GIS
Tips & Tricks

By Al Karlin, Ph.D. CMS-L, GISP

Tired of Distributing Multiple "shapefiles"? Try a GeoPackage

When Esri introduced the "shapefile" with ArcView 2.0 in the early 1990s, the idea was revolutionary. The "shapefile" represented an open, non-proprietary, 8-bit transportable format for shape geometry (the .shp file), tabular-like attributes (the .dbf file) and a spatial index (the .shx file) that could be easily ingested into GIS software, both Esri and portable to other platforms. The shapefile quickly replaced the older Esri GIS "coverage" format, and it persists today coexisting with 32-bit feature classes in Esri file-geodatabases.

For beginning and some intermediate GIS students and particularly for students not familiar with Microsoft file structures, the "shapefile" is a source of never-ending confusion. First of all, the "shapefile" actually consists of three required computer files. The file that holds the geometry is called the shapefile and has the .shp extension; a major point of confusion. The attribute file is a holdover from those early 1990s and a database product, dBase™, with a .dbf extension. The third file is the index, the .shx file, to connect the .shp with the .dbf file. It would be great if that were all the individual files comprising the "shapefile", but there are more, optional but very important files. For the "shapefile" to be projected and rendered in the correct geographic space, it must have an accompanying projection, a .prj file, and to include metadata, a .xml file is needed. If you want to include legend symbology with the "shapefile" an .avl file is added to the list. As if this were not enough, to assist in rendering speed, additional index files are needed. So… it is not uncommon for a "shapefile" to contain 8 or more individual files! Try explaining that to students only familiar with iOS and MacBooks! Then, there are the limitations of the "shapefile" format. "Shapefiles" (1) can only contain vector-based shapes, (2) are limited to 2GB is size, (3) field names are limited to 10 characters, (4) can only store one geometry type, and the list goes on.

By the early 2000s, other "GIS" file formats were constructed to imitate the portability of the Esri "shapefiles". GeoJSON was constructed to be an open-source portable GIS format, more compact than "shapefiles". Other open-source formats, such as Keyhole Markup Language (.kml) and Extensible Markup Language (.xml) appeared about the same time. The newest GIS open-source file format, the "GeoPackage" emerged in the mid-2010s and is supported by most popular GIS packages (Esri Desktop and Pro, QGIS, and others), as well as Python and R. For details and comparisons between shapefiles and GeoPackages, see: https://www.geopackage.org/ or watch the many videos on YouTube. Although this month's Tips & Tricks focus on making GeoPackages in QGIS and ArcGIS Pro, you can also make GeoPackages using Python and/or R as the container is an opensource SQLite database.

TIP #1 — CREATING A GEOPACKAGE IN QGIS

For this tip, I am creating a GeoPackage from existing Esri shapefiles using QGIS "Lima"; one (Canadian Provinces) file has polygon- geometry and the other (Canadian Cities) has point-geometry, Figure 1, but Esri Feature Classes residing
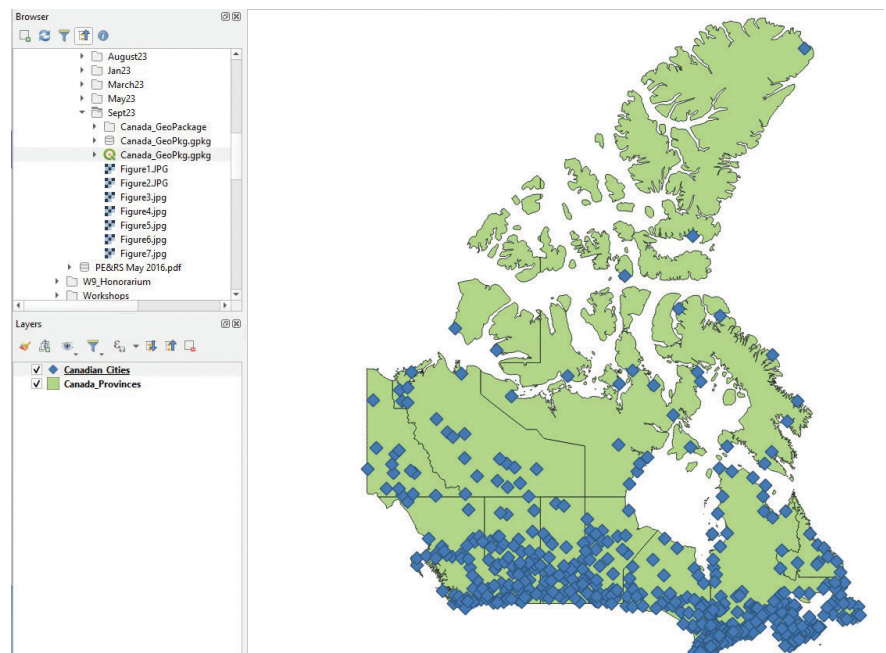

Figure1. QGIS Lima displaying two Esri shapefiles; a point feature (the Canadian Cities) and a polygon feature (the Canadian Provinces.)

in a file-Geodatabase could just as easily be integrated into GeoPackages (see later example). Both shapefiles will be exported into a single GeoPackage.

Step 1 — Open QGIS and import the shapefiles from the Browser window into the Layers.

Step 2 — Right-click on the polygon shapefile in the Layers Window and choose "export | save features as" and choose GeoPackage, Figure 2.
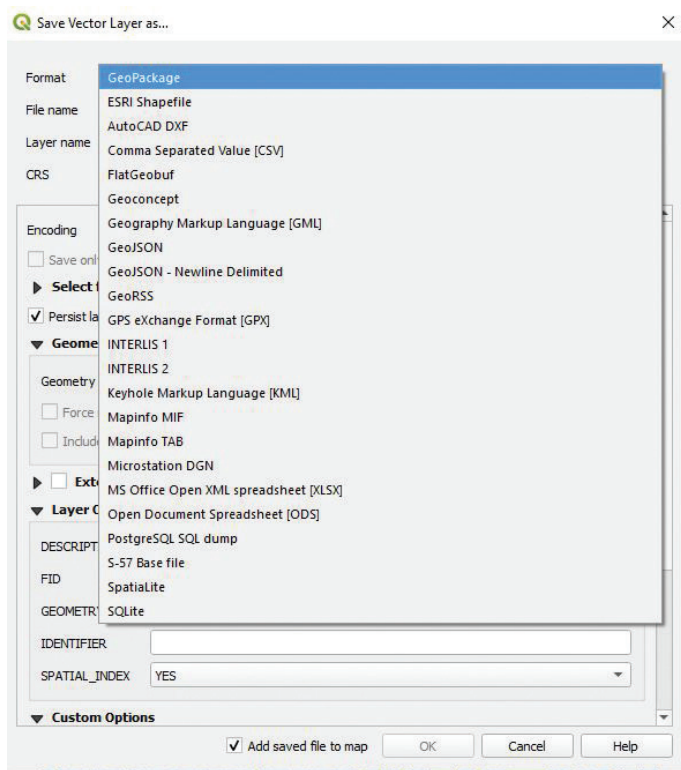

Figure 2. Saving an Esri shapefile to a GeoPackage.

Step 3 — Use the ellipses by the File name fill-in to navigate to a folder and provide a name for the GeoPackage, Figure 3.

Step 4 — Define any Layer Options (Description, etc.) and Custom Options.

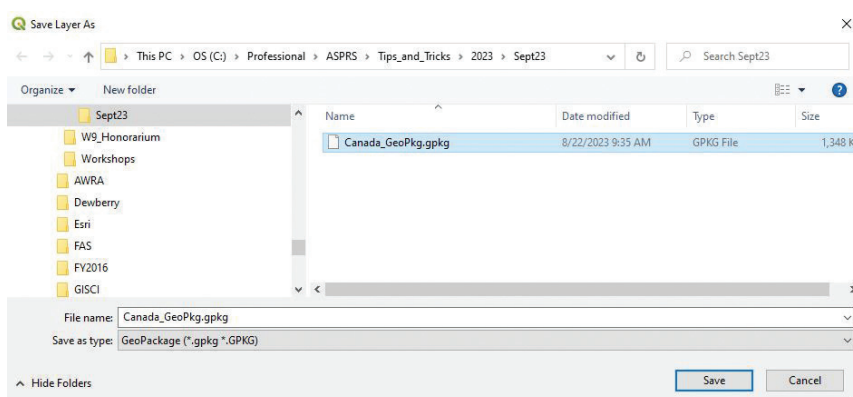**Step 5 —** Press Save to construct the GeoPackage containing the shapefile.

Figure 3. Saving a QGIS layer into a GeoPackage.

Step 6 — To ADD additional layers into the GeoPackage:

1. In the Layers panel, click the "Create a new layer" button to create a new vector layer, or right-click on an existing layer and choose "Export" to export it to a new GeoPackage file.
2. In the "Create a Layer" or "Export" dialog box, choose "GeoPackage" as the file format.
3. Choose the GeoPackage file created previously,
4. Choose the type of data you want to store in the GeoPackage, such as point, line, or polygon data.
5. Define the properties of the new layer, such as the name, attributes, and coordinate system.
6. Add data to the new layer by importing or creating new features, or by loading data from other sources.
7. Save the changes to the GeoPackage by choosing the option to save or export the layer to the GeoPackage format.

TIP #2 — CREATING A GEOPACKAGE IN ARCGIS PRO

Constructing a GeoPackage in ArcGIS Pro 3.13 is a two-step process; (1) first you create a SQLite database (.gpkg) as a container, and then (2) use the Catalog pane to load/import feature classes or shapefiles into the database container. (Esri provides a special tool for loading rasters into the GeoPackage, see Tip #3.)

Step 1— Make the SQLite database: In the Data Management |Workspace toolset, select the Create SQLite Database script, Figure 4.
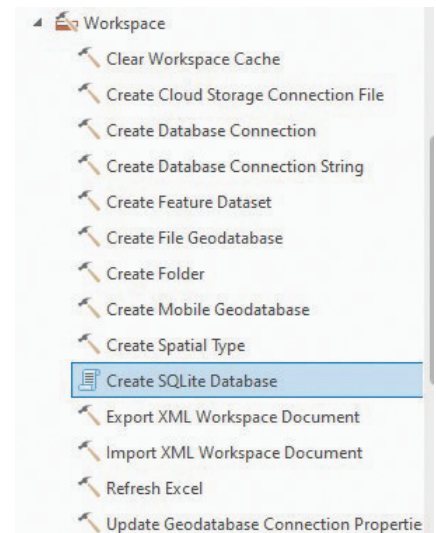

Figure 4. The Create SQLite Database script in the Data Management | Workspace Geoprocessing Toolset

Step 2 — Use the Folder icon to navigate to a file folder and provide a name for you GeoPackage, and be sure to change the Spatial Type to GeoPackage (equivalent to GeoPackage 1.3) as below (there are no Environment variables to set) and press "Run", Figure 5.
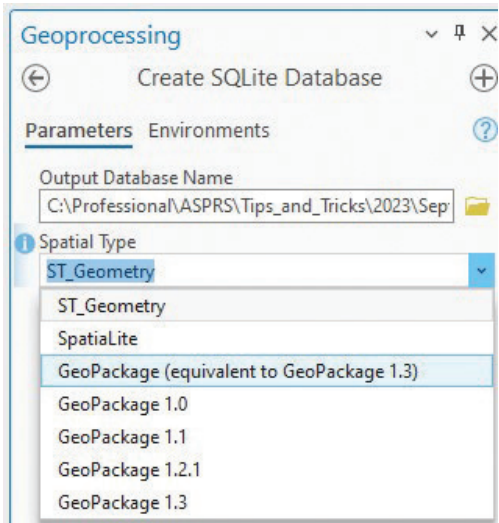

Figure 5. The Create SQLite Database dialog box.

Step 3 — Open a Catalog pane, use the "Folder" tab to navigate to your GeoPackage container (the .gpkg file), right-click on the GeoPackage contained and select "Import", Figure 6.
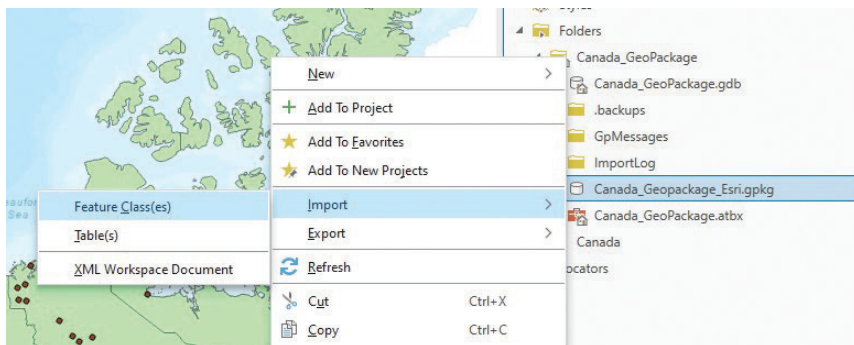

Figure 6. The Catalog Pane showing Importing Feature Class(es) or shapefiles into the GeoPackage.

Step 4 — The Feature Class to Geodatabase script will open and on the dialog menu select (or navigate) to as many shapefiles or feature classes that you want to add to the GeoPackage. Check that the correct GeoPackage is loaded into the "Output Geodatabase" line, and press "Run", Figure 7. (NOTE: You can specify Environment Variables on the Environments tab).
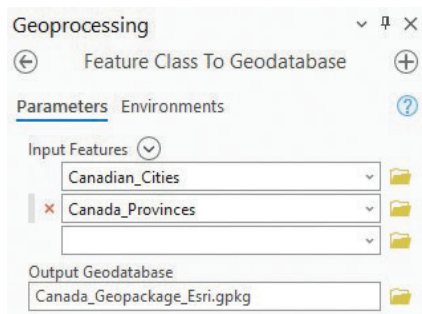

Figure 7. The Geoprocessing dialog box showing importing multiple shapefiles into the GeoPackage.

Step 4 — In the Catalog pane, opening the GeoPackage will display the features added. You can drag & drop these into your map or navigate to the features through the standard Esri ArcGIS Pro interface, Figure 8.
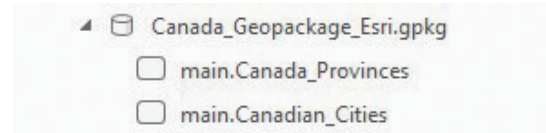

Figure 8. The Catalog Pane view of the GeoPackage populated with the two shapefiles.

Tip #3: Adding a Raster to a GeoPackage

ArcGIS Pro provides a separate tool to add a raster to an existing GeoPackage. The Geoprocessing Tool is located in the "Data Conversion | To GeoPackage" toolset. Fill-in the required fields (Input Raster, Target GeoPackage, and Raster Name) and the raster file be added to the GeoPackage.

Figure 9. Adding a raster to the GeoPackage from the Conversion Tools | To GeoPackage toolset.

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Tip #4 — Creating a GeoPackage in ArcGIS Desktop

Creating a GeoPackage in ArcGIS Desktop uses the same workflow and identical tools as were used in ArcGIS Pro, i.e. use the Geoprocessing tool: Data Conversion | Workspace | Create SQLite Database script to create the .gpgk file, and then use Catalog to import shapefiles and/or feature classes into the GeoPackage, Figure 10.

Also, as in ArcGIS Pro, to add a raster to the GeoPackage, use the Data Conversion | To GeoPackage | Add Raster to GeoPackage tool.

It is that easy to make GeoPackages that can be sent to other users and imported into multiple GIS software packages.
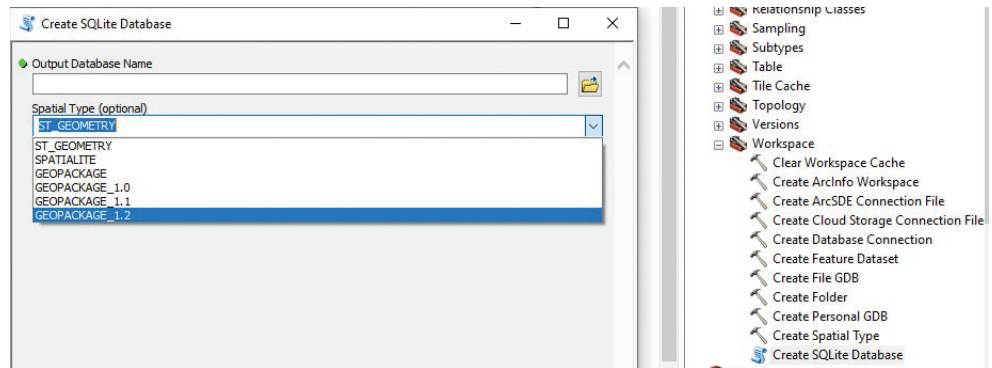

Figure 10. The Create SQLite Database tool in ArcGIS Desktop.

Send your questions, comments, and tips to GISTT@ASPRS.org.

Al Karlin, Ph.D., CMS-L, GISP is with Dewberry's Geospatial and Technology Services group in Tampa, FL. As a senior geospatial scientist, Al works with all aspects of Lidar, remote sensing, photogrammetry, and GIS-related projects.

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