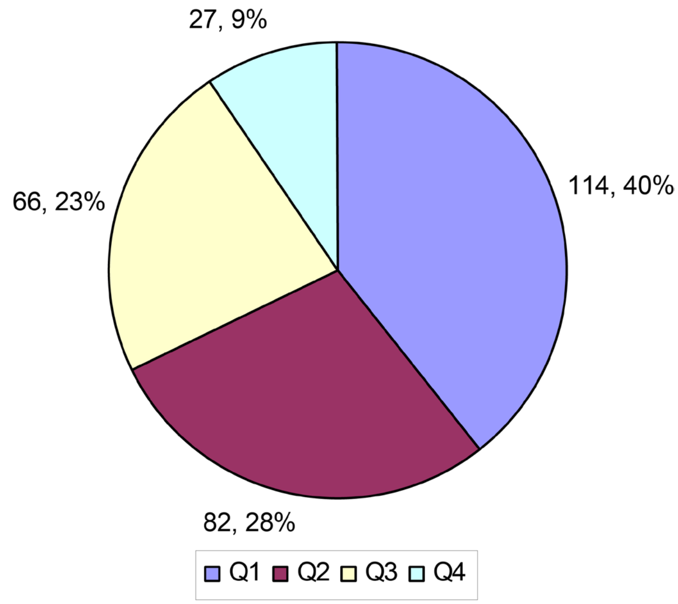


Figure 8. Number and percent of articles published in journals at each quartile rank.

Forty percent of journal articles citing GAP data were published in quartile 1 (Q1) level journals. These are journals that are considered top level journals within their respective disciplines. Twenty-eight percent of the articles were published in quartile 2 (Q2) level journals. A slightly smaller proportion, 23 percent, of articles citing GAP data were published in quartile 3 level journals. In reviewing the quartile rank information provided previously in table 2, many of the journals that appear at the third and fourth quartiles of their respective disciplines are regional in nature. For example, Q3 level journals include Northeastern Naturalist and the Southern Journal of Applied Forestry. These are journals that are likely to be circulated and cited less frequently than journals that have broader appeal such as Landscape Ecology, a Q1 level journal.

The actual citation counts should be considered when interpreting the journal impact factor (Wallin, 2005). Because of issues affecting calculation of journal impact factors, such as the limited time frame represented, the number of citations to a paper may be a better indicator of the impact of the paper than the journal impact factor (Fava and Ottolini, 2000; Retzer and Jurasinski, 2009).

Citation Count

Citation analysis indicates what is being cited and by whom (Melkers, 1993). Within the context of the larger program analysis of GAP, publication counts and citation analysis provided information about the use and impact of GAP data. Citation counts for an article can vary from year to year. Because of this phenomenon, the recommendation when using citation counts in bibliometric analyses is that the time period over which counts are taken should not be too limited (Verbeek and others, 2002). Citations are an imperfect but useful measure of research impact (Kostoff, 1995; Narin and Hamilton, 1996; Narin and others, 1994; Okubo, 1997; Porter and others, 2003; Verbeek and others 2002) and visibility in the research community (Frame, 1983). Citation data should not be interpreted as a measure of research quality (Seglen, 1997). Even though citations counts are considered imperfect, they are a conventional measure used to measure impact (Herbstein, 1993; Shapira and others, 2003).

Research has demonstrated a correlation between citation data and other measures of influence or impact such as peer reviews (Garfield and Welljams-Dorof, 1992). The concerns about citation data tend to be reduced at higher levels of aggregation (Garfield and Welljams-Dorof, 1992, Okubo, 1997; Schubert and others, 1988). In this case we aggregated data at the program level for GAP and we did not evaluate publications at the level of individual authors. Bornmann and Daniel (2008) concluded in their review of studies of citation behavior that citations are a multidimensional measure. In part, citations do measure the impact of a paper and therefore can be used as a partial measure of research impact (Bornmann and Daniel, 2008).

Because of what is commonly known as the "time lag" in publications—the time it takes to write, revise, and publish an article—bibliometric analyses are appropriate for publications at least 2-3 years old (Herbstein, 1993) but not for very recent ones. When citation analyses are included in a bibliometric approach, as they are here, the time lag required is even longer (Frame, 1983). The article must be published and available for long enough for others to see it, cite it and then have their article published. In many circumstances this phenomenon would be considered a drawback. However, in program evaluation the effects of interest often do not occur until years after research is conducted or a program begins (Garfield and Welljams-Dorof, 1992; Kostoff, 1995). In this respect, bibliometric analyses fit well with the objectives of program evaluation. In the case of GAP, the time lag in publications means that many of the publications included in the literature review and bibliometric analyses cited the use of the state rather than regional datasets. However, when evaluating the impact of a scientist, a paper, or a program, more relevant information is provided by citation frequencies than by journal impact factors (Garfield, 2001). The citation frequencies reflect the impact over the life of an article whereas impact factors are based on a time limited (two or five year) average for the journal in which an article appears (Fava and Ottolini, 2000). Therefore, we used citation frequencies as part of our bibliometric analysis even though we knew that this approach would be less accurate for the more recent regional and national datasets.

We searched Web of Science to obtain citation lists. At the time of our citation search, the citation database had been updated on August 10, 2011. When conducting citation searches in Web of Science we used author name and year as search terms. One of the drawbacks to using a database such as this is the presence of errors, such as misspellings in authors' names, which are often present in source documents (Wallin, 2005). We used only the search terms of author name and year in order to minimize the chance that we would miss relevant citations due to reporting errors in source document data. We searched for citation information for publications of all types, not just journal articles. The publications included in our list of publications using GAP data were cited a total of 5,556 times with an average of 8.6 citations per publication. There were 280 publications for which did not yield any citations in our search.

In table 3, we list the publications that have been cited by other publications and the number of citations. Publications are identified by the author(s), year of publication, and the title. Full reference citations for the publications included in this table are provided in the list of references. In the table, the publications are listed in descending order of citation frequency. Only the publications cited at least once were included in this table; not all of the publications that we found that used GAP data are included in this table.

Table 3. Citation count for publications using GAP data.

Publication Reference	Citation Count
Homer, Collin; Huang, Chengquan; Yang, Limin; Wylie, Bruce; and Coan, Michael, 2004, Development of a 2001 National Land Cover Database for the United States.	272
Breshears, D.D., Cobb, N.S., Rich, P.M., Price, K.P., Allen, C.D., Balice, R. G., Romme, W.H., Kastens, J.H., Floyd, M.L., Belnap, Jayne, Anderson, J.J., Myers, O.B., and Meyer, C.W., 2005, Regional vegetation die-off in response to global-change-type drought.	254
Church, R.L., Stoms, D.M., and Davis, F.W., 1996, Reserve selection as a maximal covering location problem.	200
Scott, J.M., Davis, F.W., McGhie, G., Wright, R.G., Groves, C., and Estes, J., 2001, Nature reserves—Do they capture the full range of America's biological diversity?	179
Vogelmann, J.E., Sohl, T.L., Campbell, P.V., and Shaw, D.M., 1998, Regional land cover characterization using Landsat thematic mapper data and ancillary data.	118
Homer, Collin; Dewitz, Jon; Fry, Joyce; Coan, Michael; Hossain, Nazmul; Larson, Charles; Herold, Nate; McKerrow, Alexa; VanDriel, J.N.; and Wickham, James, 2007, Completion of the 2001 National Land Cover Database for the conterminous United States.	113
Carroll, Carlos, Noss, R.F. and Paquet, P.C., 2001, Carnivores as focal species for conservation planning in the Rocky Mountain region.	106
Noss, R.F.; Carroll, Carlos; Vance-Borland, Ken; and Wuerthner, George, 2002, A multicriteria assessment of the irreplaceability and vulnerability of sites in the Greater Yellowstone Ecosystem.	106
Polasky, Stephen, Camm, J.D., Solow, A.R., Csuti, Blair, White, Denis, and Ding, Rugang, 2000, Choosing reserve networks with incomplete species information.	95
Guerry, A.D., and Hunter, M.L., Jr., 2002, Amphibian distributions in a landscape of forests and agriculture—An examination of landscape composition and configuration.	94
Kiester, A.R.; Scott, J.M.; Csuti, Blair; Noss, R.F.; Butterfield, Bart; Sahr, Kevin; and White, Denis, 1996, Conservation prioritization using GAP data.	93
Theobald, D.M., 2001, Land-use dynamics beyond the American urban fringe.	83
Guerra, Marta; Walker, Edward; Jones, Carl; Paskewitz, Susan; Cortinas, M.R.; Stancil, Ashley; Beck, Louisa; Bobo, Matthew; and Kitron, Uriel, 2002, Predicting the risk of Lyme Disease—Habitat suitability for *Ixodes scapularis* in the north central United States.	74
DeAngelis, D.L., Gross, L.J., Huston, M.A., Wolff, W.F., Fleming, D.M., Comiskey, E.J., and Sylvester, S.M., 1998, Landscape modeling for Everglades ecosystem restoration.	65
Edwards, T.C., Jr., Deshler, E.T., Foster, Dan, and Moisen, G.G., 1996, Adequacy of wildlife habitat relation models for estimating spatial distributions of terrestrial vertebrates.	63
Sponseller, R.A., and Benfield, E.F., 2001, Influences of land use on leaf breakdown in southern Appalachian headwater streams—A multiple-scale analysis.	60
Dark, S.J., 2004, The biogeography of invasive alien plants in California—An application of GIS and spatial regression analysis.	53
Marshall, C.H., Pielke, R.A., Sr., Steyaert, L.T., and Willard, D.A., 2004, The impact of anthropogenic land-cover change on the Florida peninsula sea breezes and warm season sensible weather.	53
Moritz, M.A., Keeley, J.E., Johnson, E.A., and Schaffner, A.A., 2004, Testing a basic assumption of shrubland fire management—How important is fuel age?	51

Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
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Guo, Qinghua, Kelly, Maggi, and Graham, C.H., 2005, Support vector machines for predicting distribution of Sudden Oak Death in California.	47
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Westerink, J.J., Luettich, R.A., Feyen, J.C., Atkinson, J.H., Dawson, Clint, Roberts, H.J., Powell, M.D., Dunion, J.P., Kubatko, E.J., and Pourtaheri, Hasan, 2008, A basin- to channel-scale unstructured grid hurricane storm surge model applied to southern Louisiana.	37
Cushman, S.A., McGarigal, Kevin, and Neel, M.C., 2008, Parsimony in landscape metrics—Strength, universality, and consistency.	36
Wardlow, B.D., and Egbert, S.L., 2008, Large-area crop mapping using time-series MODIS 250 m NDVI data—An assessment for the U.S. central Great Plains.	34
Borak, J.S., and Strahler, A.H., 1999, Feature selection and land cover classification of a MODIS-like data set for a semiarid environment.	33
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Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
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Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
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Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
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Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
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Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
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Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
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Bunya, S., Dietrich, J.C., Westerink, J.J., Ebersole, B.A., Smith, J.M., Atkinson, J.H., Jensen, R., Resio, D.T., Luettich, R.A., Dawson, C., Cardone, V.J., Cox, A.T., Powell, M.D., Westerink, H.J., and Roberts, H.J., 2010, A high-resolution coupled riverine flow, tide, wind, wind wave, and storm surge model for southern Louisiana and Mississippi—Part I–model development and validation.	10
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Table 3. Citation count for publications using GAP data.—Continued

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Kocovsky, P.M., and Carline, R.F., 2006, Influence of landscape-scale factors in limiting brook trout populations in Pennsylvania streams.	7
Larson, B.D., and Sengupta, R.R., 2004, A spatial decision support system to identify species-specific critical habitats based on size and accessibility using US GAP data.	7

Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
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Beck, J.L., Reese, K.P., Connelly, J.W., and Lucia, M.B., 2006, Movements and survival of juvenile greater sage-grouse in southeastern Idaho.	6
Dauwalter, D.C., and Jackson, J.R., 2004, A provisional fish index of biotic integrity for assessing Ouachita mountains streams in Arkansas, USA.	6
Doren, R.F., Rutchey, Ken, and Welch, Roy, 1999, The Everglades—A perspective on the requirements and applications for vegetation map and database products.	6
Fecske, D.M., Jenks, J.A., and Smith, V.J., 2002, Field evaluation of a habitat-relation model for the American marten.	6
Huang, Cho-ying, Asner, G.P., Martin, R.E., Barger, N.N., and Neff, J.C., 2009, Multiscale analysis of tree cover and aboveground carbon stocks in pinyon-juniper woodland.	6
King, D.T., and Michot, T.C., 2002, Distribution, abundance and habitat use of American white pelicans in the delta region of Mississippi and along the western Gulf of Mexico coast.	6
Larrucea, E.S., and Brussard, P.F., 2008, Habitat selection and current distribution of the pygmy rabbit in Nevada and California, USA.	6
Liu, Zhongwei, Volin, J.C., Owen, V.D., Pearlstine, L.G., Allen, J.R., Mazzotti, F.J., and Higer, A.L., 2009, Validation and ecosystem applications of the EDEN water-surface model for the Florida Everglades.	6
Moen, Ron, Burdett, C.L., and Niemi, G.J., 2008, Movement and habitat use of Canada lynx during denning in Minnesota.	6
Pease, K.M.; Freedman, A.H.; Pollinger, J.P.; McCormack, J.E.; Buermann, Wolfgang; Rodzen, Jeff; Banks, Jim; Meredith, Erin; Bleich, V.C.; Schaefer, R.J.; Jones, Ken; and Wayne, R.K., 2009, Landscape genetics of California mule deer (*Odocoileus hemionus*)—the roles of ecological and historical factors in generating differentiation.	6
Pyke, C.R., 2005b, Interactions between habitat loss and climate change—Implications for fairy shrimp in the central valley ecoregion of California, USA.	6

Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
Shriver, D.M., and Randhir, T.O., 2006, Integrating stakeholder values with multiple attributes to quantify watershed performance.	6
Strickland, B.K., and Demarais, Stephen, 2008, Influence of landscape composition and structure on antler size of white-tailed deer.	6
Beckage, Brian; Comiskey, Jane; and Duke-Sylvester, Scott, 2005, Response to Maehr and Larkin—Natural fire regimes in southern Florida.	5
Bradley, B.A., 2010, Assessing ecosystem threats from global and regional change—Hierarchical modeling of risk to sagebrush ecosystems from climate change, land use and invasive species in Nevada, USA.	5
Burns, K.S., Schoettle, A.W., Jacobi, W.R., and Mahalovich, M.F., 2008, Options for the management of white pine blister rust in the Rocky Mountain region.	5
Buyantuyev, A., and Wu, J., 2009, Urbanization alters spatiotemporal patterns of ecosystem primary production—A case study of the Phoenix metropolitan region, USA.	5
Dauwalter, D.C., Pert, E.J., and Keith, W.E., 2003, An index of biotic integrity for fish assemblages in Ozark highland streams of Arkansas.	5
Dean, D.J., Wilson, K.R., and Flather, C.H., 1997, Spatial error analysis of species richness for a Gap Analysis map.	5
Efroymson, R.A.; Dale, V.H.; Baskaran, L.M.; Chang, Michael; Aldridge, Matthew; and Berry, M.W., 2005, Planning transboundary ecological risk assessments at military installations.	5
Goheen, E.M., Hansen, E., Kanaskie, A., Osterbauer, N., Parke, J., Pscheidt, J., and Chastagner, G., 2006, Sudden Oak Death and *Phytophthora ramorum*—A guide for forest managers, Christmas tree growers, and forest-tree nursery operators in Oregon and Washington.	5
Gori, D.F., and Enquist, C.A.F., 2003, An assessment of the spatial extent and condition of grasslands in central and southern Arizona, southwestern New Mexico and northern Mexico.	5
Heathman, G.C., Larose, M., and Ascough, J.C., 2009, Soil and water assessment tool evaluation of soil and land use geographic information system data sets on simulated stream flow.	5
Hopton, M.E., and Mayer, A.L., 2006, Using self-organizing maps to explore patterns in species richness and protection.	5
Huang, Cho-ying, and Geiger, E.L., 2008, Climate anomalies provide opportunities for large-scale mapping of non-native plant abundance in desert grasslands.	5
Jacobs, B.F., Romme, W.H., and Allen, C.D., 2008, Mapping old versus young piñon–juniper stands with a predictive topo-climatic model in north-central New Mexico, USA.	5
Kanda, L.L., Fuller, T.K., Sievert, P.R., and Kellogg, R.L., 2009, Seasonal source-sink dynamics at the edge of a species' range.	5
Lindell, C.A., McCullough, D.G., Cappaert, David, Apostolou, N.M., and Roth, M.B., 2008, Factors influencing woodpecker predation on emerald ash borer.	5
Love, J.W., and May, E.B., 2007, Relationships between fish assemblage structure and selected environmental factors in Maryland's coastal bays.	5
Martin, August, Gunter, J.T., and Regens, J.L., 2003, Estimating erosion in a riverine watershed—Bayou Liberty-Tchefuncta river in Louisiana.	5

Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
Maxwell, S.K., Hoffer, R.M. and Chapman, P.L., 2002, AVHRR composite period selection for land cover classification.	5
Menking, K.M., Syed, K.H., Anderson, R.Y., Shafike, N.G., and Arnold, J.G., 2003, Model estimates of runoff in the closed, semiarid Estancia basin, central New Mexico, USA.	5
Roth, J.E., Kelly, J.P., Sydeman, W.J., and Colwell, M.A., 2004, Sex differences in space use of breeding common ravens in western Marin County, California.	5
Shirk, A.J., Wallin, D.O., Cushman, S.A., Rice, C.G., and Warheit, K.I., 2010, Inferring landscape effects on gene flow—A new model selection framework.	5
Stoms, D.M., Bueno, M.J., Davis, F.W., Cassidy, K.M., Driese, K.L., and Kagan, J.S., 1998, Map-guided classification of regional land cover with multi-temporal AVHRR data.	5
Teels, B.M., Rewa, C.A., and Myers, John, 2006, Aquatic condition response to riparian buffer establishment.	5
Wamsley, T.V., Cialone, M.A., Smith, J.M., Atkinson, J.H., and Rosati, J.D., 2010, The potential of wetlands in reducing storm surge.	5
Alfieri, J.G.; Niyogi, Dev; LeMone, M.A.; Chen, Fei; and Fall, Souleymane, 2007, A simple reclassification method for correcting uncertainty in land use/land cover data sets used with land surface models.	4
Bauer, M.E., Loeffelholz, Brian, and Wilson, Bruce, 2005, Estimation, mapping, and change analysis of impervious surface area by Landsat remote sensing.	4
Bauer, M.E., Loeffelholz, B.C., Wilson, Bruce, 2007, Estimating and mapping impervious surface area by regression analysis of Landsat imagery.	4
Chen, Y.D., McCutcheon, S.C., Carsel, R.F., Donigian, A.S., Jr., Cannell, J.R., and Craig, J.P., 1995, Validation of HSPF for the water balance simulation of the Upper Grande Ronde watershed, Oregon, USA.	4
Diamond, D.D., True, C.D., Gordon, T.M., Sowa, S.P., Foster, W.E., and Jones, B.K., 2005, Influence of targets and assessment region size on perceived conservation priorities.	4
Falzarano, S.R., and Thomas, K.A., 2004, Fuzzy set and spatial analysis techniques for evaluating thematic accuracy of a land-cover map.	4
Greenwood, D.L., and Weisberg, P.J., 2009, GIS-based modeling of pinyon-juniper woodland structure in the Great Basin.	4
Gregory, C.J., Carthy, R.R., and Pearlstine, L.G., 2006, Survey and monitoring of species at risk at Camp Blanding training site, northeastern Florida.	4
Howell, J.E., Peterson, J.T., and Conroy, M.J., 2008, Building hierarchical models of avian distributions for the state of Georgia.	4
Kim, Jin-Woo; Lu, Zhong; Lee, Hyongki; Shum, C.K.; Swarzenski, C.M.; Doyle, T.W.; and Baek, Sang-Ho, 2009, Integrated analysis of PALSAR/Radarsat-1 InSAR and ENVISAT altimeter data for mapping of absolute water level changes in Louisiana wetlands.	4
Mahan, C.G., and O'Connell, T.J., 2005, Small mammal use of suburban and urban parks in central Pennsylvania.	4

Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
Mattice, J.A., Brauning, D.W., and Diefenbach, D.R., 2005, Abundance of grassland sparrows on reclaimed surface mines in western Pennsylvania.	4
Riitters, K.H., Coulston, J.W., and Wickham, J.D., 2003, Localizing national fragmentation statistics with forest type maps.	4
Roth, T.C., II, Vetter, W.E., and Lima, S.L., 2008, Spatial ecology of winting accipiter hawks—Home range, habitat use, and the influence of bird feeders.	4
Sacks, B.N., Chomel, B.B., and Kasten, R.W., 2004, Modeling the distribution and abundance of the non-native parasite, canine heartworm, in California coyotes.	4
Stein, B.A.; Scott, Cameron; and Benton, Nancy, 2008, Federal lands and endangered species—The role of military and other federal lands in sustaining biodiversity.	4
Taft, O.W, Haig, S.M., and Kiilsgaard, Chris, 2004, Use of radar remote sensing (RADARSAT) to map winter wetland habitat for shorebirds in an agricultural landscape.	4
Telesco, R.L., Van Manen, F.T., Clark, J.D., and Cartwright, M.E., 2007, Identifying sites for elk restoration in Arkansas.	4
Thorne, J.H., Morgan, B.J., and Kennedy, J.A., 2008, Vegetation change over sixty years in the central Sierra Nevada, California, USA.	4
Trapp, J.R., 2004, Wolf den site selection and characteristics in the northern Rocky Mountains—A multi-scale analysis.	4
Wade, A.A., and Theobald, D.M., 2010, Residential development encroachment on U.S. protected areas.	4
Wang, Dali, Carr, Eric, Gross, L.J., and Berry, M.W., 2005, Toward ecosystem modeling on computing grids.	4
Yanoff, Steven, and Muldavin, Esteban, 2008, Grassland–shrubland transformation and grazing—A century-scale view of a northern Chihuahuan Desert grassland.	4
Benjamin, M.T.; Winer, A.M.; Karlik, John; Campbell, Skip; Jackson, Bruce; and Lashgari, Ash, 1998, Assembling a biogenic hydrocarbon emissions inventory for the SCOS97–NARSTO modeling domain.	3
Caratti, J.F., 2006, The LANDFIRE Prototype Project reference database.	3
Conway, C.J., and Kirkpatrick, Chris, 2007, Effect of forest fire suppression on buff-breasted flycatchers.	3
Crowe, R.E., 1996, Use of gap analysis in regional planning in southern California.	3
Dilts, T.E., Sibold, J.S., and Biondi, Franco, 2009, A weights-of-evidence model for mapping the probability of fire occurrence in Lincoln County, Nevada.	3
Gunter, J.T., Hodges, D.G., and Regens, J.L., 2005, Probability models for predicting local water quality regulations in the southern United States.	3
Jones, J.W., and Price, S.D., 2007, Conceptual design of the Everglades Depth Estimation Network (EDEN) grid.	3
Lennartz, Steven, 2005, Oregon forest land change mapping.	3
Manier, D.J., Hobbs, N.T., Theobald, D.M., Reich, R.M., Kalkhan, M.A., and Campbell, M.R., 2005, Canopy dynamics and human caused disturbance on a semi-arid landscape in the Rocky Mountains, USA.	3

Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
Matocq, M.D., and Murphy, P.J., 2007, Fine-scale phenotypic change across a species transition zone in the genus *Neotoma*—Disentangling independent evolution from phylogenetic history.	3
Nesslage, G.M., Maurer, B.A., and Gage, S.H., 2007, Gypsy moth response to landscape structure differs from neutral model predictions—Implications for invasion monitoring.	3
Oleson, K.W., Driese, K.L., Maslanik, J.A., Emery, W.J., and Reiners, W.A., 1997, The sensitivity of a land surface parameterization scheme to the choice of remotely sensed land-cover datasets.	3
Parajuli, P.B., Douglas-Mankin, K.R., Barnes, P.L., and Rossi, C.G., 2009, Fecal bacteria source characterization and sensitivity analysis of SWAT 2005.	3
Peterson, D.L., Egbert, S.L., Price, K.P., and Martinko, E.A., 2004, Identifying historical and recent land-cover changes in Kansas using postclassification change detection techniques.	3
Peterson, E.B., 2006, A map of invasive annual grasses in Nevada derived from multitemporal Landsat 5 TM imagery.	3
Ramsey, Elijah, III; Rangoonwala, Amina; Middleton, Beth; and Lu, Zhong, 2009, Satellite optical and radar data used to track wetland forest impact and short-term recovery from Hurricane Katrina.	3
Rimmer, C.C., McFarland, K. P., Lambert, J.D., and Renfrew, R.B., 2004, Evaluating the use of Vermont ski areas by Bicknell's Thrush—Applications for Whiteface Mountain, New York.	3
Sader, S.A., and Legaard, K.R., 2008, Inclusion of forest harvest legacies, forest type, and regeneration spatial patterns in updated forest maps—A comparison of mapping results.	3
Schumacher, J.V., Redmond, R.L., Hart, M.M., and Jensen, M.E., 2000, Mapping patterns of human use and potential resource conflicts on public lands.	3
Stoner, D.C., Rieth, W.R., Wolfe, M.L., Mecham, M.B., and Neville, Ann, 2008, Long-distance dispersal of a female cougar in a basin and range landscape.	3
Storm, D.E., White, Michael, Smolen, M.D., and Zhang, Hailin, 2001, Modeling phosphorous loading for the Lake Eucha Basin—Final report.	3
Thatcher, C.A., Van Manen, F.T., and Clark, J.D., 2009, A habitat assessment for Florida panther population expansion into central Florida.	3
Theobald, D.M., Norman, J.B., and Sherburne, M.R., 2006, FunConn v1 user's manual—ArcGIS tools for functional connectivity modeling.	3
Thompson, B.C., Hughes, M.A., and Anderson, M.C., 2001, Effects of including non-breeding bird species on predicted bird distributions for conservation planning in New Mexico.	3
Thorne, J.H.; Kennedy, J.A.; Quinn, J.F.; McCoy, Michael; Keeler-Wolf, Todd; and Menke, John, 2004, A vegetation map of Napa County using the Manual of California Vegetation Classification and its comparison to other digital vegetation maps.	3
van Leeuwen, W.J.D., 2008, Monitoring the effects of forest restoration treatments on post-fire vegetation recovery with MODIS multitemporal data.	3
Volin, J.C.; Liu, Zhongwei; Higer, Aaron; Mazzotti, Frank; Owen, Dianne; Allen, Jenny; and Pearlstine, Leonard, 2008, Validation of a spatially continuous EDEN water-surface model for the Everglades, Florida.	3

Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
Weber, T.C., 2007, Development and application of a statewide conservation network in Delaware, U.S.A.	3
Allen, K.E., Bradley, R.D., Monk, R.R., Knyazhnitskiy, O.V., Parker, N.C., Schmidly, D.J., and Baker, R.J., 2001, Employment of geographic information systems for determining the accuracy of museum voucher specimen data.	2
Barrow, Wylie, Jr.; Buler, J.; Couvillion, Brady; Diehl, Robb; Faulkner, Stephen; Moore, F.; and Randall, Lori, 2007, Broad-scale response of landbird migration to the immediate effects of Hurricane Katrina.	2
Brady, L.M., Gray, Floyd, Wissler, C.A., and Guertin, D.P., 2001, Spatial variability of sediment erosion processes using GIS analysis within watersheds in a historically mined region, Patagonia Mountains, Arizona.	2
Brinda, J.C., Stark, L.R., Shevock, J.R., and Spence, J.R., 2007, An annotated checklist of the bryophytes of Nevada, with notes on collecting history in the state.	2
Cassidy, K.M., and Grue, C.E., 2000, The role of private and public lands in conservation of at-risk vertebrates in Washington State.	2
Chung, Y.J., and Winer, A.M., 1999, Field assessment of the California Gap Analysis program database for San Diego county.	2
Clark, J.D., Dobey, Steven, Masters, D.V., Scheick, B.K., Pelton, M.R., and Sunquist, M.E., 2005, American black bears and bee yard depredation at Okefenokee Swamp, Georgia.	2
Cogan, Christopher, 1997, California biodiversity project—Application of ecological data to biodiversity analysis.	2
Crist, M.R., Wilmer, Bo, 2002, Roadless areas—The missing link in conservation—An analysis of biodiversity and landscape connectivity in the northern Rockies.	2
Diefenbach, D.R., Riegner, C.F., and Hardisky, T.S., 2000, Harvest and reporting rates of game-farm ring-necked pheasants.	2
Doleman, W.H., 2005, Environmental constraints on forager mobility and the use of cultigens in southeastern Arizona and southern New Mexico.	2
Dymond, R.L., Regmi, B., Lohani, V.K., and Dietz, R., 2004, Interdisciplinary web-enabled spatial decision support system for watershed management.	2
Enwright, Nicholas, and Hudak, P.F., 2009, Spatial distribution of nitrate and related factors in the High Plains Aquifer, Texas.	2
Fertig, Walter, and Thurston, Robert, 2003, Modeling the potential distribution of BLM sensitive and USFWS threatened and endangered plant species in Wyoming.	2
Frescino, T.S., 1998, Development and validation of forest habitat models in the Uinta Mountains, Utah.	2
González, Grizelle, Gould, W.A., Hudak, A.T., and Hollingsworth, T.N., 2008, Decay of aspen (*Populus tremuloides Michx.*) wood in moist and dry boreal, temperate, and tropical forest fragments.	2
Hanser, S.E., and Huntly, N.J., 2006, The biogeography of small mammals of fragmented sagebrush-steppe landscapes.	2
Hoffman, J.D., and Choate, J.R., 2008, Distribution and status of the yellow-faced pocket gopher in Kansas.	2

Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
Hoffman, J.D., Choate, J.R., and Channell, Rob, 2007, Effects of land use and soil texture on distributions of pocket gophers in Kansas.	2
Huang, Chengquan, Homer, Collin, and Yang, Limin, 2003, Regional forest land cover characterisation using medium spatial resolution satellite data.	2
Hudak, P.F., and Wachal, D.J., 2001, Oil production, agriculture and groundwater quality in the southeastern Gulf Coast Aquifer, Texas.	2
Hunter, L.M., and Brehm, J.M., 2004, A qualitative examination of value orientations toward wildlife and biodiversity by rural residents of the intermountain region.	2
Hychka, K.C., Wardrop, D.H., and Brooks, R.P., 2007, Enhancing a landscape assessment with intensive data—A case study in the Upper Juniata watershed.	2
Jantz, Patrick, and Goetz, Scott, 2008, Using widely available geospatial data sets to assess the influence of roads and buffers on habitat core areas and connectivity.	2
Karlik, J.F., Chung, Y.J., and Winer, A.M., 2003, Biogenic emission inventory development—Field assessment of the GAP vegetation database in California.	2
Kirkpatrick, Chris, Conway, C.J., Hughes, K.M., and Devos, J.C., 2007, Probability of detecting band-tailed pigeons during call-broadcast versus auditory surveys.	2
Kretser, H.E., Sullivan, P.J., and Knuth, B.A., 2008, Housing density as an indicator of spatial patterns of reported human-wildlife interactions in northern NewYork.	2
Landis, J.D.; Monzon, J.P.; Reilly, Michael; and Cogan, Chris, 1998, Development and pilot application of the California Urban and Biodiversity Analysis (CURBA) model.	2
Munson, A.B., and Delfino, J.J., 2007, Minimum wet-season flows and levels in southwest Florida rivers.	2
Neely, Betsy; Comer, Pat; Moritz, Cherie; Lammert, Mary; Rondeau, Renee; Pague, Chris; Bell, Gary; Copeland, Holly; Humke, John; Spackman, Susan; Schulz, Terri; Theobald, David; and Valutis, Laura, 2001, Southern Rocky Mountains—An ecoregional assessment and conservation blueprint.	2
Radwell, Andrea, 2000, Ecological integrity assessment of Ozark rivers to determine suitability for protective status.	2
Scarborough, James; Clinton, Nicolas; Pu, Ruilang; and Gong, Peng, 2001, Creating a statewide spatially and temporally allocated wildfire and prescribed burn emission inventory using consistent emission factors.	2
Theobald, D.M., Peterson, Nathan, and Romme, W.H., 2004, The Colorado vegetation model—Using national land cover data and ancillary spatial data to produce a high resolution, fine-classification map of Colorado.	2
Toschik, P.C., Christman, M.C., Rattner, B.A., and Ottinger, M.A., 2006, Evaluation of osprey habitat suitability and interaction with contaminant exposure.	2
Twilley, R.R.; Couvillion, B.R.; Hossain, Imtiaz; Kaiser, Carola; Owens, A.B.; Steyer, G.D.; and Visser, J.M., 2008, Coastal Louisiana ecosystem assessment and restoration program—The role of ecosystem forecasting in evaluating restoration planning in the Mississippi River Deltaic plain.	2
Wall, S.S., and Berry, C.R., Jr., 2006, The importance of multiscale habitat relations and biotic associations to the conservation of an endangered fish species, the Topeka shiner.	2

Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
Ward, Kathleen, and Juzwik, Jennifer, 2005, Change in the Minneapolis/St. Paul Metropolitan area oak forests from 1991 to 1998.	2
Ward, Kathleen; Ostry, Michael; Venette, Robert; Palik, Brian; Hansen, Mark; Hatfield, Mark, 2009, Assessment of black ash (*Fraxinus nigra*) decline in Minnesota.	2
Webb, E.B., Smith, L.M., Vrtiska, M.P., and Lagrange, T.G., 2010, Effects of local and landscape variables on wetland bird habitat use during migration through the Rainwater Basin.	2
Wright, R.G., and Scott, J.M., 1996, Evaluating the ecological suitability of lands for parks and protected areas using gap analysis databases.	2
Barker, C.M., Bolling, B.G., Moore, C.G., and Eisen, Lars, 2009, Relationship between distance from major larval habitats and abundance of adult mosquitoes in semiarid plains landscapes in Colorado.	1
Borak, J.S, and Strahler, A.H., 1996, Feature selection using decision trees—An application for the MODIS land cover algorithm.	1
Boykin, K.G., 2006, Multiscale analysis of habitat, vegetation change, and streamflow as ecological factors affecting population dynamics of *Rana chiricahuensis*.	1
Brenner, John; Paustian, Keith; Buhm, George; Cipra, Jan; Easter, Mark; Foulk, Robin, Killian, Kendrick; Moore, Ron; Schuler, Jill; Smith, Phil; and Williams, Steve, 2002, Quantifying the change in greenhouse gas emissions due to natural resource conservation practice application in Nebraska.	1
Briggs, N.A., and Sader, S.A., 2009, Tracking forest change and development using low-cost remote sensing imagery and GIS integration.	1
Briskey, J.A., Schulz, K.J., Mosesso, J.P., Horwitz, L.R., and Cunningham, C.G., 2007, Environmental planning issues and a conceptual global assessment of undiscovered nonfuel mineral resources.	1
Clinton, Nicholas; Scarborough, James; Tian, Yong; and Gong, Peng, 2003, A GIS based emissions estimation system for wildlife and prescribed burning.	1
Dietz, R.W., 2000, The use of GIS for integrated watershed analysis—Integration of environmental models with GIS in the Upper Roanoake River Watershed.	1
Dzialak, M.R., Carter, K.M., and Lacki, M.J., 2007, Perch site selection by reintroduced peregrine falcons *Falco peregrinus*.	1
Enquist, C.A.F., and Gori, D.F., 2008, Application of an expert system approach for assessing grassland status in the U.S.–Mexico borderlands—Implications for conservation and management.	1
Estrada-Peña, Agustín, 2009, Diluting the dilution effect—A spatial Lyme model provides evidence for the importance of habitat fragmentation with regard to the risk of infection.	1
Fisher, H., Butcher, J., Creager, C., and Saucerman, S., 2004, Application of a linked water quality response model for establishing nutrient criteria for the California oak and chaparral sub-ecoregion.	1
Fletcher, J.J., Eli, R.N., Strager, M.P., Sun, Qingyun, Churchill, J.B., Lamont, S.J., Galya, T.A., and Schaer, A.N., 2004, The watershed characterization and modeling system (WCMS)—Support tools for large watershed CHIA and NPDES analyses.	1
Greenwald, D.N., and Bradley, Curtis, 2008, Assessing protection for imperiled species of Nevada, U.S.A.—Are species slipping through the cracks of existing protections?	1

Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
Greenwood, D.L., 2006, Landscape analysis of tree mortality and pinyon-juniper woodland structure in the Great Basin.	1
Hagen, C.A., Pitman, J.C., Robel, R.J., Loughin, T.M., and Applegate, R.D., 2007, Niche partitioning by lesser prairie-chicken *Tympanuchus pallidicinctus* and ring-necked pheasant *Phasianus colchicus* in southwestern Kansas.	1
Hamazaki, Toshihide, Thompson, B.C., Locke, B.A., and Boykin, K.G., 2003, Analysis of ecological context for identifying vegetation and animal conservation planning foci—An example from the arid south-western USA.	1
Heaton, J.S., Kiester, A.R., and Meyers, S.M., 2006, LizLand—A geomorphic approach to lizard habitat modeling in the Mojave Desert.	1
Heller, J.A., Guertin, D.P., Miller, S.N., and Stone, J.J., 1999, GIS for watershed assessment—Integrating spatial and tabular data to derive parameters for a hydrologic simulation model (ARDBSN).	1
Hubbard, Brett, and Serfass, Tom, 2004, Assessing the distribution of reintroduced populations of river otters in Pennsylvania (USA)—Development of a landscape-level approach.	1
Hunter, L.M., Beal, John, and Dickinson, Thomas, 2003, Integrating demographic and GAP analysis biodiversity data—Useful insight?	1
Islas, C.G.R., 1996, A sensitivity test for species distribution models used for gap analysis in New Mexico.	1
Jochimsen, D.M., 2005, Factors influencing the road mortality of snakes on the Upper Snake River Plain, Idaho.	1
Kanda, L.L., Fuller, T.K., Sievert, P.R., and Friedland, K.D., 2005, Variation in winter microclimate and its potential influence on Virginia opossum (*Didelphis virginiana*) survival in Amherst, Massachusetts.	1
Kocovsky, P.M., Ross, R.M., Dropkin, D.S., and Campbell, J.M., 2008, Linking landscapes and habitat suitability scores for diadromous fish restoration in the Susquehanna River Basin.	1
Kostelnick, J.C., Peterson, D.L., Egbert, S.L., McNyset, K.M., and Cully, J.F., 2007, Ecological niche modeling of black-tailed prairie dog habitats in Kansas.	1
Kunert, Kelly, 2005, A GIS approach to habitat restoration site selection and prioritization in the New York–New Jersey Harbor Estuary.	1
Kunzmann, M.R., Rybak, Alexander, and Bennett, P.S., 2000, Yellow-billed cuckoo (*Coccyzus americanus occidentalis*) habitat identification using GPS and GIS based survey information.	1
LaBram, J.A., Peck, A.E., and Allen, C.R., 2007, Monitoring-based assessment of Gap-analysis models.	1
Lipow, S.R., Vance-Borland, Kenneth, St. Clair, J.B., Henderson, J.A., and McCain, Cindy, 2007, In situ gene conservation of six conifers in western Washington and Oregon.	1
Lopez, R.D., Nash, M.S., Heggem, D.T., and Ebert, D.W., 2008, Watershed vulnerability predictions for the Ozarks using landscape models.	1
Martin, D.J., White, G.C., and Pusateri, F.M., 2007, Occupancy rates by swift foxes (*Vulpes velox*) in eastern Colorado.	1
Martinuzzi, Sebastian, Vierling, L.A., Gould, W.A., Vierling, K.T., and Hudak, A.T., 2009, Incorporating remotely sensed tree canopy cover data into broad scale assessments of wildlife habitat distribution and conservation.	1

Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
Mawdsley, J.R., 2001a, Ecology, biogeography, and conservation of checkered beetles (Insecta: Coleoptera: Cleridae) in southeastern Arizona—A geographic information system (GIS) study.	1
Moen, Ronald, Niemi, Gerald, and Burdett, C.L., 2008, Canada lynx in the Great Lakes region.	1
Monahan, W.B. and Koenig, W.D., 2007, Potential effects of Sudden Oak Death on the oak woodland bird community of coastal California.	1
Morrison, P.H, Karl, J.W., Harma, K.J., Swope, Lindsey, Allen, T.K., and Becwar, Pamela, 2000, Assessment of summer 2000 wildfires—Landscape history, current condition and ownership.	1
Murray, Michael, 2005, Our threatened timberlines—The plight of whitebark pine ecosystems.	1
O'Brien, C.S., Ockenfels, R.A., Bristow, K.D., and Boe, S.R., 2006, Habitat models—Desert bighorn sheep in the Silver Bell Mountains revisited.	1
Overton, C.T., Schmitz, R.A., and Casazza, M.L., 2006, Linking landscape characteristics to mineral site use by band-tailed pigeons in western Oregon—Coarse-filter conservation with fine-filter tuning.	1
Park, Sunyurp, and Egbert, S.L., 2008, Remote sensing-measured impacts of the conservation reserve program (CRP) on landscape structure in southwestern Kansas.	1
Potere, David; Woodcock, C.E.; Schneider, Annemarie; Ozdogan, Mutlu; and Baccini, Alessandro, 2007, Patterns in forest clearing along the Appalachian Trail corridor.	1
Randhir, Timothy, and Ekness, Paul, 2009, Urbanization effects on watershed habitat potential—A multivariate assessment of thresholds and interactions.	1
Regmi, Binaya, 2002, Web-enabled spatial decision support system for interdisciplinary watershed management.	1
Rice, M.B., Ballard, W.B., Fish, E.B., McIntyre, N.E., and Holdermann, D., 2008, The importance of accurate landuse/landcover maps for assessing habitat suitability for black bear (*Ursus americanus*) in the Trans-Pecos region of Texas.	1
Rink, G.R., and Cully, A.C., 2007, A checklist of the vascular flora of Yucca House National Monument and surrounding lands, Montezuma County, Colorado.	1
Rogers, P.C., Leffler, A.J., and Ryel, R.J., 2010, Landscape assessment of a stable aspen community in southern Utah, USA.	1
Sader, S.A., Jin, Suming, Metzler, J.W., and Hoppus, Michael, 2006, Exploratory analysis of forest harvest and regeneration pattern among multiple landowners.	1
Sherrouse, B.C., Clement, J.M., and Semmens, D.J., 2011, A GIS application for assessing, mapping, and quantifying the social values of ecosystem services.	1
Shilling, Fraser; Girvetz, Evan; Erichsen, Chris; Johnson, Brenda; and Nichols, Pete, 2002, A guide to wildlands conservation in the Greater Sierra Nevada bioregion.	1
Shinneman, D.J., Watson, John, and Martin, W.W., 2000, The state of the southern Rockies ecoregion—A look at species imperilment, ecosystem protection, and a conservation opportunity.	1
Sridhar, Venkataramana, 2007, Evapotranspiration estimation and scaling effects over the Nebraska Sand Hills.	1
Steinitz, Carl; Anderson, Robert; Arias, Hector; Bassett, Scott; Flaxman, Michael; Goode, Tomas; Maddock, Thomas, III; Mouat, David; Peiser, Richard; Shearer, Allan, 2005, Alternative futures for landscapes in the Upper San Pedro River Basin of Arizona and Sonora.	1

Table 3. Citation count for publications using GAP data.—Continued

Publication Reference	Citation Count
Taylor, K.J., 2003, Bayesian belief networks—A conceptual approach to assessing risk to habitat.	1
Theobald, D.M., and Hobbs, N.T., 1999, Calculating landscape fragmentation using a gradient-based approach.	1
Thorne, Jim, Camerson, Dick, and Jigour, Verna, 2002, A guide to wildlands conservation in the central coast region of California.	1
Toney, Chris; Rollins, Matthew; Short, Karen; Frescino, Tracey; Tymcio, Ronald; and Peterson, Birgit, 2005, Use of FIA plot data in the LANDFIRE project.	1
Tumbusch, M.L., and Plume, R.W., 2006, Hydrogeologic framework and ground-water levels in basin-fill deposits of the Diamond Valley flow system, central Nevada.	1
Vogelmann, James; Zhu, Zhilang; Kost, Jay; Tolk, Brian; and Ohlen, Donald, 2006, Perspectives on LANDFIRE prototype project accuracy assessment.	1
Wang, Steven; Stiles, Thomas; Flynn, Trevor; Stahl, A.J.; Gutierrez, J.L.; Angelo, R.T.; and Frees, Lyle, 2009, A modeling approach to water quality management of an agriculturally dominated watershed, Kansas, USA.	1
Warren, D.L., and Seifert, S.N., 2011, Environmental niche modeling in Maxent—The importance of model complexity and the performance of model selection criteria.	1
Webb, W.C., Boarman, W.I., and Rotenberry, J.T., 2009, Movements of juvenile common ravens in an arid landscape.	1
Winer, A.M., and Karlik, J.F., 2001, Development and validation of databases for modeling biogenic hydrocarbon emissions in California's airsheds.	1
Wooten, George, 2002, Shrub-steppe conservation prioritization in Washington state.	1
Zasada, Michal, Cieszewski, C.J., and Lowe, R.C., 2003, Impact of stream management zones and road beautifying buffers on long-term fiber supply in Georgia.	1
Zicus, M.C., Rave, D.P., Fieberg, J.R., Guidice, J.H., and Wright, R.G., 2008, Distribution and abundance of Minnesota breeding ring-necked ducks *Aythya collaris*.	1

Publications using GAP data have been cited, some of them extensively, in other publications. This suggests that when publications cite GAP data there is a potential secondary diffusion effect of information regarding GAP data. Those who are not otherwise familiar with GAP data may be introduced to GAP through these publications.

We cross-referenced the publications and their respective citation counts with the datasets used in the publications. We made this comparison to determine if certain datasets were used in publications that were cited more frequently. In table 4, we provided a list of the datasets, the number of publications using each dataset, and the number of publications that cite the publications using the datasets. For example, the Arkansas land-cover dataset was used in 13 publications and those 13 publications were cited in 241 other publications.

Table 4. Datasets, number of publications using each dataset, and number of citations.

	Data Set	Number of Publications Using	Number of Publications Citing
Alabama			
	Land Cover	3	
	Predicted Species Distribution	1	
	Stewardship	1	
Arizona			
	Analysis	1	1
	Land Cover	35	442
	Predicted Species Distribution	6	33
	Stewardship	7	43
Arkansas			
	Land Cover	13	241
	Predicted Species Distribution	1	
	Stewardship	4	192
California			
	Analysis	1	3
	Land Cover	93	927
	Predicted Species Distribution	11	223
	Stewardship	21	380
Colorado			
	Land Cover	22	422
	Predicted Species Distribution	3	31
	Stewardship	5	83
Connecticut			
	Land Cover	1	
	Stewardship	1	2
Delaware			
	Land Cover	4	10
	Predicted Species Distribution	1	3
	Stewardship	3	5
Florida			
	Land Cover	26	286
	Predicted Species Distribution	2	
	Stewardship	2	
Georgia			
	Land Cover	12	13
	Predicted Species Distribution	3	
	Stewardship	2	
Hawaii			
	Land Cover	3	
	Stewardship	1	4

Table 4. Datasets, number of publications using each dataset, and number of citations.—Continued

	Data Set	Number of Publications Using	Number of Publications Citing
Idaho			
	Land Cover	32	760
	Predicted Species Distribution	7	158
	Stewardship	10	326
Illinois			
	Land Cover	5	37
	Predicted Species Distribution	1	10
	Stewardship	2	10
Indiana			
	Land Cover	13	78
	Predicted Species Distribution	1	10
	Stewardship	1	10
Iowa			
	Land Cover	6	71
	Predicted Species Distribution	1	
	Stewardship	3	17
Kansas			
	Land Cover	21	127
	Predicted Species Distribution	2	10
Kentucky			
	Land Cover	5	19
	Stewardship	2	2
Louisiana			
	Land Cover	19	106
	Predicted Species Distribution	1	
	Stewardship	1	
Maine			
	Land Cover	11	346
	Predicted Species Distribution	3	31
	Stewardship	2	181
Maryland			
	Land Cover	4	7
	Stewardship	3	2
Massachusetts			
	Land Cover	7	13
	Predicted Species Distribution	4	14
	Stewardship	3	21
Michigan			
	Land Cover	5	92
	Predicted Species Distribution	1	10

Table 4. Datasets, number of publications using each dataset, and number of citations.—Continued

	Data Set	Number of Publications Using	Number of Publications Citing
Minnesota			
	Land Cover	19	44
	Predicted Species Distribution	1	1
	Stewardship	2	
Mississippi			
	Land Cover	7	22
	Predicted Species Distribution	2	
	Stewardship	1	
Missouri			
	Land Cover	3	
	Predicted Species Distribution	1	4
	Stewardship	2	27
Montana			
	Land Cover	16	376
	Predicted Species Distribution	4	109
	Stewardship	8	311
Nebraska			
	Land Cover	8	19
	Predicted Species Distribution	1	
	Stewardship	1	
Nevada			
	Land Cover	16	70
	Predicted Species Distribution	1	
	Stewardship	2	13
New Hampshire			
	Land Cover	1	
	Stewardship	2	2
New Jersey			
	Land Cover	4	8
	Stewardship	4	3
New Mexico			
	Land Cover	30	549
	Predicted Species Distribution	7	24
	Stewardship	10	274
New York			
	Land Cover	8	43
	Predicted Species Distribution	2	1
	Stewardship	5	5

Table 4. Datasets, number of publications using each dataset, and number of citations.—Continued

Data Set		Number of Publications Using	Number of Publications Citing
North Carolina			
	Land Cover	2	
	Predicted Species Distribution	2	
	Stewardship	3	2
North Dakota			
	Land Cover	2	
	Stewardship	1	
Ohio			
	Land Cover	1	
Oklahoma			
	Land Cover	9	19
	Stewardship	1	33
Oregon			
	Analysis	1	5
	Land Cover	29	250
	Predicted Species Distribution	3	95
	Stewardship	7	49
Pennsylvania			
	Land Cover	13	112
	Predicted Species Distribution	2	3
	Stewardship	3	5
Puerto Rico			
	Land Cover	4	9
	Predicted Species Distribution	1	
Rhode Island			
	Land Cover	1	
	Stewardship	1	2
South Carolina			
	Land Cover	7	10
	Predicted Species Distribution	3	10
	Stewardship	2	
South Dakota			
	Land Cover	7	106
	Predicted Species Distribution	1	
Tennessee			
	Land Cover	2	18
	Stewardship	1	2

Table 4. Datasets, number of publications using each dataset, and number of citations.—Continued

Data Set		Number of Publications Using	Number of Publications Citing
Texas			
	Land Cover	13	15
	Predicted Species Distribution	8	32
	Stewardship	2	
Utah			
	Land Cover	31	970
	Predicted Species Distribution	4	3
	Stewardship	6	192
Vermont			
	Land Cover	1	
	Stewardship	1	2
Virginia			
	Land Cover	8	69
	Predicted Species Distribution	1	
	Stewardship	3	2
Washington			
	Analysis	1	
	Land Cover	20	150
	Predicted Species Distribution	12	2
	Stewardship	8	38
West Virginia			
	Land Cover	10	8
	Predicted Species Distribution	1	5
	Stewardship	2	7
Wisconsin			
	Land Cover	3	91
	Stewardship	1	
Wyoming			
	Land Cover	32	500
	Predicted Species Distribution	4	56
	Stewardship	9	312
Southeast GAP			
	Land Cover	4	
	Predicted Species Distribution	6	
	Stewardship	1	
Southwest ReGAP			
	Land Cover	61	127
	Predicted Species Distribution	8	
	Stewardship	4	1

Table 4. Datasets, number of publications using each dataset, and number of citations.—Continued

Data Set		Number of Publications Using	Number of Publications Citing
Northwest GAP			
	Land Cover	2	5
National			
	Stewardship	3	5

There is a strong correlational relationship between the number of publications in which a dataset was used and the number of citations: $r = 0.75$, $n = 105$. Generally, a higher number of publications using a dataset is positively related to the number of citations to the publications using that dataset. However, this is not a perfect relationship. Because the California land-cover dataset was used most frequently in publications, it is reasonable to expect that this dataset would be associated with the most citations. The 93 publications using California land cover were cited in a total of 927 publications. Utah land cover was used in fewer publications—this dataset was used in 31 publications—yet publications using this data were cited in a total of 970 publications. Utah was one of the first states to complete a GAP project which may contribute to the number of citations attributed to publications that utilized Utah GAP data (Jocelyn Aycrigg, GAP, oral commun., 2010).

It is difficult to determine from available evidence why some publications are cited more than others. Less cited publications may appear in journal outlets that are of regional interest with limited circulation. They may receive less exposure and therefore are cited less frequently. It may be that the characteristics of some datasets make them more useful. It is clear that some datasets are not benefitting as much as others from a secondary diffusion via use in the published literature.

Notably, publications using the regional and national GAP datasets lack citations. The SWReGAP land-cover dataset is the only one that frequently appeared in publication citations. The lack of citations for publications using regional datasets is not surprising given that these are newer datasets. It is likely that the publications using these datasets are more recent and therefore have not been available long enough to accumulate a citation history.

In a figure paralleling figure 6 which depicts the number of times each dataset was used, figure 9 depicts the number of citations associated with publications using each dataset. Datasets were not included in this figure if there were no citations associated with any publication using that dataset. The number of citations are provided in the figure when there were more than 100 citations.

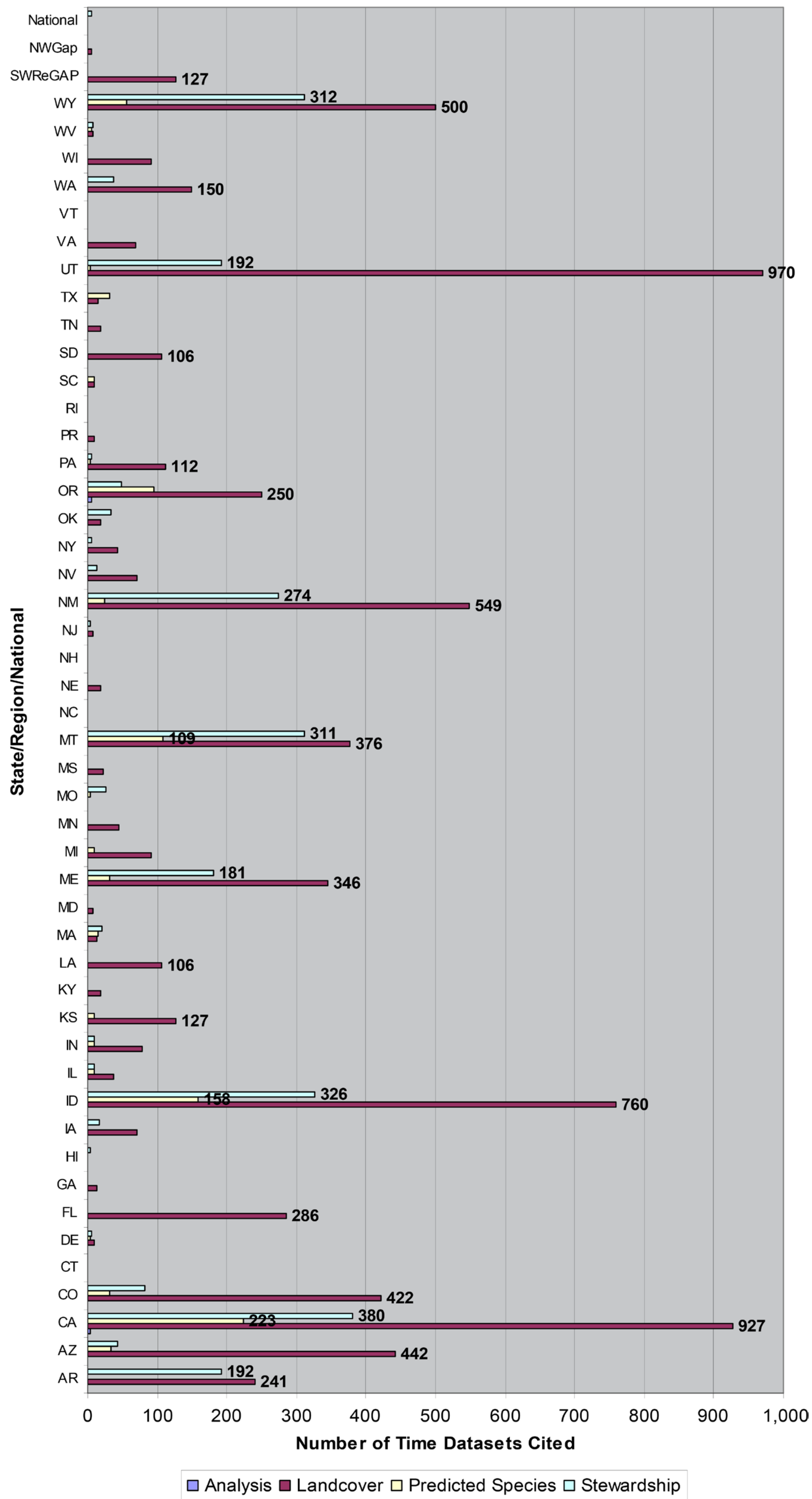

Figure 9. Number of citations associated with publications using each dataset.

Summary

The bibliometric analysis of published literature citing use of GAP data was limited in focus. We did not compare the research resulting from use of GAP data with research using other similar datasets. When bibliometric analysis is used for evaluation purposes, comparisons are often made among programs (Davis and Royle, 1996), disciplines (Mullins, 1987), or geographic entities such as states (Shapira and others, 2003) or countries (Garg, 2003). Our analysis lacked these comparisons. However, this bibliometric analysis was only a small part of the overall program evaluation and served the purpose of determining an added benefit of GAP—research productivity. The 342 journal articles appeared in 161 journals associated with 34 disciplines. This suggests that GAP data are used in many disciplines for purposes beyond conservation of biodiversity.

We identified the journal impact factors for the published journal articles using GAP data. Publications using GAP data appeared in a variety of journals with a wide range of impact factors. In bibliometric research, impact factors are used to indicate the impact of the articles included in the journal (Davis and Royle, 1996; Seglen, 1997) and indicate the prestige of the journal (Davis and Royle, 1996). Forty percent of the journal articles included in the publications using GAP data were published in journals that are considered top journals within their respective disciplines based on the impact factors. Smaller proportions of journal articles were published in the second and third quartiles of impact rank, 28 percent and 23 percent respectively. Many of the journals in the third quartile were more likely to appeal to a regional rather than national audience which may have affected the impact factors.

Citation rates tend to be skewed (Pendlebury, 2009; Seglen, 1997) with a small number of articles being cited frequently and a large number of articles being cited infrequently. This pattern was evident in the citations to publications using GAP data. Older publications tend to have higher citation counts. Yet, the publication using GAP data that was most frequently cited was published in 2004. The publications that are among the most frequently cited are a mix of early (mid-1990s) publications using GAP data and those published in the early 2000s.

The datasets used in the most publications are not necessarily those in the publications with the most citations. Citation behavior is complex. Based on the available information, it is difficult to determine why some datasets were used more frequently in publications or why publications using particular datasets were cited more frequently than others. The frequency data does suggest that land-cover data is used more frequently than the other types of datasets and that publications using some land-cover datasets are cited more frequently than those using other datasets.

The diversity in journals publishing articles using GAP data, the range of journal impact factors associated with these publication outlets, and the variation in citation rates for these publications suggest variation in exposure to and reaction to the different datasets. This has specific implications for the survey of GAP users. The survey must include questions to determine the dataset each survey respondent is most familiar with and the questions must be specific to GAP datasets. This requires an adaptive survey. For example, we included questions early in the survey that identify which dataset the respondent has used and that facilitate directing that respondent to questions particular to that dataset.

Discussion

We located 646 publications that clearly stated a use of GAP data. One early concern in the search for published literature using GAP was the possibility that people were using GAP but not correctly identifying GAP as the source of their data. There may be some people who are using the data and not attributing it to GAP, but evidence suggests that people do reference the data they use to GAP.

There were a few publications in which the authors noted that they used GAP data in their acknowledgments section but did not specifically identify any GAP dataset in the text of the publication. Other than correct attribution to a source, the diffusion of information regarding GAP datasets and GAP itself is an important reason for GAP data to be identified when it is used in a publication. Publishing the use of GAP data is one way to publicize the data as a resource. Impact of a program as determined by publication and citation counts can be affected by the visibility of the program (Martin and Irvine, 1983). A circular pattern exists. The impact of a program is affected by publication based on the program's datasets; more publications are generally interpreted as a greater impact. When more publications are available, there is greater likelihood that others will be exposed to information regarding the program and the datasets it produces and additional use of the program data will result. Increased use of the data, particularly when publications are produced, leads to a higher impact as measured by publication and citation counts.

Many publications used GAP data. These publications were produced by many authors—not a limited group of authors. This suggests that knowledge about GAP and the datasets it produces is not restricted to a particular group of individuals. The publications were mostly journal articles but also included conference presentations, dissertations and theses, reports, and book chapters. The prominence of journal articles may be an artifact of the reliance on databases in the search method used to find publications using GAP data. The publications in journals were not limited to a select list of titles. The journals in which these articles were published represented a broad range of topics and disciplines. Due to the nature of the search method, the results may over-represent academic research rather than use of GAP data for on-the-ground conservation decisions.

As anticipated, the datasets cited in the published articles were primarily from state and not regional or national projects. This does not mean that the regional and national datasets are less useful or that they will have less impact. It simply means that they may be too recent to have accumulated a publication and citation history. Continued use of state datasets suggests that, contrary to conventional wisdom that older data is not as good, older GAP data is still useful. Even the publications produced in the first six months of 2010 used state datasets; this suggests that GAP data has a long "shelf life." Older data is necessary for studies of landscape and climate change. Ramsey and others (2009) used GAP data in a study of the recovery after Hurricane Katrina.

Based on the sample of publications using GAP data that were included in this study, land-cover data appears to be used more than the other types of data produced by GAP. When we looked at number of publications using each type of data, land-cover data was used in 73 percent of the publications. The summary of the number of times each dataset was used indicated that the California land-cover dataset was used most frequently. In the analysis of citation counts associated with datasets, the Utah land-cover dataset was used in the publications that received the most citations in other publications.

We searched the text of the publications for statements regarding GAP data. The following six themes emerged from the statements: description of data, how data were used, critiques, comparisons, commentary, and reference to GAP data. We described each of these themes and provided examples. The theme including statements regarding how GAP data were used yielded two points of particular interest. First, some of the statements described how GAP data were transformed by adding data, removing data, or otherwise altering existing GAP data. This suggests that some level of GIS expertise is necessary to use GAP data. Second, GAP data were used in a wide array of applications. The evaluative statements in the critique, comparisons, and commentary themes were a combination of favorable and unfavorable statements regarding GAP data. The mixed tenor of these comments suggests that the issues raised in some of the statements may be specific to particular uses of GAP data and not the data. An issue such as the datedness of the data may be problematic in some circumstances but beneficial in others.

The bibliometric analysis indicates that journal articles using GAP data appear in journals affiliated with multiple disciplines and at all levels of impact as defined by the journal impact factors. The set of publications used in this study were cited in a combined number of 2,295 other publications. People who read publications in which the authors used GAP data and specifically identified the data as from GAP are exposed to GAP data. It may be the reader's initial introduction to GAP. Other readers who are familiar with GAP and the data it provides may develop a greater understanding of GAP data and potential uses of these datasets. There is evidence that publications using GAP data have served as a means to diffuse this information.

Citation counts indicate that publications using GAP data have been cited in other publications at varied rates. Some publications have been cited very frequently. For example, the Homer and others (2004) article describing the development of a national land-cover database has—as of the date the citation search was conducted in August 2011—been cited in over 250 other publications.

The results of this published literature study point to diversity in the uses of GAP data. The publications that used GAP data appeared in a variety of types of publications although primarily in journals. The journals were numerous and from a wide variety of disciplines. Even though most of the datasets used were land-cover data, many specific datasets were used in the publications. The text of the publications indicated that GAP data were used for different purposes and in different ways. The publications appeared in journals at all levels of impact as defined by journal impact factors and within-discipline quartile ranks. There was diversity in the publications, datasets, comments, and citation patterns. The primary implication of this diversity for the development of the survey is that the survey questions needed to be tailored to specific datasets. To achieve this tailoring, particular attention is necessary in the construction of the survey. The analysis of adaptive survey data is more complicated than for a simpler survey.

In summary, the implications for the survey of GAP users include developing specific questions based on issues identified in the qualitative analysis of statements made in the publications, and tailoring questions so that they are specific to datasets. The authors who published these articles have clearly used GAP data and will be included in the survey sample.

Acknowledgments

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List of References

This list of references includes the references cited in text; the list of publications that cited GAP data, some of which were cited in text, marked with an asterisk (*); and the secondary references that occurred within the quotations we used from the publications that cited GAP data, marked with two asterisks (**). These secondary citations are provided only as a courtesy to the reader.

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