ArcGIS Pro: Working with Temporal Data

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Types of Temporal Data

Moving Features
- Airplanes, boats, vehicles
- People, animals
- Storm centers

Discrete Events
- Crimes
- Accidents
- Earthquakes, lightning strikes, volcanic events

Stationary Recorders
- Weather stations
- Traffic sensors
- Stream gauges

Change & Growth
- Demographics
- Fire perimeters
- Flood extents
- Country Boundaries
The nature of temporal data

• Conceptualizations of time can vary
  - **Linear** (directional)
    - Each moment is unique, time moves forward
    - Eg: Purchase of a home
  - **Cyclic** (repeating)
    - Moments are repeated, time loops back around
    - Eg: Daily feeding schedule at a zoo

• ArcGIS assumes that time is **linear**

The nature of temporal data

- Time is relative to something
  - **Clock-driven time**
    - “On Jan 10th, 1990, at 11.00am, …” (Gregorian Calendar, UTC)
    - Hourly water temperatures
    - Crime occurrences
  - **Event-driven time**
    - “At T-minus 10 minutes, …”
    - Days since a specific earthquake
    - Planning / conducting a military exercise
  - **State-driven time**
    - “2 seconds after the vehicle stops, …”
    - Automated factory scheduling
    - Melting of ice sheets

The nature of temporal data

- **Temporal data can be:**
  - **A moment**
    - Information is captured / defined for a specific point in time
    - Described as a single time-value
    - Eg: *The exam starts at 9.00am*
  - **A duration**
    - Information is captured / defined for an interval of time
    - Can be described as either \([\text{start-time} + \text{length-of-time}]\) or \([\text{start time} + \text{end-time}]\)
      - ArcGIS Pro requires the latter storage format
    - Eg: *The exam lasts for 90 minutes*; or *The exam ends at 10.30am*
The nature of temporal data

• The frequency of data collection can be:
  - **Regular**
    - Data values are collected at a constant rate
    - Eg: Hourly GPS positions from a vehicle tracker
    - Eg: A 10-year census
  - **Irregular**
    - Data values are collected on indeterminate events, or whenever required
    - Eg: The occurrence of crimes
    - Eg: Changes in political boundaries

GIS integrates temporal data

- ArcGIS integrates time across the platform
  - ArcGIS for Desktop
  - ArcGIS Pro
  - ArcGIS Portal
  - ArcGIS Online
  - ...

- ArcGIS can be used to:
  - Manage
  - Visualize
  - Analyze
  - Share

Temporal data sources:
- Fixed time
- Stationary
- Mobile
- Real-time sensor network
- Analysis, simulation, & modeling
A quick note

This session covers:
  - Structuring…
  - Visualizing…
  - Sharing…

...Temporal Data in ArcGIS Pro

• Not:
  - Analyzing, Editing, Generating Space-Time Cubes, …
Structuring temporal data
Supported data storage types

• **Data that can be presented as tabular rows**
  - Feature layers
  - Mosaic datasets
  - NetCDF layers
  - Tables
  - Raster catalogs
  - Tracking layers / Stream layers
  - Network dataset layers with traffic data

• **Plus service layers with historical content and updating data feeds**
Storing temporal values – best practice

**Store time values in a date field**
- A field type that stores dates, times, or dates-and-times
- Supports more sophisticated database queries
- Easiest to configure on the layer
- *Note: we will cover using ‘Range’ (numbers) for time values later*

**Store temporal data in row format**
- Pro filters tabular content by rows
- Each time-aware data entry should be a single record/row

**Index the date field**
- Interactively filtering rows means many database queries

**Consider storing date values in UTC or GMT**
- If your data covers multiple time zones, ‘10am’ becomes unreliable
When data comes from across multiple time zones…?

- Pro does integrate, and allow for, data across different time zones
  - The *map* has a time zone (values shown on the Time Slider)
  - A *layer* has a time zone, and all values must be for the *same time zone*
- **Ensure all values in the layer are in the same time zone**
  - Use the Convert Time Zone GP tool, as needed
  - Adjusts the rows’ time values (in a date field) from one time zone to another

- **Tip: Convert to standard time (UTC\(^1\) or GMT\(^2\))**
  - Avoid issues with daylight savings time

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\(^1\) Coordinated Universal Time
\(^2\) Greenwich Mean Time
When temporal values are not in Date format…?

- **Convert values into a date field type**
  - Use the Convert Time Field GP tool
  - Converts Text/Number fields into a new Date field
    - “July 09, 2016” ⇒ 07/09/2016 ⇒ MM/DD/YYYY
    - You can define a custom text format, if needed

- **The tool allows other time conversions**
When temporal values are stored across multiple columns…?

- **Expand the data into one time-stamp per row**
  - Use the **Transpose Fields** GP tool
  - Shifts data stored in columns into individual rows
  - Geometry shapes are duplicated
  - Choose which other fields are brought across

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>539</td>
<td>708</td>
<td>707</td>
</tr>
<tr>
<td>Alaska</td>
<td>180</td>
<td>215</td>
<td>274</td>
</tr>
<tr>
<td>Arizona</td>
<td>109</td>
<td>115</td>
<td>117</td>
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<td>Arkansas</td>
<td>101</td>
<td>113</td>
<td>138</td>
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<tr>
<td>California</td>
<td>20</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>Colorado</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Connecticut</td>
<td>106</td>
<td>105</td>
<td>115</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STATE_NAME</th>
<th>DateField</th>
<th>Expense</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>Y1980</td>
<td>539</td>
</tr>
<tr>
<td>Alaska</td>
<td>Y1980</td>
<td>180</td>
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<tr>
<td>Arizona</td>
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<td>California</td>
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<td>Colorado</td>
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<td>Alabama</td>
<td>Y1981</td>
<td>215</td>
</tr>
<tr>
<td>Alaska</td>
<td>Y1981</td>
<td>115</td>
</tr>
<tr>
<td>Arizona</td>
<td>Y1981</td>
<td>113</td>
</tr>
</tbody>
</table>
When you need durations between events…?

- **Pull the next row’s time-value into the current row**
  - Use the **Calculate End Time** GP tool
  - Populates an end time field with the next record’s start time
  - The last record duplicates its start and end times

**Result**

<table>
<thead>
<tr>
<th>Start_Time</th>
<th>End_Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/5/2010 6:00:00 AM</td>
<td>1/6/2010 1:00:00 PM</td>
</tr>
<tr>
<td>1/6/2010 1:00:00 PM</td>
<td>1/7/2010 4:00:00 PM</td>
</tr>
<tr>
<td>1/7/2010 4:00:00 PM</td>
<td>1/8/2010 11:00:00 AM</td>
</tr>
<tr>
<td>1/8/2010 11:00:00 AM</td>
<td>1/10/2010 2:00:00 PM</td>
</tr>
<tr>
<td>1/10/2010 2:00:00 PM</td>
<td>1/10/2010 2:00:00 PM</td>
</tr>
</tbody>
</table>
Modeling data... as separate rows (best general interaction)

- Each row contains all feature values, regardless of which ones change
  - Pros: anything can change per row (including shape), simple to configure, one table
  - Cons: potential for significant duplicated content

- Well-suited for:
  - Moving objects, like vehicle tracking
  - Changing polygonal areas, like fires boundaries

<table>
<thead>
<tr>
<th>OBJECTID</th>
<th>Shape*</th>
<th>Name</th>
<th>State_Name</th>
<th>POP</th>
<th>DATE_ST</th>
<th>DATE_END</th>
<th>Shape_Length</th>
<th>Shape_Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>2698</td>
<td>Polygon</td>
<td>Abbeville</td>
<td>South Carolina</td>
<td>33400</td>
<td>01/01/1900</td>
<td>01/01/1910</td>
<td>162402.504779</td>
<td>1339524251.7354</td>
</tr>
<tr>
<td>5944</td>
<td>Polygon</td>
<td>Abbeville</td>
<td>South Carolina</td>
<td>34804</td>
<td>01/01/1910</td>
<td>01/01/1920</td>
<td>162402.504779</td>
<td>1339524251.7354</td>
</tr>
<tr>
<td>8975</td>
<td>Polygon</td>
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<td>South Carolina</td>
<td>27139</td>
<td>01/01/1920</td>
<td>01/01/1930</td>
<td>162402.504779</td>
<td>1339524251.7354</td>
</tr>
<tr>
<td>12185</td>
<td>Polygon</td>
<td>Abbeville</td>
<td>South Carolina</td>
<td>23323</td>
<td>01/01/1930</td>
<td>01/01/1940</td>
<td>162402.504779</td>
<td>1339524251.7354</td>
</tr>
<tr>
<td>15135</td>
<td>Polygon</td>
<td>Abbeville</td>
<td>South Carolina</td>
<td>22931</td>
<td>01/01/1940</td>
<td>01/01/1950</td>
<td>162402.504779</td>
<td>1339524251.7354</td>
</tr>
<tr>
<td>18243</td>
<td>Polygon</td>
<td>Abbeville</td>
<td>South Carolina</td>
<td>22456</td>
<td>01/01/1950</td>
<td>01/01/1960</td>
<td>162402.504779</td>
<td>1339524251.7354</td>
</tr>
<tr>
<td>21371</td>
<td>Polygon</td>
<td>Abbeville</td>
<td>South Carolina</td>
<td>21417</td>
<td>01/01/1960</td>
<td>01/01/1970</td>
<td>162402.504779</td>
<td>1339524251.7354</td>
</tr>
<tr>
<td>24464</td>
<td>Polygon</td>
<td>Abbeville</td>
<td>South Carolina</td>
<td>20112</td>
<td>01/01/1970</td>
<td>01/01/1980</td>
<td>162402.504779</td>
<td>1339524251.7354</td>
</tr>
</tbody>
</table>
Modeling data... using a joined table (optimal database method)

- A primary table, with a one-to-many join to a time-centric data table
  - Pros: optimized data storage, decide which values update, not hard to configure
  - Cons: multiple tables, slower general performance

- Well-suited for:
  - Stationary objects, like stream-gauge monitoring devices
  - Mostly-static polygonal areas, like parcels to a tax assessment table
Modeling temporal data... using Range (for numeric values)

- Same rules as previous, but values are stored as numbers (instead of dates)
- Can save needless conversion to Date format
- Well-suited for:
  - Event-driven sequential data, like “contamination levels each hour after the spill”
  - Huge time extents, like “tectonic plate movement across 100 million years”
  - “Stop-motion” style animation
    (using interpolated positions)
Visualizing temporal data
Visualizing temporal data in ArcGIS Pro – two steps

1. Configure time data properties for each layer
   - Specify which field/s drive time
   - Set the layer’s full time extent
   - Indicate a refresh rate for live feed data
   - Set the time zone

2. Set the current time extent for the map
   - The map has a well-defined temporal extent (and timezone)
   - Use the interactive slider to change the map time
   - Use the time step for regularly-captured time data

The time slider automatically appears with time-enabled layers (and range)
Demo

Temporal data in ArcGIS Pro
- Import MXD workflow
- Configuration of the time slider
- Using Range instead of Time
Modeling data in Mosaic Datasets

- Mosaic datasets are like a table of raster images
  - The table can contain date field/s
  - Common in long-term aerial imagery capture
  - Also common for storing analysis results through time
- They act just like feature data stored as separate rows
- Open the Mosaic dataset table from the Footprint layer
Modeling data from NetCDF layers

- NetCDF is a file format for spatio-temporal data
  - Contains multiple dimensions (x, y, z, t)
  - Often has many variables (temp, pressure, salinity, …)

- Time values are (often) available as a dimension

- Author the NetCDF Layers to include the time dimension
  - You can author feature or raster layers from NetCDF

- They act just like feature data stored as separate rows
Demo
NetCDF Data
Sharing temporal data
A variety of ways to share temporal visualizations

- **As a time-enabled web map**
  - TIP: Publish time-aware web maps from Pro (instead of per-layer in 10.x)
    - Open Pro, import an mxd, and publish the web map directly
    - *Extra tip:* Replace the basemap (to avoid group layers)
- **As time-enabled image services** (Portal only)
- **As an animation / video**
- **As a series of exported images**
- **As a temporal map book**
- **As “small multiples” on a single layout**
- **As map or layer packages**
Create web map services

- Map services preserve the time information from time-enabled layers
  - Used to query and display content (with the time slider)

- Example temporal web maps:
  - Atlantic Storms (1993-95)
    - Imported an MXD, updated the basemap, publish
  - One year of ice pack imagery (North Pole)
    - Time-aware aerial imagery
Demo

Time-aware web maps

Using Z for time (space-time cube)

Authoring Temporal Animations
- Introduction to keyframing
Demo

Authoring Temporal Animations
- Telling a GIS story
- Using time and range
- Adding information & overlays
- Using dynamic text elements
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Questions???

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