[CP-05-024] ArcGIS Online

Abstract

ArcGIS Online is a hosted geographic information system (GIS) created and hosted by Environmental Systems Research Institute (Esri). In a few short years, it has eclipsed desktop software as the most popular tool for mapping and spatial analysis. ArcGIS Online is more than a traditional GIS software in that it also includes access to a wide range of authoritative datasets. ArcGIS fits into the Web 2.0 model where users of the platform are able to create and share maps.

Keywords: data dissemination, data visualization, Esri, interactive mapping, SAAS, software as a service, spatial analysis, spatial data, web GIS

Author & citation

Kne, L. (2022). ArcGIS Online. The Geographic Information Science & Technology Body of Knowledge (2nd Quarter 2022 Edition), John P. Wilson (Ed.) DOI: 10.22224/gistbok/2022.2.13.

Explanation

1. Definitions
2. Introduction to ArcGIS Online
3. Using ArcGIS Online Map Viewer
4. ArcGIS Online Administration

1. Definitions

ArcGIS Online Subscription - There are two levels of access to ArcGIS Online, the public account and a subscription account. The public version provides free access to a limited set of map making tools and data resources. The subscription unlocks a larger set of geoprocessing tools and data that can be used by individuals and organizations. The cost of the subscription is based on the number of users and the types of tasks to be performed. Pricing also varies by sector (i.e., government, education, or a for-profit company).

Service Credits - Beyond the resources which are freely available on the public version of ArcGIS Online, service credits are charged for performing tasks and storing data. For example, tasks such as geocoding can consume large numbers of credits. Esri provides resources to estimate how many credits are needed for different tools.

Content – At its core, ArcGIS Online is a content management system. ArcGIS Online is composed of items, such as maps, 3D scenes, apps, and data that are made available through the platform. Content is created by Esri, such as seen in the Living Atlas of the World, as well as other users of ArcGIS Online. Some of the content is created by authoritative sources, such as government agencies, while other content is created by users who are only identified only by their alias on the platform. All users are able to add content to ArcGIS Online and choose how their content will be shared. Users can manage

their items through the “Content” tab.

2. Introduction to ArcGIS Online

The adoption of web-based mapping has been growing strongly for more than two decades. These services allow anyone with an internet connection the ability to interact with maps created by others across the globe; make and share their own maps to express ideas through visual narrative; and perform now simple analysis like querying, spatial overlay, buffering, and routing. Interactive maps are now common, with readers even expecting them to be part of many news articles and social media platforms because of their effectiveness and power in disseminating information. Several platforms (e.g., GeoCommons, ArcGIS Online, Mapbox) have grown to have more functionality, tools, and data to create robust web-based GIS applications that rival the capabilities reserved for desktop software only a few short years ago. This topic focuses on one specific web-based mapping platform, ArcGIS Online. See Web Mapping and Web GIS for more information on the underlying technologies and GIScience related to web-based GIS, as well as Enterprise GIS for a description of implementing GIS across an organization.

ArcGIS Online was publicly released on June 14, 2012 and quickly became the central tenant of the Esri platform. ArcGIS Online is more than a tool for making maps because it includes access to curated and un-curated data resources, a wide variety of analytic tools, as well as being a platform for hosting and sharing spatial data. It is used world-wide by governments, private industry, non-government organizations (NGO), and academia (Esri, 2012) to share maps, apps and data internally and externally; manage spatial data through the complete data life cycle (i.e., create, collect, edit, analyze, archive, etc.); and perform analysis with user created data and resources of the Living Atlas. Tasks that ArcGIS Online does not do well include the creation of static, cartographically complex maps; customized analytic tools except by exporting data to a third-party application; and management of complex relational datasets.

ArcGIS Online is an example of a software as a service (SaaS) platform, being available to anyone with a modern browser and internet connection. SaaS is now common with the wide adoption of platforms like Google Docs and Microsoft 365. ArcGIS Online is hardware and operating system agnostic and can be used by people on devices from smartphones to desktop computers. The primary ArcGIS Online interface cannot be accessed offline, although some components of the ArcGIS Online ecosystem (e.g., ArcGIS Field Maps) are designed to function without an internet connection and synchronize data when one is available.

Web-based platforms typically have a short development cycle. This agile approach allows for new features to be added incrementally, as well as quick resolution of security issues and bugs. ArcGIS Online is updated quarterly, with many of the updates providing more spatial analytic tools. The platform has reached a point where most common geospatial analysis can now be performed with ArcGIS Online; a full description of tools available can be found in section 2.1 and at the ArcGIS Online website.

Similar to many cloud-based offerings, ArcGIS Online offers a free public account which allows a user to sign-in using their social logins (e.g., Facebook, Google, GitHub, etc.), or by creating an Esri account. The free accounts have limited functionality which include a

subset of map making tools, data resources, and map sharing options. A subscription to ArcGIS Online is a paid version that allows an individual or organization to purchase the level of access and functionality desired. The pay as you go model has become the norm with web-based services, benefiting the service provider with an ongoing revenue stream, while also benefiting the end user by only paying for the resources needed through the purchase of credits. This differs from the traditional software model where an individual or organization purchases the software and may perform unlimited analysis. ArcGIS Online charges by the volume and type of services consumed. See Section 4 for more information about credits.

2.1 ArcGIS Online Ecosystem

Table 1. Applications with the ArcGIS Online Ecosystem

Visualization Tools	
Map Viewer	A core component of ArcGIS Online used to create interactive maps, perform analysis, visualize data, and share content with others.
Scene Viewer	A core component of ArcGIS Online that allow visualization of spatial data in 3D.
Data Collection	
ArcGIS Field Maps	A customizable field data collection application that runs on mobile devices (e.g.: Android, iOS, Windows).
ArcGIS Quick Capture	A field data collection application design for rapid collection of a limited number of attributes that runs on mobile devices (e.g.: Android, iOS, Windows).
Survey123 for ArcGIS	Similar to many other online survey authoring tools, and it saves the data into Hosted Feature Services for good integration into maps and other ArcGIS Online applications.
Data Science Tools	
Business Analyst Online	An easy-to-use tool to explore census, American Community Survey, business data, and much more to help make decisions.
GeoPlanner for ArcGIS	An application using the principles of geodesign to perform analysis that drives decisions.
ArcGIS Dashboards	A tool to configure real-time monitoring of data (e.g., fleet vehicle location) with maps, charts and other visualizations.
ArcGIS Notebooks	Data science and the ability to perform reproducible research is available through hosted Jupyter Notebooks.
Custom Applications	
StoryMaps	A popular tool that uses maps and multimedia content to create a narrative through time and space.
ArcGIS Hub	Template driven content management platform that includes built in resources for sharing data and engaging communities through campaigns.
ArcGIS Experience Builder	Widget-based tools that allows application development with little or no coding. Apps can be hosted on ArcGIS Online or another web server.
Configurable Apps	A suite of templates that take an ArcGIS Online map and add functionality with no coding. Some example templates include the basic viewer, swipe maps, and crowdsourcing apps.

2.2 ArcGIS Online in Higher Education

In 2006, the NRC report Learning to Think Spatially was the call to action to incorporate spatial thinking into K-16 education and beyond (National Research Council, 2006). SaaS platforms such as ArcGIS Online provide the needed technology to make the vision a

reality. We are seeing widespread adoption of ArcGIS Online as a platform for teaching spatial literacy in education (Kholoshyn, 2019 & Pánek, 2016). Esri has a long-standing commitment to supporting education by providing ArcGIS Online (and the entire suite of desktop software) to institutions of higher education at reduced prices. In 2014, in cooperation with the Obama White House, Esri announced their Connect Ed program which provides ArcGIS Online at no cost to all qualifying K-12 schools and education-focused NGOs in the United States (Esri, 2014). Esri has since made ArcGIS Online freely available to primary and secondary schools throughout the world (Esri, n.d.-a).

While some people who traditionally used desktop GIS software have moved much of their work to ArcGIS Online, most people using ArcGIS Online have not made use of GIS software in the past. In fact, many may not realize that they are using GIS, rather they are making maps and performing spatial analysis. The effort needed to become proficient with ArcGIS Online is far less than any desktop GIS software. In academia, this has allowed students, faculty, and staff throughout all discipline to quickly create compelling maps without taking a semester-long GIS course. Thinking spatially, through the integration of ArcGIS Online and StoryMaps into non-GIS curriculum has become common throughout many disciplines (Krzyzanowski, 2022). A look at the gallery (Figure 1 below) highlights the depth and breadth of maps created by students at one university.

An unintended consequence of the rapid development cycle (a new release every three months) is that for those teaching with ArcGIS Online, it can be difficult to keep their training materials current with resulting updates to the user interface.

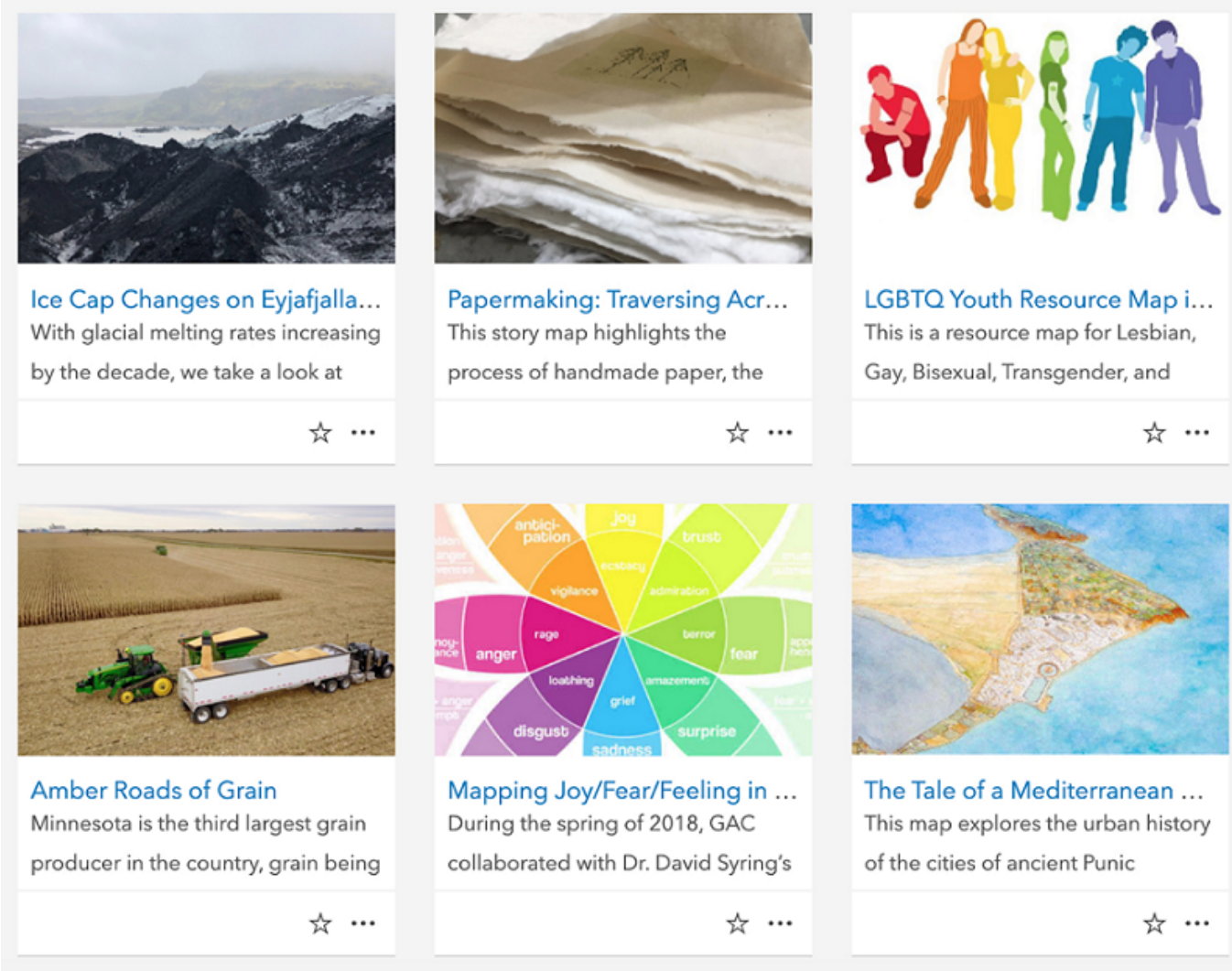


Figure 1 - Sample of University of Minnesota ArcGIS Online Gallery from students in Nursing, Anthropology, History, Business, Geography, Economics, and Natural Resources. Source: author.

3. Using ArcGIS Online Map Viewer

As a browser-based application, ArcGIS Online can be used on a wide range of devices, from desktop computers to smart phones. ArcGIS Online and related applications use responsive design to support map visualization on varying screen sizes and aspect ratios. Localization refers to how software implements language support for the application and content. Currently ArcGIS Online supports at least 40 languages (Esri, n.d.-g). Note that this article is not meant to be a discussion of Esri's commitment to accessible technology, see their website for more information on accessible design.

ArcGIS Online guides users to create maps with a suite of tools for styling data layers and map components. Considerations for creating a map can broadly be summarized into four tasks including: (1) what layers and data to include, (2) types of spatial analysis, (3) cartographic choices, and (4) best practices for saving and sharing maps and apps. What follows is a brief overview of using ArcGIS Online Map Viewer; reference online documentation, quick tutorials, and context-sensitive help for assistance using ArcGIS

Online and keeping up with the latest features.

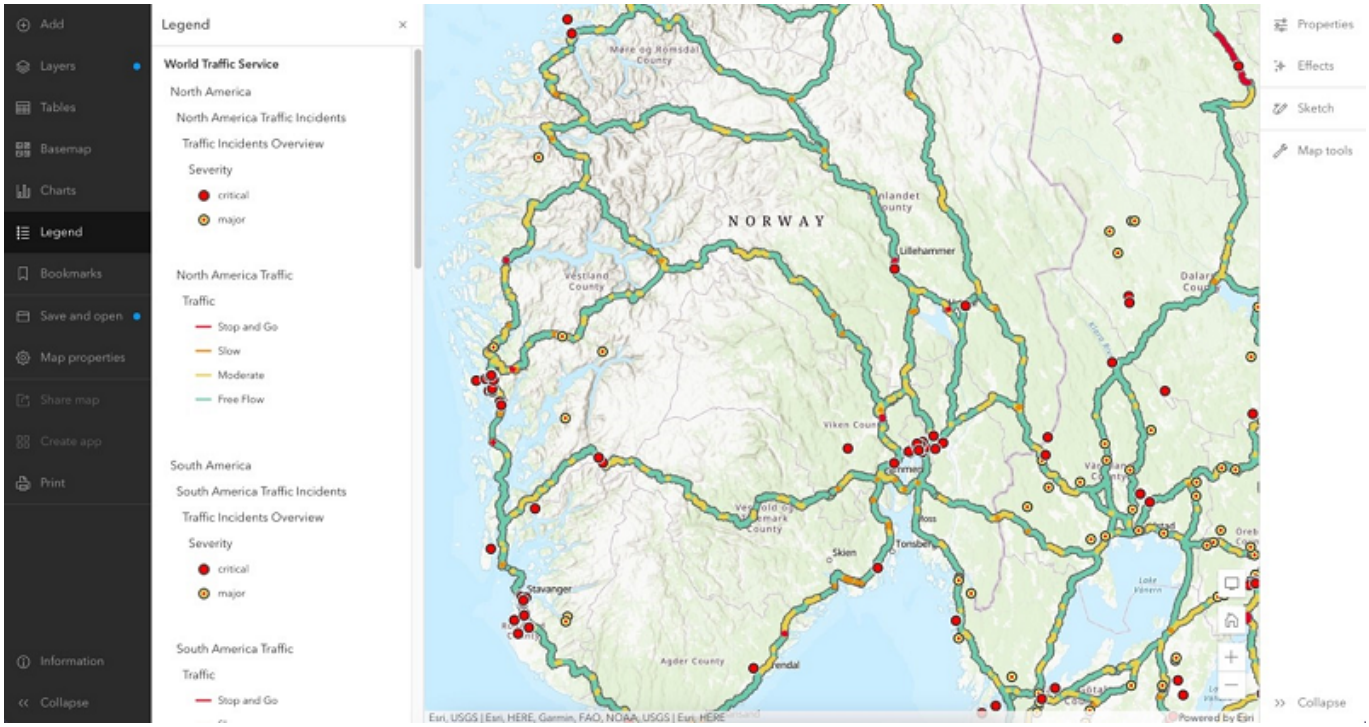


Figure 2. Example of the ArcGIS Online Map Viewer displaying the World Traffic Service available in the Living Atlas. Source: author.

3.1 Adding and Consuming Thematic and Raster Layers

While a map creator can import their own data to ArcGIS Online, when getting started, it is helpful to use data already available on the ArcGIS Online platform. The ArcGIS Online community creates vast numbers of thematic data layers that can be added to a map. Resources like the Living Atlas of the World are curated and provide foundational layers for many topics. Publicly shared user content from throughout ArcGIS Online can also be added to a map. Note that care is needed to determine the fitness of use when using a layer that may have little or no metadata.

Metadata is crucial for people to determine the provenance of data and its fitness for use (as well as your future self when retrieving items). While it is possible to enable standards-based metadata for content on ArcGIS Online, it is more common that users will include only a short description and tags to describe an item. ArcGIS Online does provide feedback to users about how to improve item information, hopefully making the content more useful to the ArcGIS Online community. There is a process to mark your data as authoritative which requires Esri verifying the identity of the content creator (Smith, 2019). Just like managing files on your computer, content management is also an important consideration when using ArcGIS Online. In addition to tags, content can be stored in folders and categories, and filtered to help organize the large number of items created by analytic tools.

A map creator can import their own data, with some size limitations, into their content on ArcGIS Online. Recognized file types include the comma separated values (CSV) text file, shape file, GeoJSON, Keyhole Markup Language (KML), and GPS Exchange Format (gpx). There are actually many more file types that can be uploaded into ArcGIS Online, however they are not able to be directly displayed in the map viewer (Esri, n.d.-d). When importing a CSV file, one or more of the columns need to provide spatial reference in order to display the data on the map. This is commonly accomplished by providing latitude and longitude, or address information (e.g. street address, city, and postal code) to geocode the data, a process of changing addresses into points on the map. ArcGIS Online uses the World Geocoding Service (Esri, n.d.-e) as its default, a service that does cost credits to perform.

A Hosted Feature Layer is a type of content that is used to store vector data (i.e., points, lines and polygons). Along with the spatial data, Hosted Feature Layers contain attribute information of the features represented and can be shared through popups. Users can create a Hosted Feature Layer while signed onto ArcGIS. Users of ArcGIS Pro or ArcGIS Desktop are able to publish directly from their desktop software to ArcGIS Online. A benefit of this method is that all the symbology and scale dependencies defined in the desktop version are transferred to the Hosted Feature Layer created in their content on ArcGIS Online. Once published to ArcGIS Online, these layers can then again be consumed by desktop GIS software, as well as web-based applications if the sharing settings are appropriately assigned.

ArcGIS Online provides storage of raster data. Raster data stored as a Hosted Tile Layer allow for fast visualization, but will not be stored in a native raster format (i.e., TIF, JPG, etc.). With the optional ArcGIS Image package for ArcGIS Online, it is possible to host common raster formats that retain their original cell resolution, enabling raster processing and querying (Delgadillo and Shelby, 2021).

Another common method for bringing data into a map is through web services, which include the standards-based services of the Open Geospatial Consortium (OGC), as well as Esri REST services typically hosted on an ArcGIS Enterprise platform. Many government agencies freely provide much of their authoritative spatial data through these web-based services. While for many uses it is convenient that data will be maintained and updated by the organization responsible for it, it is worth noting that you will likely be unable to control the version or date of the data provided by the service without making your own copy.

3.2 Spatial Analysis

Once data layers are added to the map, ArcGIS Online contains a suite of tools for spatial analysis to provide insight and answers. New tools are being added in most quarterly releases of ArcGIS Online, with most commonly used GIS tools now available. These include common geospatial functions such as clip, overlay, point in polygon, buffer, near, and routing. Data Enrichment is a powerful tool that on its surface is a simple spatial join, except it offers easy access to thousands of foundational data layers (e.g., Census, American Community Survey (ACS), consumer behaviors, land cover, etc.) with a few mouse clicks. It uses apportionment to create custom geographic units, which should be interpreted with caution when creating small polygons which may not fully represent the uncertainty of the underlying source data. For example, many data enrichment variables are from ACS, which often have large margins of error when the geographic unit is small (e.g., block group).

Note that access to the spatial analysis tools requires a subscription to ArcGIS Online and an adequate number of service credits. Most tools will create a new Hosted Feature Layer as part of the output that can be shared just like any other layer in ArcGIS Online. By default, the new layer will be added to “My Content”, thus it is beneficial to have a personal data management plan that uses a consistent naming convention and metadata containing a description, tags. and retention schedule. Similar to performing analysis in desktop software, it is easy to create lots of temporary layers that may not be needed to be part of the final project documentation. Thinking about what layers to retain will ensure that key stages of analysis are archived, while ephemeral layers are removed to reduce future clutter. It may be worth investigating ArcGIS Notebooks (see Table 1) when needing reproduceable results.

3.3 Cartographic Choices

ArcGIS Online aspires to create cartographically appropriate maps with just a few mouse clicks. Options range from changing the color and shape of a feature, to automated clustering and hotspot creation. Smart Mapping was added in 2015 and examines the data to offer symbolization suggestions (Harrower, 2015). Smart Mapping selections can be overridden, allowing the map creator to symbolize quantitative and qualitative data with a variety of standard methods. Pop ups can be configured to share attribute information about layers on a map. For advanced users, there are several methods for accessing ArcGIS Online content and geoprocessing tools via scripting languages and APIs. Arcade is Esri’s expression language that can be used in the Map Viewer to manipulate symbology or calculate new attributes.

The default projection of ArcGIS Online is the ubiquitous Web Mercator. Using this projection allows you to choose from over 20 basemaps which include imagery, transportation, crowd-sourced, and thematic layers appropriate for choropleth maps. ArcGIS Online does support using other projections by setting the basemap to your projection of choice. An example would be using a polar stereographic projection when mapping Antarctica.

3.4 Sharing Maps and Apps

By default, when you first save a map, it is private; only you will have access to view it. You are able to share your map with everyone (public) via a web URL that can be sent in an email, social media, or embedded in a web page. If you are a member of a subscription with more than one named user, you may have additional sharing options. This includes groups that you are able to define and manage, as well as the ability to share items with all other members of your ArcGIS Online organization.

As a web-based platform, map creators should understand the ArcGIS Online terms of use and how it applies to their content, especially when sharing maps publicly. ArcGIS Online makes it easy to add images and content from throughout social media and the internet, thus care is needed to respect the rights and copyrights of content from others. For further information about the rights and restrictions of content on ArcGIS, see the Online terms of use documentation.

4. ArcGIS Online Administration

Esri offers subscriptions to ArcGIS Online for teams and individuals. Purchasing a subscription unlocks a larger set of geoprocessing tools and data over the public version. Factors to consider when selecting a subscription and number of service credits include the number of named users and the types of tasks a user will perform. Different levels of user types allow organizations to purchase access based on how users will interact with ArcGIS Online (Esri, n.d.-b). Most organizations will choose to also manage access to Esri ArcGIS Pro by having authorized users sign on to their ArcGIS Online subscription.

Service credits are the tender used by Esri to perform geoprocessing tasks and purchase data storage on ArcGIS Online. While credits are consumed by storing data in ArcGIS Online, the largest use of credits for most subscriptions will probably result from geoprocessing tasks such as geocoding, network analysis, and data enrichment. For example, using the World Geocoder to locate 40 addresses would cost one credit, while storage of features cost 2.4 credits per 10 MB stored each month (Esri, n.d.-c). Service credits can be purchased in blocks of 1,000 for $100 (Esri, n.d.-f). It should be noted that many organizations or industries negotiate site licenses with Esri to bundle the access to the Esri platform that fits their needs.

When setting up an ArcGIS Online subscription, the administrator will need to decide how to manage user access. User accounts can be created and managed through ArcGIS Online, however, an institution can take advantage of single sign-on protocols to allow users to access ArcGIS Online using their enterprise authentication. This is convenient for the user as they do not need to remember another password, as well as allowing the administrator to use enterprise systems to manage access. Enabling the enterprise sign-on functionality is considered a best practice and should be a priority for anyone administering an ArcGIS Online subscription (Miller, 2018).

Another often overlooked benefit of web-based GIS is the reduction of desktop administration required. Because ArcGIS Online functions within any modern browser, there is no need to install additional software on a computer. This can save informational technology staff at organizations huge amounts of administration time installing and supporting software. There is also no longer the need to have powerful (and relatively expensive) Microsoft Windows-based computers to run Esri software. In fact, many of the application templates on ArcGIS Online take advantage of responsive design and can be run on tablets and smartphones.

Most SaaS offerings make use of large cloud hosting services such as Amazon Web Services or Microsoft Azure. This allows the service provider to easily scale to the demand for the resources without having to operate their own data center. Relying on cloud hosting services does come with some risk of catastrophic outages when there are technical issues or hacking by bad actors. Depending on the specific use of ArcGIS Online provided services, organizations need to enable appropriate redundancy and backup plans if service is interrupted. ArcGIS provides a website that reports on the status of the platform. ArcGIS Online also provides comprehensive reporting tools to monitor activity of each individual subscription (see Figure 3 below). While Esri provides a web-based administrative interface for ArcGIS Online, many of the common tasks can be scripted with ArcGIS API for Python.

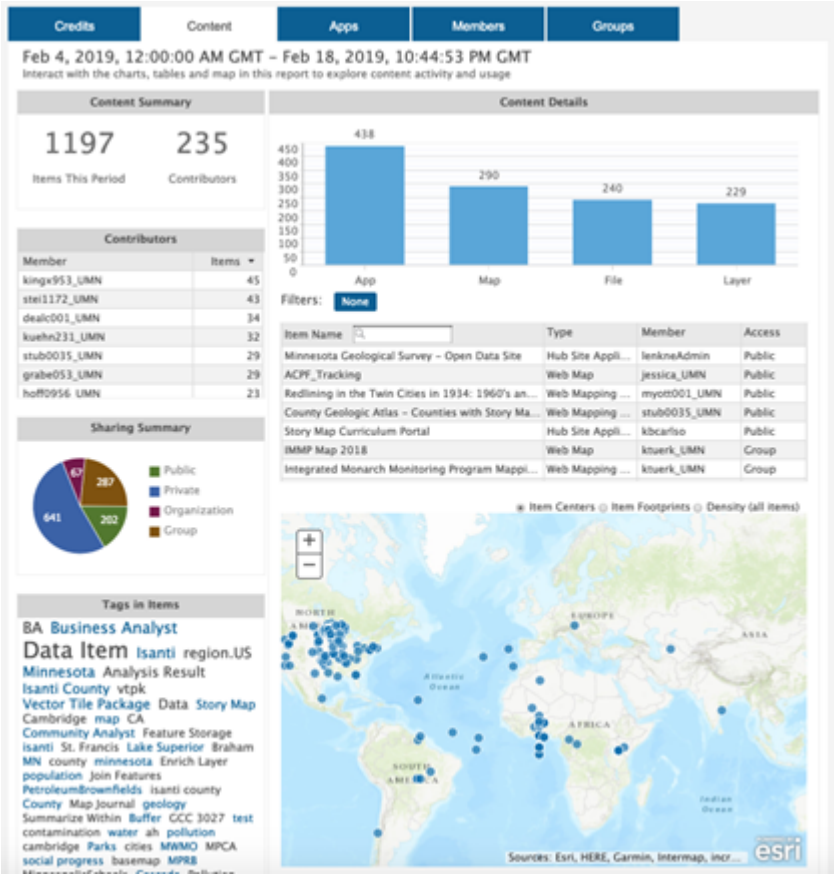


Figure 3. Example of ArcGIS Online Reporting Tools. Source: author.

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