Modeling the Florida Commercial Citrus Grove Infrastructure within a GIS

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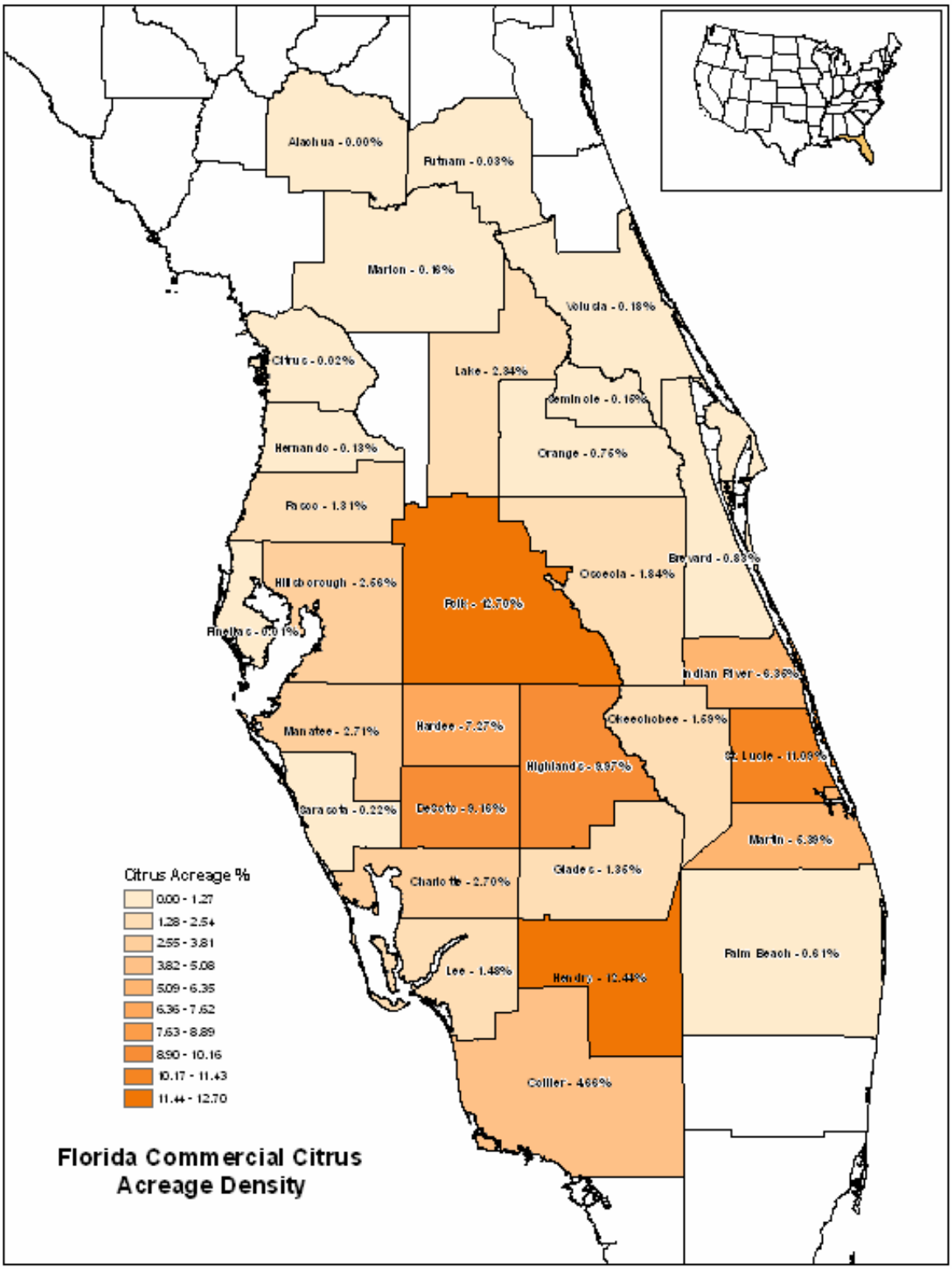
Abstract

NASS is modernizing its biennial Florida commercial citrus tree census methodology. Unchanged over 40 years, the work has been accomplished using film-based aerial photography for delineating citrus acreage and construction of survey maps. As such, each survey cycle laboriously requires flying new imagery, drawing grove boundaries, and updating a tabular database including tree counts and varieties. Additionally, limited spatial analysis is possible with the traditional system.

ArcGIS in combination with digital orthorectified imagery has shown to be an efficient tool for creating a permanent yet easily updatable digital database of citrus groves. This presentation will discuss how ArcGIS is being used as a core for building the “grove layer.” Particular focus will be on components available within the personal geodatabase including utilizing the one-to-many relational database, topology rules, and annotation layers. Also to be discussed is the ability of non-GIS fluent staff to adopt and undertake digitizing, database management, and map production.


Alachua - 0.00%
Putnam - 0.03%
Marion - 0.16%
Volusia - 0.18%
Citrus - 0.02%
Lake - 2.34%
Seminole - 0.16%
Hernando - 0.13%
Orange - 0.76%
Pasco - 1.31%
Brevard - 0.83%
Osceola - 1.84%
Hillsborough - 2.56%
Polk - 12.70%
Pinellas - 0.01%
Indian River - 6.36%
Manatee - 2.71%
Hardee - 7.27%
Okeechobee - 1.69%
St. Lucie - 11.09%
Highlands - 9.87%
Sarasota - 0.22%
DeSoto - 9.16%
Martin - 6.38%
Glades - 1.35%
Charlotte - 2.70%
Lee - 1.48%
Hendry - 12.44%
Palm Beach - 0.61%
Collier - 4.66%
Citrus Acreage %
0.00 - 1.27
1.28 - 2.54
2.55 - 3.81
3.82 - 5.08
5.09 - 6.35
6.36 - 7.62
7.63 - 8.89
8.90 - 10.16
10.17 - 11.43
11.44 - 12.70
Florida Commercial Citrus
Acreage Density

Background

For more than 40 years, a primary mission of the United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) Florida Field Office (FFO) has been to produce a biennial census of Florida's commercial citrus trees. The Florida Department of Agriculture and Consumer Services cooperate on this task sponsored by the Florida Citrus Industry. The number of trees in production along with acres utilized, variety, and year planted are tabulated. The data is aggregated and published at the county level.

The census is a major undertaking considering there are nearly 40,000 groves, totaling 700,000 acres, across peninsular Florida dedicated solely to citrus production. On average, about 130 trees are planted per acre resulting in a total citrus tree count of around 91,000,000! The majority of harvested fruit is processed into orange or grapefruit juice. Citrus is estimated to be a $9 billion a year industry and thus economically important to the State of Florida and a major component of US agriculture.

During the last year, NASS/FFO modernized its methodology for maintaining and conducting the biennial census. Previously, the citrus grove location information was stored using paper-based maps. The sheets, sized 36x36 inches and scaled roughly 1:8000, were copied from annotated panchromatic aerial photographic transparencies via an ozalid process. The products contained enough imagery detail that mature tree stands could be delineated by a photo-interpreter and located by a field enumerator.

On each map, known grove boundaries were penciled by hand. To define the current grove status the previous census's maps were used as a basis for change assessment against most recent aerial photography and field report information. In order to cover the entire citrus region, tens of thousands of groves were

delineated which required an inventory of over 1,000 of the ozalid style printouts to be maintained using manual cartographic methods. A large effort in terms of time and labor was constantly required for upkeep. Also, ancillary tables containing grove statistics such as tree count, variety, plant date, and row spacing, had to be managed in parallel (albeit stored digitally).

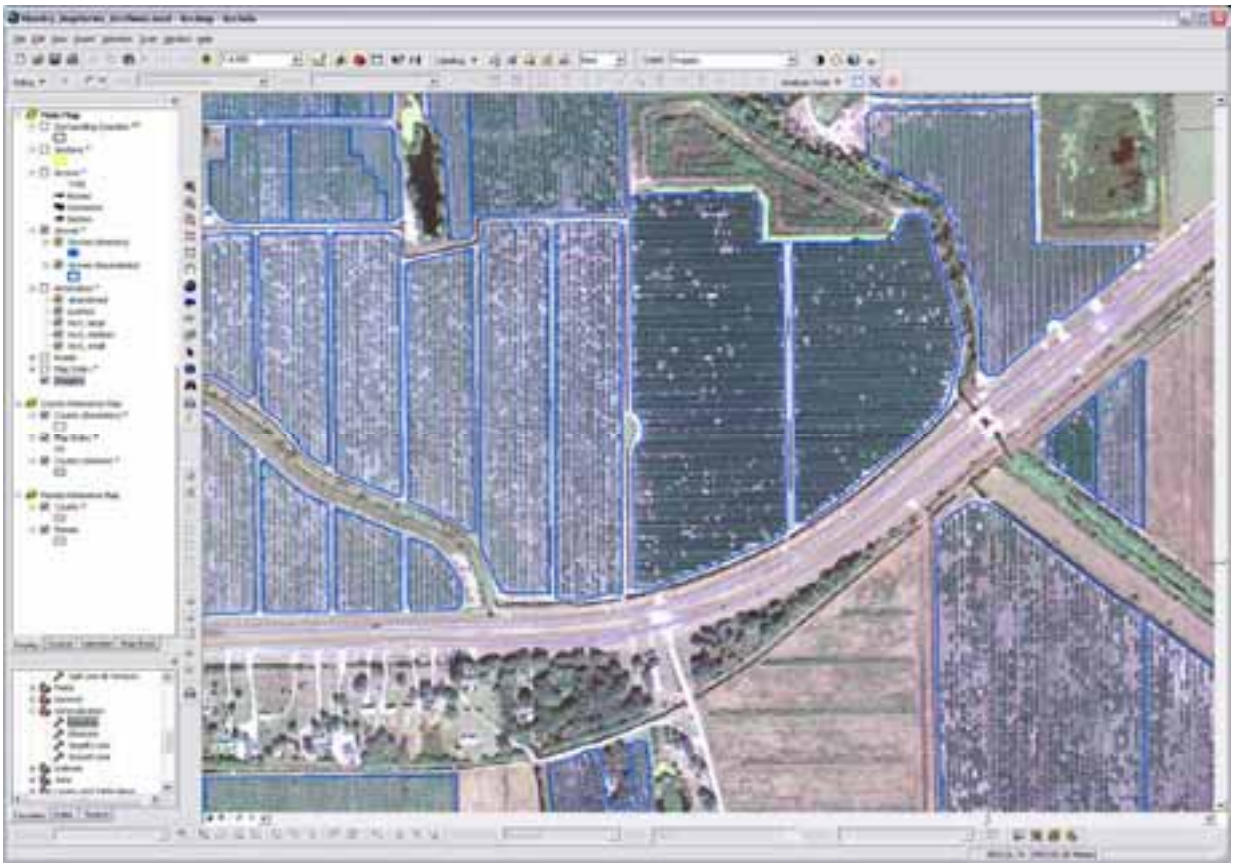
An improved system would no longer require the repetitive redrawing of groves with each census, especially since the majority of groves do not change, and would allow groves to be physically linked to their attribute data. Additionally, more flexible and consistent map products would be an upgrade along with better means for photo-interpreting change areas. ArcGIS was a natural tool for such a task and ready to implement because the USDA has a department-wide site-license for the ArcInfo series of ESRI products. Furthermore, ArcGIS is already utilized by the NASS for a variety of thematic and analytical projects, so in-house consulting was available.

Transitioning from Analog to Digital

The most laborious step of the transition consisted of heads-up digitizing of year 2004 boundaries for all citrus groves across the state. To accurately define the grove boundaries within a GIS, high quality digital orthorectified imagery was required for ground reference. Fortunately, a one meter resolution dataset had just been flown in early 2004 during a statewide endeavor sponsored by Florida's five water management districts. The provided aerial data was easy to ingest and manage within ArcGIS using an image catalog. The imagery was of sufficient detail to allow grove boundaries to be comfortably delineated within three meters of actual. Many staff members, with a variety of backgrounds and skill sets, helped in the digitizing effort of the grove boundaries. Most had never used any type of GIS software previously but took to the task once realizing the benefits of converting the groves into a digital format.

The ESRI personal geodatabase data model proved a good fit for warehousing the citrus data for several reasons. First, the geodatabase can maintain a one-to-many database record

relationship (many groves are of mixed plantings and thus have more than one data record). Second, it allows for topology checks against one or more data layers (having overlapping groves is not desirable). Third, the geodatabase's design is concise which allows feature classes and data tables to be organized and related within a single file (eases management). And finally, the geodatabase does not require support of a database administrator (less expensive infrastructure).

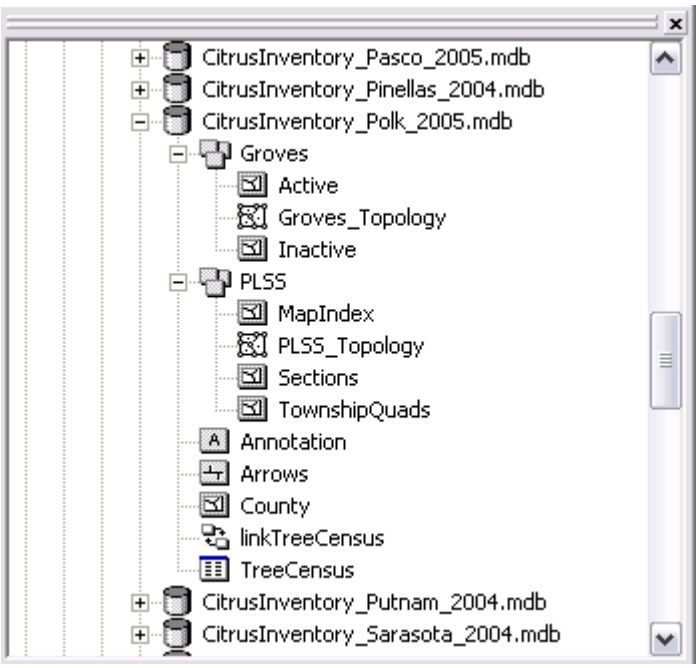


Geodatabase Specifics

A personal geodatabase containing a consistent set of spatial and tabular datasets was established for every citrus producing county in Florida. The heart of each geodatabase is a feature dataset named "groves" which contains the boundaries of the actively managed citrus groves. A topology check verifies polygons never overlap since no two groves can occupy the same physical space. A related polygon feature set of "inactive" groves was also digitized as a

placeholder for regions where groves are no longer in production but have a high potential to be reinstated in the future.

The “active” groves are linked through a one-to-many relationship to the tree census table which contains several attributes including citrus variety, planting date, row spacing, planted acreage, and tree counts. The linkage is accomplished through a unique identifier which is given to every grove. The number is derived from the associated township, range, section, and grove identifier.



A grove can have more than one trees census record because they are not always homogenous in planting. For example, a grove may have been originally planted a few decades ago with just a single tree variety. However, as time progresses certain trees within that grove may have become damaged, unproductive, or died, and as a result they were removed. Those empty areas are typically reset with new trees which will thus have a different plant date. Additionally, the new trees may be of a different variety or spacing. In larger and more mature groves mixed plantings of trees are very common.

A second feature dataset within the geodatabase houses the boundaries of the townships, ranges, and sections for that county. Like much of the agricultural regions of the United States, most of Florida was laid out on the Public Land Survey System which divides the landscape into roughly 1-mile square area sections. Most of the Florida road and canal systems follow these boundaries and the groves areas typically fall neatly into a single section. For the citrus inventory the index grid serves two main purposes. First, it is used for spatial reference on the maps for which the enumerators and citrus growers are familiar. Second, the boundaries serve as a backbone for deriving the indexing grid system needed to organize the printed map series. In regions of change, boundaries may have been edited and shifted to better represent the current physical boundary rather than the historical ones. Topology is used to assure there are no gaps or overlaps in the grid system.

Next, an annotation layer of text was added to retain unique labeling on the maps. Examples include phone numbers of growers, instructions on where to enter a property, and names of landmarks important to the enumerators.

An “arrows” line feature class was also added. Its purpose is to hold linear style annotation which is usually symbolized with arrows. For example, the direction to an access point is usually easiest to described using arrows along road and pathways than through a text description. Another use of arrows is to connect graphically multi-part polygons since some groves may span a gap such as a road or small water body.

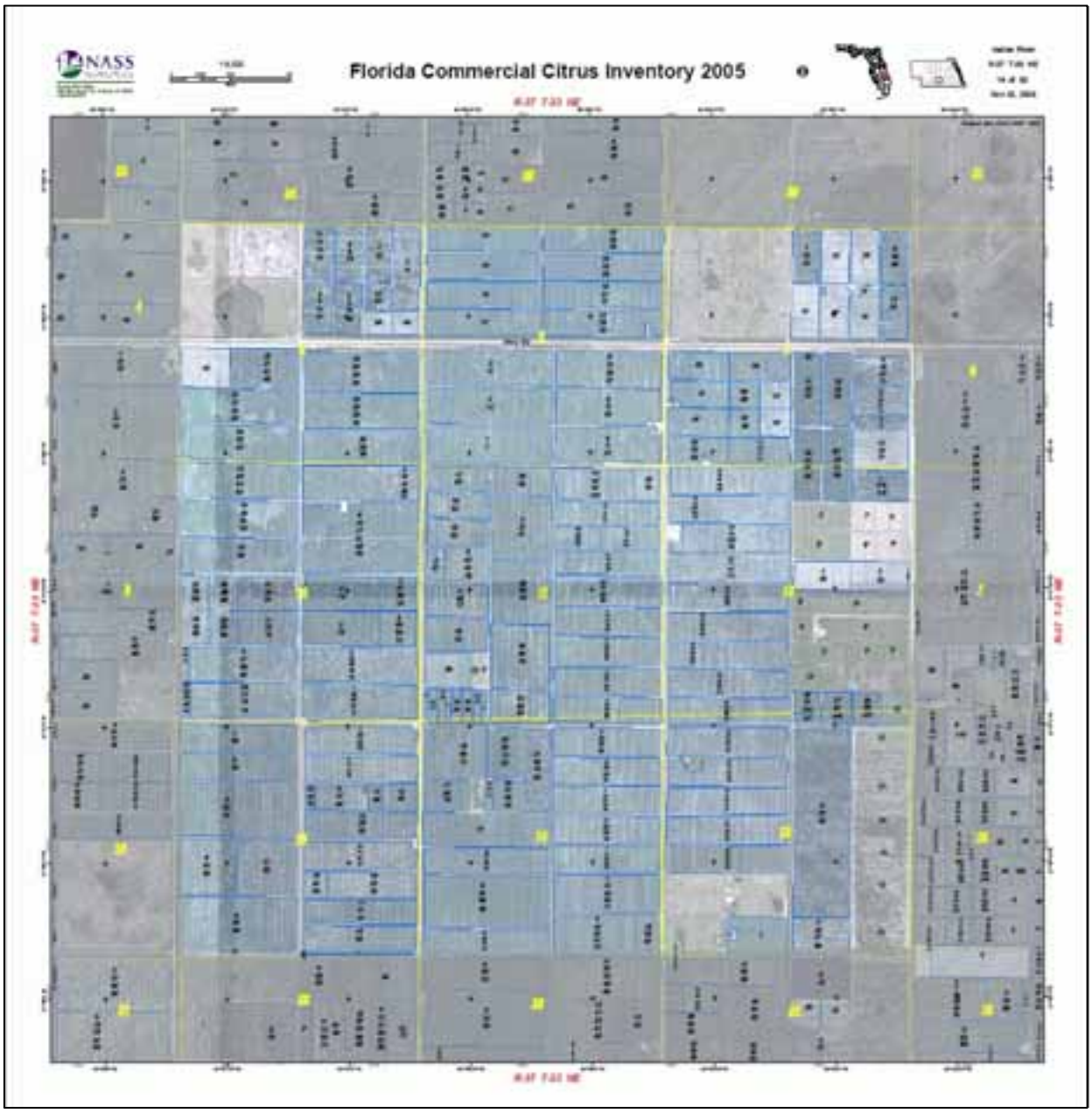
Finally, the county boundary was embedded into the geodatabase for quick reference.

The Florida Citrus Census Today

The building of the citrus GIS inventory was completed during the spring of 2006. Citrus enumerators are still relying on paper maps but are now using improved ones created from ArcMap utilizing the grove layer overlaying current digital ortho-imagery, the Public Land Survey System grid, and roads data. They are able to modify map layouts to suit cartographic needs and benefit from the increased detail the new maps afford compared to the former ozalid reproductions. Aerial photo interpretation and delineation of grove changes continues via visual inspection of before and after images (2005 imagery flown via the USDA’s National Aerial Imagery Program is now being analyzed against the 2004), but is now performed digitally within ArcMap.

Further advantages of the GIS allows for spatial analysis that was once limited. One example that has already been employed by FASS staff includes the ability to estimate the citrus groves that may have been impacted from hurricanes by overlaying wind field models. Another example is the capability to assess trees that are likely going to be quarantined and taken out of production because of proximity to nearby diseased trees. Additionally, the ability to incorporate GPS data is now being explored and it is someday hoped to transition the project away from paper entirely, relying on tablet or pocket type PCs for data maintenance in the field.

The biggest advantage of the citrus GIS however is the ability to more quickly document and publish rapid changes to the tree numbers. Citrus growers in Florida have had many negative impacts to their livelihood in recent years including large losses in capacity from disease (especially citrus canker), storm damage (increased hurricane prevalence), and rising land values (groves becoming urbanized). Ultimately, it is believed the GIS will help transition the census to an annual cycle allowing the Florida Citrus Industry to better monitor changes and thus improve on policy decision making and citrus production forecasting.



Acknowledgements

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References

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