Forest Inventory

Updating with GPS

—by Glen Jordan

Introduction

Problem

Forest inventories are never complete. It seems there are always data errors to correct, new data to add, or existing data to change. Expanding and updating forest inventories is an ongoing, never-ending process.

Sources of new data vary, and as a result, updating methods vary somewhat as well. Existing paper maps, imagery, light detection and ranging (LiDAR), and Global Positioning System (GPS) are common data sources for expanding and updating forest inventories.

While GPS data and imagery are perhaps the most common sources of update information, forest managers also commonly use various online sources of geographic data to assist in updating forest inventories. Federal, state, and provincial agencies are common sources of online data, often made available for access or download free of charge. Good examples are **Minnesota**, **Nova Scotia**, and **New Brunswick**.

Also, Esri's **ArcGIS℠ Online** provides free access to a number of map and image services. A Google search using "online GIS data sources" turns up many more useful sites.

How, though, do forest managers access and deploy these various sources of geographic data in keeping their forest inventories current; in particular, how is GPS used?

Location

A small 1,400-hectare (ha) woodlot in the Acadian-New England forest region of North America

Time to complete the lab

Approximately three hours

Keywords: imagery; GPS; digitizing; accessing GIS map service; image services; feature classes; buffer; features; overlay

Prerequisites

A basic working knowledge of GIS and ArcGIS® software in particular Experience using ArcGIS Explorer would be helpful too. Familiarity with the Woodlot geodatabase inventory is essential.

Data used in this lab

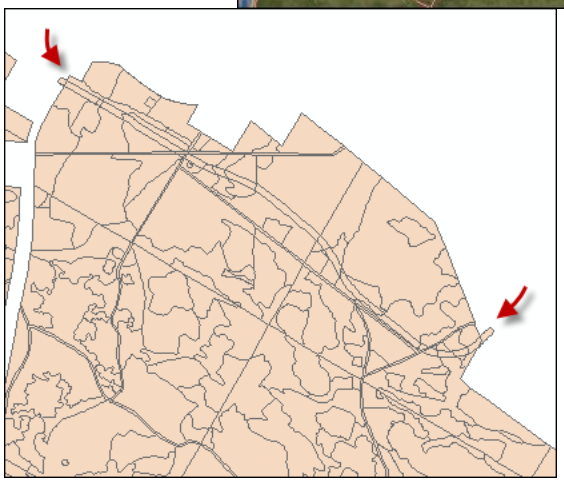
A personal geodatabase of several feature classes for a small (1,400 ha) woodlot in the Acadian-New England forest region of North America. All data is NAD83 datum with New Brunswick Double Stereographic projection, unless otherwise stated. GPS track data in the WGS84 geographic coordinate system is also used.

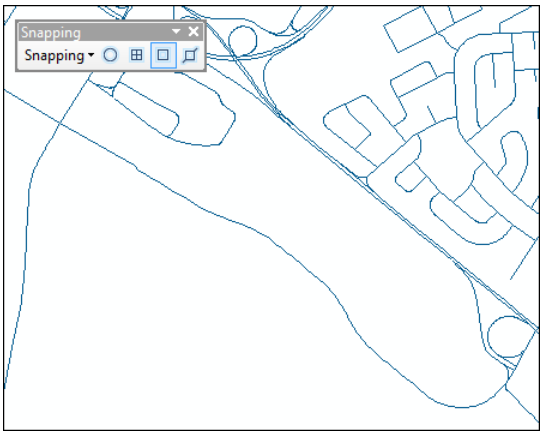
Student activity

In this exercise, you'll use GPS track data to incorporate a new line feature into the Woodlot's basemap and public roads feature classes. You'll also buffer the track to create a 30-meter (m) right-of-way that you'll then incorporate into the cover types feature class.

Results expected

The basemap, public roads, and cover types feature classes updated with the newly constructed Knowledge Park Drive.





Data available

- ArcGIS Online imagery
- GPS track (.gpx format)
- Basemap feature class—*basemap*
- Public roads feature class—*proads*
- Cover types feature class—*cover*

Solution steps

1. Examine a GPS track of a new city street.
2. Create a line feature from the GPS track.
3. Update the basemap feature class with the GPS track.
4. Update the public roads feature class with the GPS track.
5. Update the cover types feature class with the right-of-way.

EXAMINE A GPS TRACK OF A NEW CITY STREET

A new city street, Knowledge Park Drive, was recently built across the northern portion of the Woodlot, connecting Arnold Drive in the west with Allison Boulevard in the east. Its location has been digitized using GPS and offloaded as a .gpx (GPS exchange) file.

The GPS exchange file format is common, with many GPS receivers providing data as gpx files. As a result, there are many options for processing data in this format. ArcGIS, at version 10.1, provides a special tool, GPX To Features, for converting gpx track files to point features. While earlier versions of ArcGIS lack this tool, the ArcGIS Explorer program (free download) can open gpx files. Public domain software is another option. One program in particular, DNR Garmin, offers a very rich assortment of features for dealing with GPS devices and their captured data.

In this exercise, you'll use ArcGIS and the GPX To Features tool to access the GPS data.

RELATED CONCEPT: DIGITAL MAPPING—GPS DATA

1 Open ArcMap and then open the *GPS To Features* tool (*Conversion Tools » From GPS*).

2 Use the tool to create a shapefile, in the *GPS* folder, of the GPS track points – *Track_18-MAY-11 075532 AM.gpx* file located in the *GPS* folder.

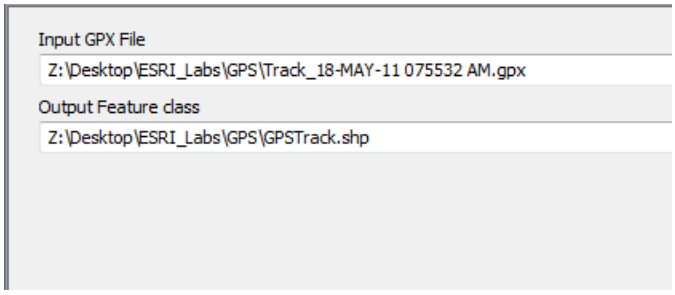


Figure 1. Saving the GPS track as a shapefile of point features.

That creates a shapefile of point features. The closely spaced points tell you that GPS observations were recorded at a high frequency capture rate.

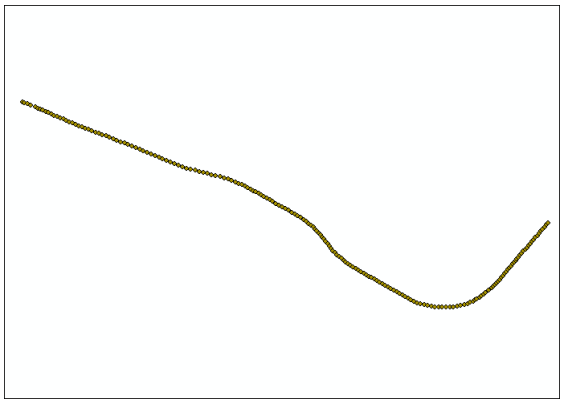


Figure 2. GPS track points added as a layer in ArcMap.

The GPS track was collected along the route of a new street recently built through the Woodlot property. If you add the Woodlot basemap and management compartments shapefiles, you'll be able to see the new street's position within the Woodlot.

3 Add the *basemap* and *compart* shapefiles (*Shapes* folder) as layers. (Ignore the coordinate systems warning message.)

Zoom out around the Woodlot property, and you can see that the new street follows a path across the north of the Woodlot, connecting with existing city streets in the west and east.

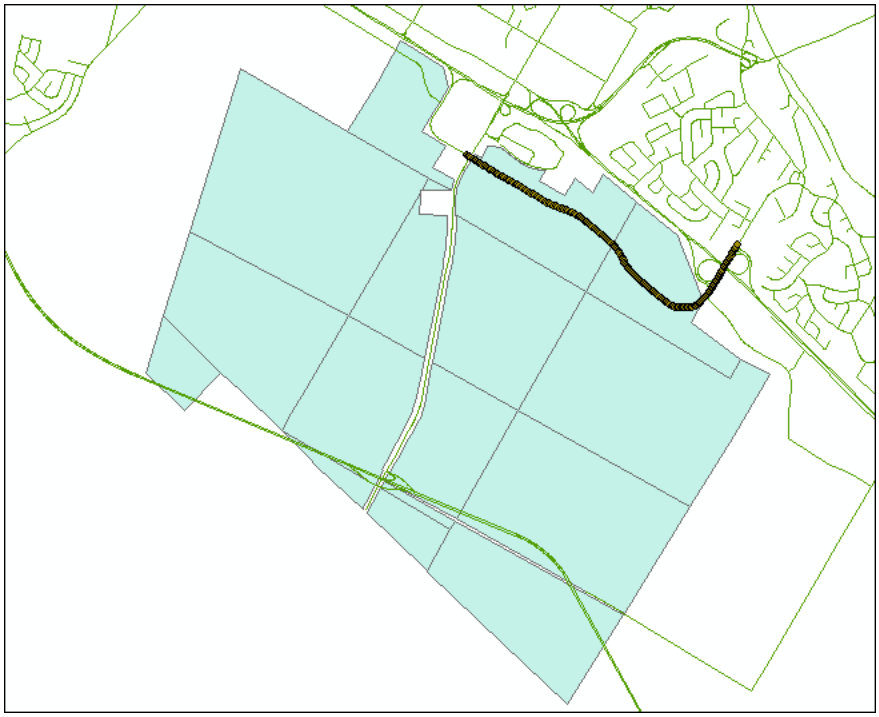


Figure 3. Position of the GPS track in the Woodlot.

How can you incorporate this new information into the Woodlot's inventory?

It will mean adding the new data to the basemap (*basemap*) and public roads (*proads*) feature classes, where it will connect to existing streets in the east and west, and incorporating its 30 m right-of-way into the cover types feature class (*cover*).

But, you'll first have to convert the GPS point features to a single linear feature.

Create a Line feature from the GPS track

GPS track data are collected as point observations in much the same way features are digitized by manual means, even though the features being digitized may be line or polygon features. Fortunately, ArcGIS makes it easy to convert point features into line or polygon features.

Related Concept: Digital mapping—Points to Line

1 Use the *Points To Line* tool (*Data Management Tools » Features*) to create a line feature class from the GPS track. Name the output "GPSTrack" in the *Woodlot* geodatabase.

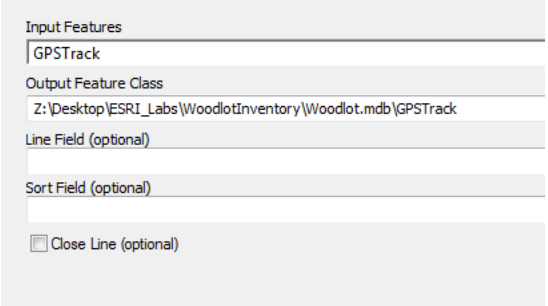


Figure 4. Converting GPS track points to a single line feature.

2 If you remove the original *GPSTrack* layer of point features, you'll see the new line feature.

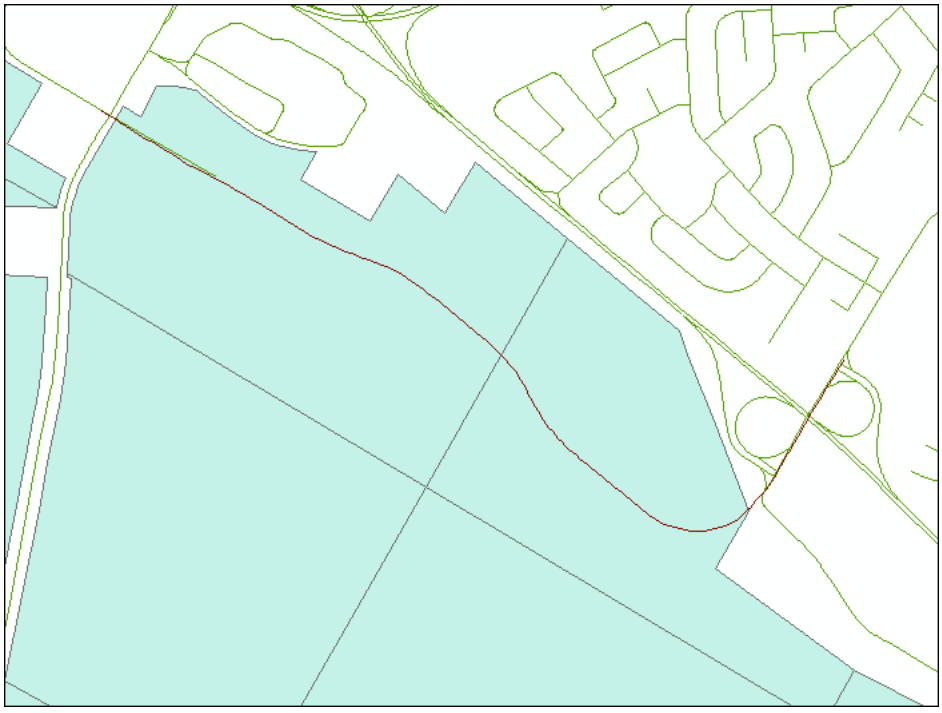


Figure 5. The GPS track line feature.

By the way, what's the spatial reference of the GPS track?

3 Double-click the *GPSTrack* layer and select *Layer properties*. In the properties dialog box, click the *Source* tab.

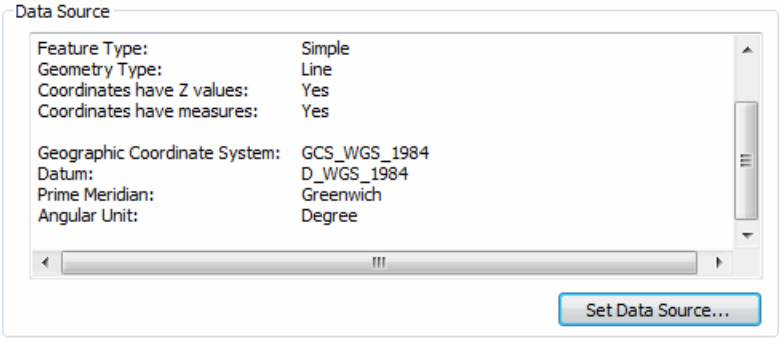


Figure 6. The coordinate system of the GPS track data is WGS 1984.

You'll find that the coordinate system is one commonly associated with GPS-collected data, namely, the WGS 1984 system. It's a nonprojected coordinate system, or geographic coordinate system, based on the WGS84 datum.

But, before you can incorporate the GPSTrack feature class into the *basemap* and *proads* feature classes, it will have to be projected into their coordinate system. That's easy using ArcToolbox.

4 Use the *Project* tool (*Projections and Transformations » Feature*) to derive a feature class from *GPSTrack* that inherits the coordinate system of *basemap*.

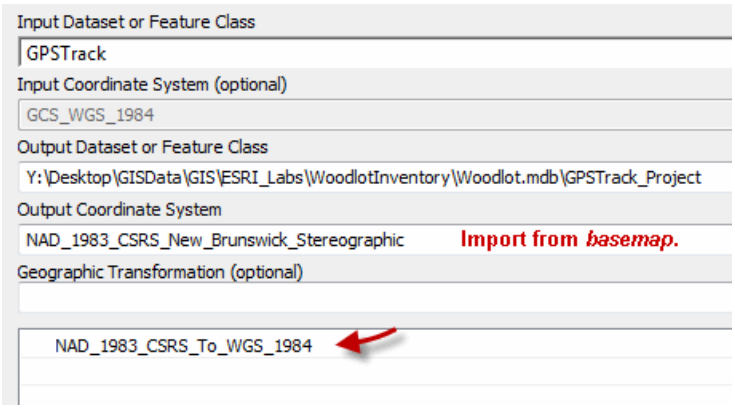


Figure 7. Project the GPS track shapefile to NAD83 New Brunswick Stereographic.

With that, you're ready to start the process of updating *basemap* and *proads* with the GPS track.

UPDATE THE BASEMAP FEATURE CLASS WITH THE GPS TRACK

Incorporating the GPS track into the *basemap* feature class isn't quite as simple as copying and pasting. You'll also have to edit its endpoints to ensure that they connect to existing streets. That will involve the ArcMap Editor.

RELATED CONCEPT: DIGITAL MAPPING—FEATURE CLASS EDITING

Before proceeding, you should clear your current ArcMap document, since it involves a mixture of coordinate systems at this point. That will hinder feature editing.

1 Clear your ArcMap document without saving the composition.

How do you add the GPS track to *basemap*? The *Merge* tool is probably the simplest way to do that; it will essentially execute a copy and paste.

2 Use the *Merge* tool (*Data Management Tools » General*) to combine the *GPX_Project* feature with *basemap*.

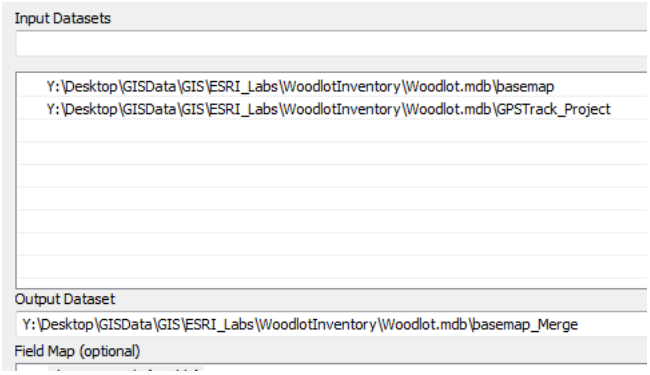


Figure 8. Combine *basemap* and the GPS track shapefile.

You now have the GPS track and *basemap* features together in a single feature class: *basemap_Merge*.

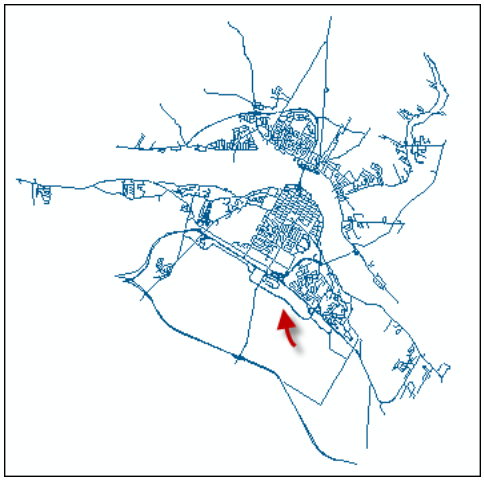


Figure 9. GPS track and *basemap* combined into a single feature class.

The process might end there, except that when zoomed in further at either end of the GPS track, you'll note that it connects poorly to existing streets.

Figure 10. There are GPS track mismatches with existing streets at both ends.

Assuming that the existing street features are in their correct geographic locations, it becomes a simple matter of editing the GPS track so that its endpoints connect to existing streets. The ArcMap Editor provides tools for doing that.

3 Add the Editor toolbar via *Customize » Toolbars*. Position it at a convenient location.

4 Next, from the *Editor* drop-down list, click *Start Editing*. You can also close the *Editor* window, or pin it.

Before you start modifying the *basemap_Merge* feature class, you'll need to set a snapping specification. That will make it easy for you to connect the endpoints of the GPS track in *basemap_Merge* to existing streets.

5 In the *Editor* toolbar drop-down list, click *Snapping » Snapping Toolbar* and enable vertex snapping.

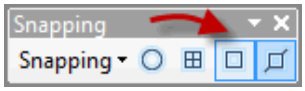


Figure 11. Enable vertex snapping.

When you move a vertex (x,y point) of the GPS track toward an existing feature, it will automatically snap to the nearest vertex in that feature.

6 Zoom in on the western end (left) of the GPS track until the mismatch with the *basemap* feature is obvious.

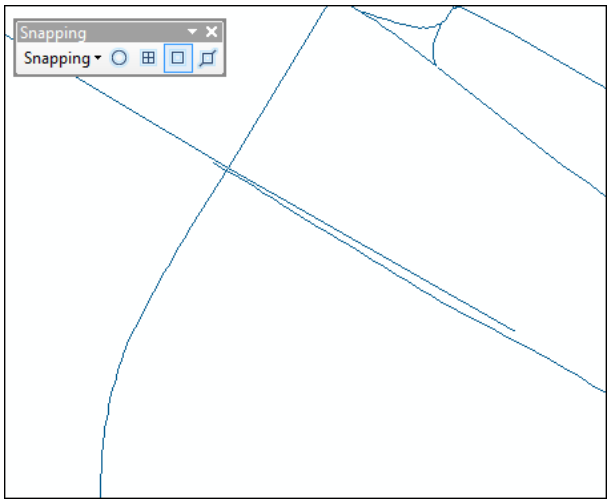


Figure 12. When zoomed in, the GPS track does not connect to the existing street feature.

The GPS track needs to be shortened (vertices deleted) and then connected to the *basemap* feature.

7 Double-click the GPS track with the *Editor* pointer (

) to reveal individual vertices.

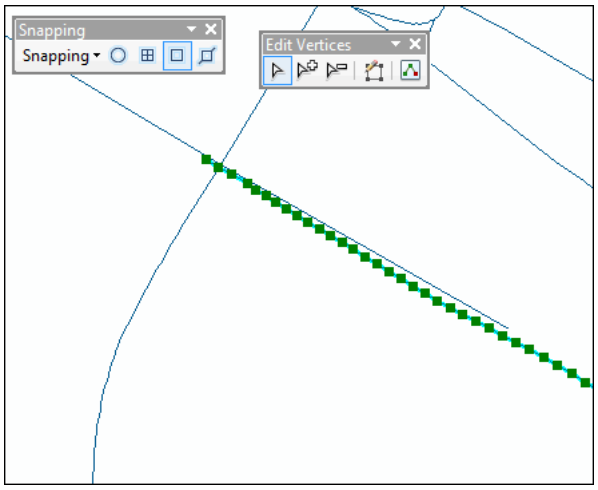


Figure 13. Double-click the GPS track to expose its vertices and display the Edit Vertices toolbar.

That exposes the feature's constituent vertices (green squares) and the Edit Vertices toolbar. Excess vertices are obvious and easily deleted.

8 Click the *Delete Vertices* tool on the *Edit Vertices* toolbar.

Figure 14. Select the Delete Vertices tool.

9 With the *Editor* pointer, delete the dozen or more vertices that extend beyond the existing street endpoint by clicking and dragging around them.

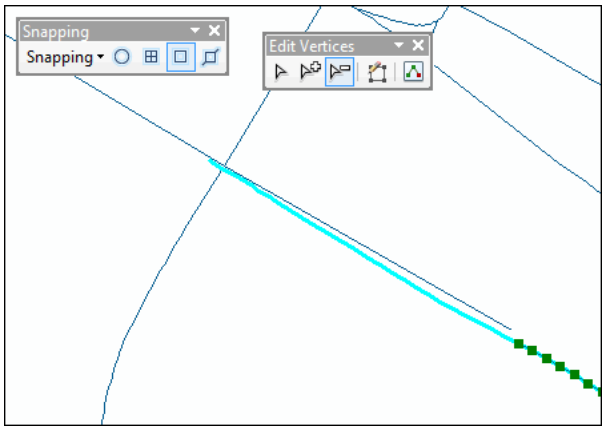


Figure 15. Delete vertices from the GPS track.

That deletes the corralled vertices, leaving a ghost line (turquoise) where they once existed. Now it's simply a matter of clicking and dragging the endpoint vertex of the GPS track until it connects with the endpoint of the existing street.

10 On the *Edit Vertices* toolbar, return to the *Modify Sketch Vertices* tool.

Figure 16. Select the Modify Sketch Vertices tool.

11 Click and drag the endpoint vertex of the GPS track until it snaps to the endpoint vertex of the existing street feature.

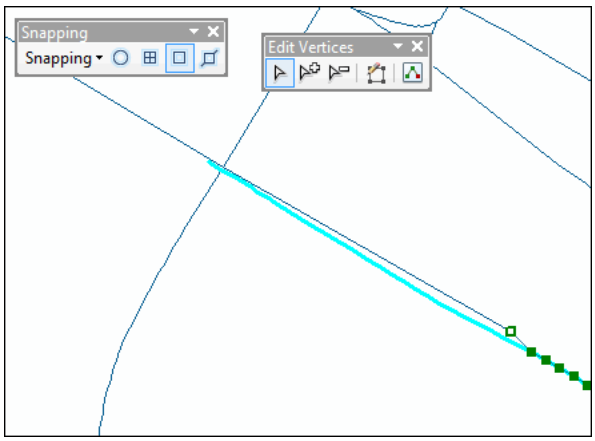


Figure 17. Connect the GPS track to the existing street.

If you mess up, you can undo by pressing Crtl+Z or by clicking the Undo *tool* .

Question 1: *How might you avoid the slight dogleg produced with this approach?*

12 Perform a similar edit on the eastern end of the GPS track.

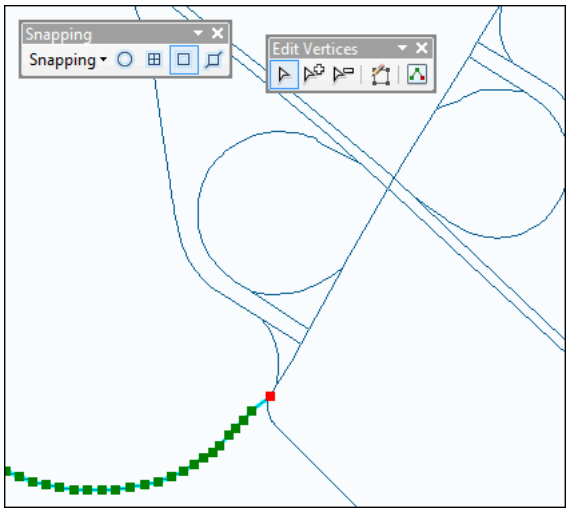


Figure 18. Shorten the east end of the GPS track and snap to the existing street.

If you zoom out from the new street to about 1:20,000, you'll see that your GPS track is now properly integrated into the *basemap* feature class.

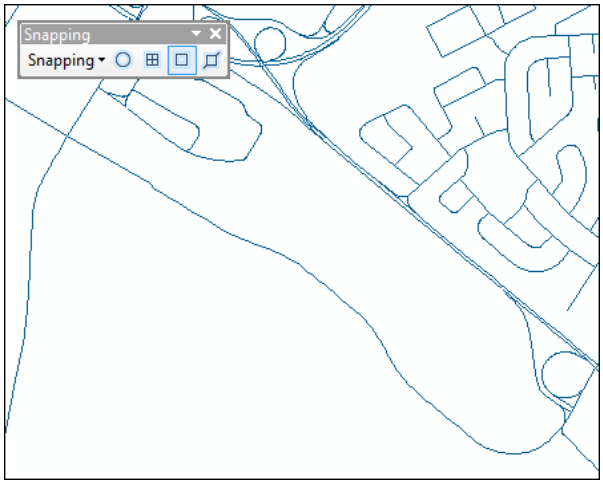


Figure 19. The GPS track incorporated into the *basemap* feature class.

13 From the *Editor* drop-down list, save your edits.

You're not done quite yet, though. You also need to incorporate the new street into the Woodlot public roads feature class (*proads*). That's next.

UPDATE THE PUBLIC ROADS FEATURE CLASS WITH THE GPS TRACK

The *proads* feature class, as you may recall, contains the public roads and city street network surrounding the Woodlot. The GPS track needs to be incorporated into that network.

RELATED CONCEPT: DIGITAL MAPPING—FEATURE CLASS EDITING

Rather than merging and editing the GPS track, as you did for *basemap*, you can simply copy and paste the already edited version from *basemap* into *proads*. Here's how.

1 Add the *proads* feature class as a layer alongside *Bishop_Merge* in ArcMap.

Hopefully, *proads* was symbolized with a distinctly different color than *Bishop_Merge*; if not, change it to something that is.

2 Pan to the western end (left) of the GPS track.

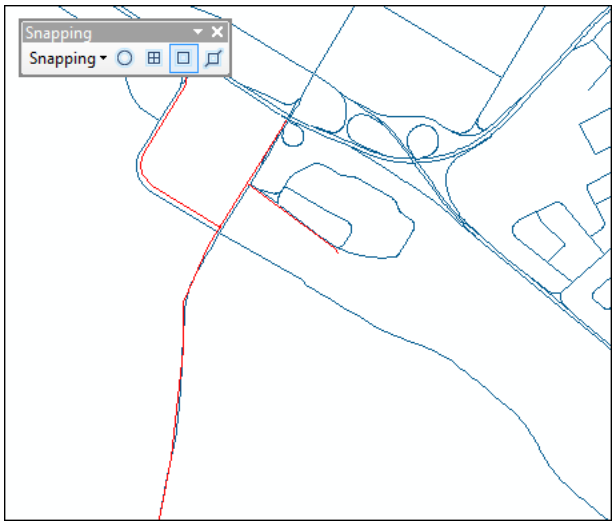


Figure 20. Public roads (red) overlain on *basemap_Merge*.

It looks once again like there is some mismatching. What's going on, since *proads* features should align perfectly with corresponding *basemap* features? Which features are in their correct location, and which are not?

Assume that *Bishop_Merge* (derived from *basemap*) is correct.

3 Using the *Editor* pointer (

), click the eastern-most portion of the GPS track to select it in *Bishop_Merge*. Then, copy and paste (Ctrl+C and Ctrl+V) into the *Public Road Centerlines* layer.

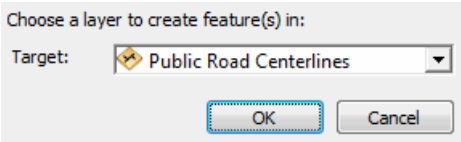


Figure 21. Indicate the paste target.

That doesn't appear to have accomplished anything.

4 Turn off *basemap_Merge* to see the effect of your copy and paste.

Now you can see that the GPS track feature has been added to *Public Road Centerlines*, but there is a mismatch at the western end.

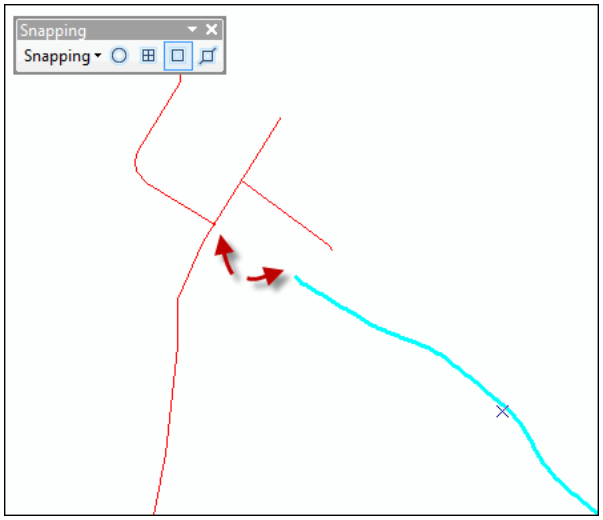


Figure 22. GPS track feature pasted into the *proads* feature class.

Now, it would be a simple matter of connecting the endpoint of the GPS track to the existing street intersection in *Public Road Centerlines*; however, as noted earlier, the existing street does not line up with the corresponding feature in *basemap_Merge*. Take a look.

5 Turn *basemap_Merge* back on so the misalignment is obvious.

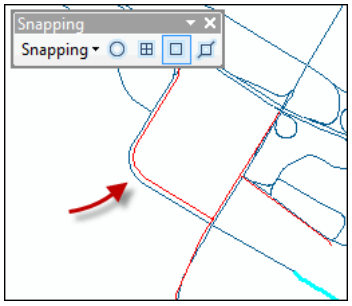


Figure 23. A feature in *proads* (red) does not align with the corresponding feature in the Woodlot basemap.

How can you fix that?

It's easy; simply delete the incorrectly located feature in *Public Road Centerlines* and substitute the correctly located feature from *basemap_Merge* by copying and pasting.

6 Using the *Editor* pointer (

), click the incorrectly positioned feature in *Public Road Centerlines,* then press the Delete key.

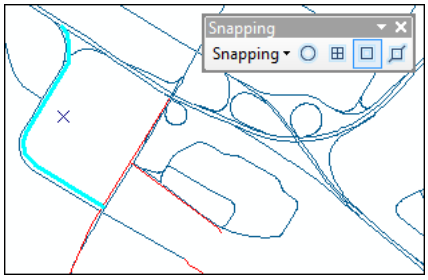


Figure 24. Misaligned feature in *proads* selected for deletion.

Now, you need to select and copy and paste the corresponding feature from *basemap_Merge*. As it turns out, though, there are actually three features that you need to copy.

7 Click, then press Shift and click to select the three features.

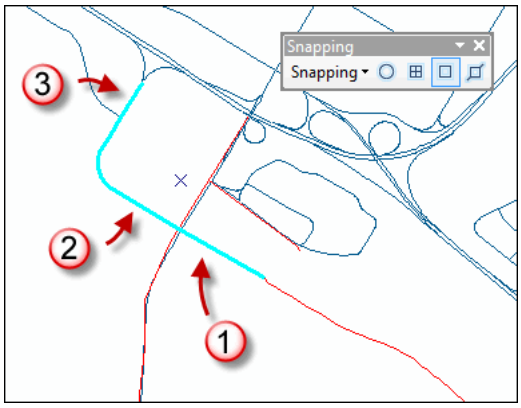


Figure 25. Press Shift and click to select three features in *basemap_Merge*.

8 Copy and paste the three into *Public Road Centerlines*.

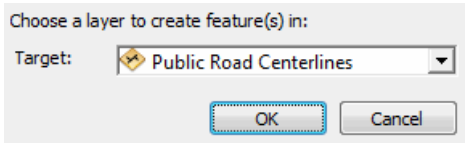


Figure 26. Indicate the paste target.

9 Turn *basemap_merge* off.

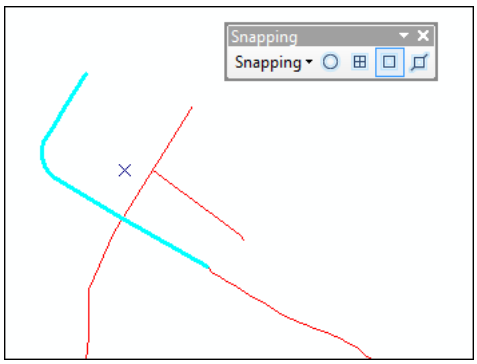


Figure 27. Three *basemap_Merge* features pasted into *Public Road Centerlines*.

10 Stop editing, save your edits, and close the *Snapping* toolbar.

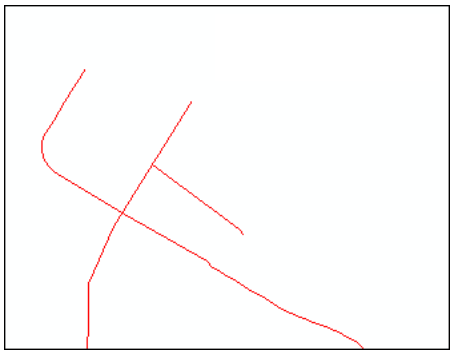


Figure 28. Public roads feature class updated with the GPS track and incorrectly located city streets repositioned.

If you'd like to confirm the accuracy of your public roads and basemap edits, adding recent imagery for the area would help.

11 Click the *Add Data* drop-down arrow , select *Add Data From ArcGIS Online*, then search for "New Brunswick".

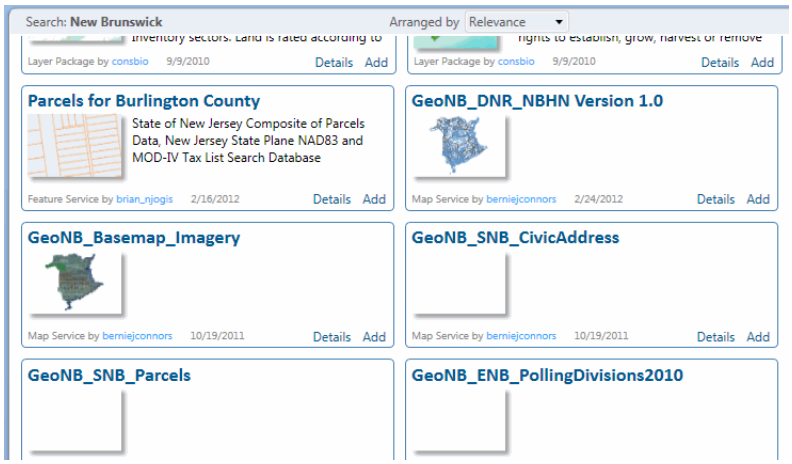


Figure 29. New Brunswick online data sources.

12 Add *GeoNB_Basemap_Imagery*.

Figure 30. Recent imagery in the area of the GPS track.

The New Brunswick imagery is obviously more recent than what you used earlier, and as a result, you can see the new street being constructed across the Woodlot property.

It looks like you've achieved a very good fit in the edited *proads* and *basemap* feature classes.

There's only one thing left to do, namely, adding CLASS field values for the new and modified features in *proads*. (The *basemap* feature class doesn't have a CLASS attribute.)

13 Start editing again, click the GPS track feature in *Public Road Centerlines*, and click  to open its attributes table (or right-click the feature and select *Attributes*). Select *City Street* for the CLASS field value.

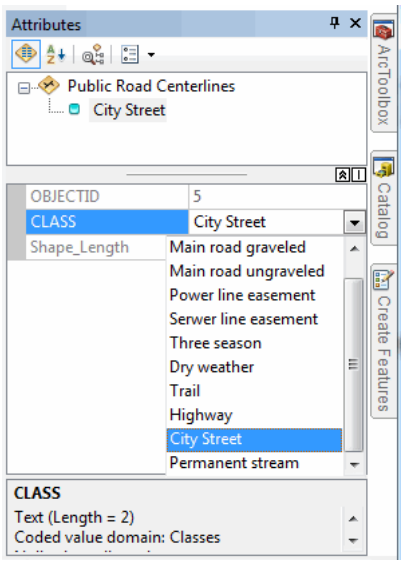


Figure 31. Assign the *City Street* classification to the CLASS field.

The coded domain descriptions painstakingly entered in an earlier exercise make things easier now.

14 Repeat the process for each of the three existing street features that you copied and pasted earlier.

15 Stop editing and save your edits.

Just one last bit of house cleaning remains.

16 Close ArcMap and start ArcCatalog. Rename *basemap_Merge as basemap_update* and set its alias as *Basemap Update.*

Now it will be obvious later on what it contains.

Likewise, it would be smart to rebrand the *proads* feature class.

17 Rename *proads* as *proads_update* and assign an alias of *Public Roads Update*.

18 Last, delete *GPSTrack_Project*, the original GPS-captured feature.

With that, you now have the Woodlot's *basemap* and *proads* feature classes updated with the new city street—Knowledge Park Drive.

The new street is, of course, more than a thin line in the Woodlot. Its construction created a 30 m right-of-way that cut through some of the Woodlot's more mature stands. That's evident in the background imagery.

Any thoughts on how you might update the cover types feature class (*cover*) with the Knowledge Park Drive right-of-way? That's next.

UPDATE THE COVER TYPES FEATURE CLASS WITH THE RIGHT-OF-WAY

Creating a 30 m right-of-way for Knowledge Park Drive is easy using the *Buffer* tool. Pasting that right-of-way into the *cover* feature class is not so straightforward. That will require overlaying the buffer on the cover types feature class, followed by some careful editing of the result.

RELATED CONCEPT: DIGITAL MAPPING—FEATURE CLASS EDITING

1 Using the  tool, shift-click to select the two features in *Public Road Centerlines* that define Knowledge Park Drive.

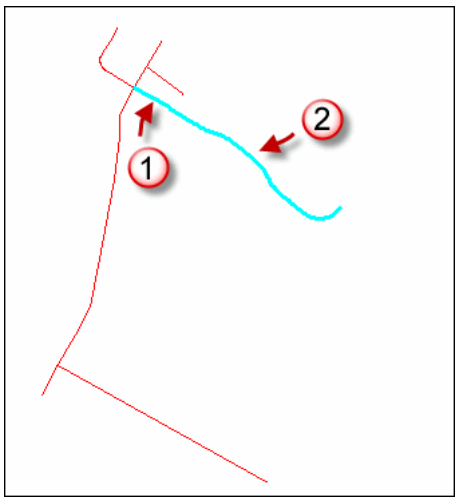


Figure 32. Knowledge Park Drive features selected.

2 Use the *Buffer* tool in ArcToolbox (*Analysis Tools » Proximity*) to buffer the selected features to 15 m on either side. Name the output *ParkROW*.

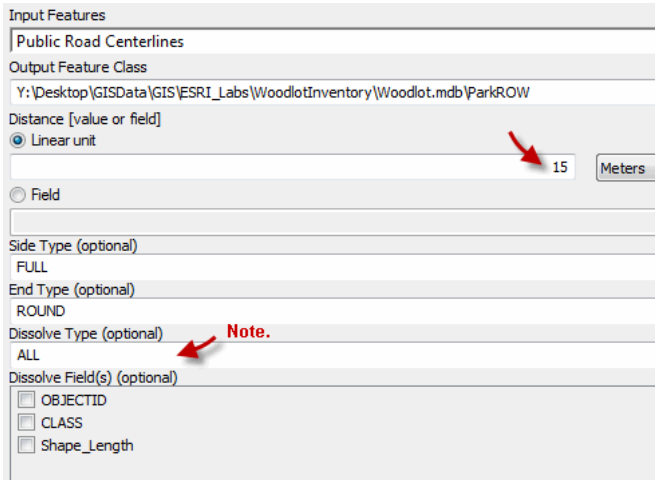


Figure 33. Create a 30 m right-of-way feature for Knowledge Park Drive.

Question 2: *What would happen if Dissolve Type were left set to the None default?*

If you zoom to the layer for *ParkROW*, you'll see your 30 m right-of-way.

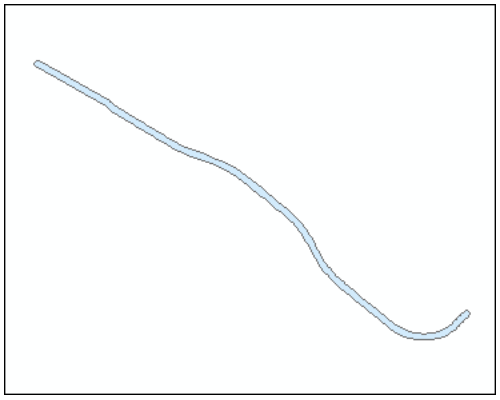


Figure 34. Knowledge Park Drive 30 m right-of-way feature class.

Unlike updating *basemap* and *proads*, where line features were involved, simply merging *ParkROW* with *cover* polygon features will not cut a right-of-way through the Woodlot. That's a job for a map overlay.

3 Use the *Union* tool in ArcToolbox (*Analysis Tools » Overlay*) to overlay *cover* with *ParkROW*. Name the output *ParkCover*.

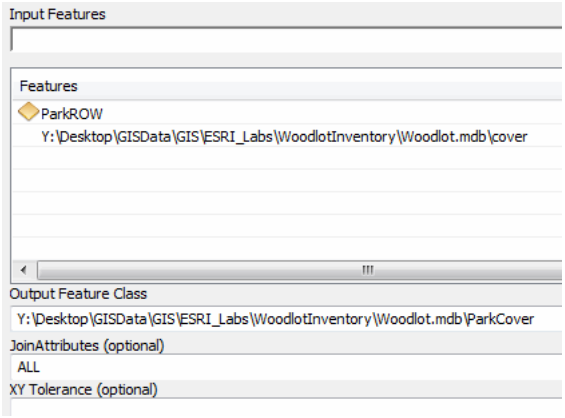


Figure 35. Overlay the cover types feature class on the Knowledge Park Drive right-of-way.

Unlike a merge, the overlay has integrated the *ParkROW* polygon with *cover* polygons by cutting the latter into pieces where intersects occurred.

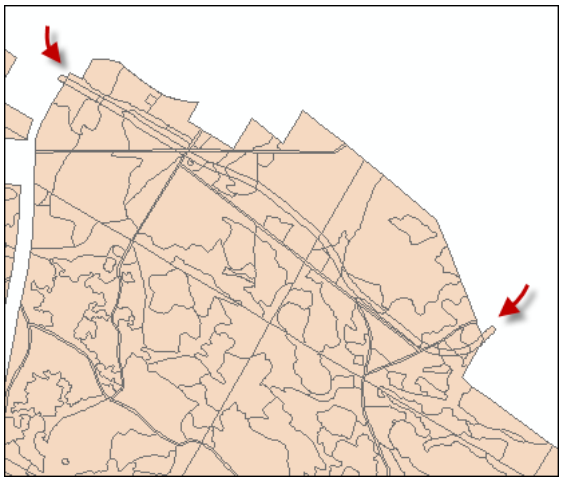


Figure 36. A union of cover types features and Knowledge Park Drive right-of-way features.

If you zoom in around an area of the right-of-way, you'll see that new polygons have been formed where *cover* polygons were intersected.

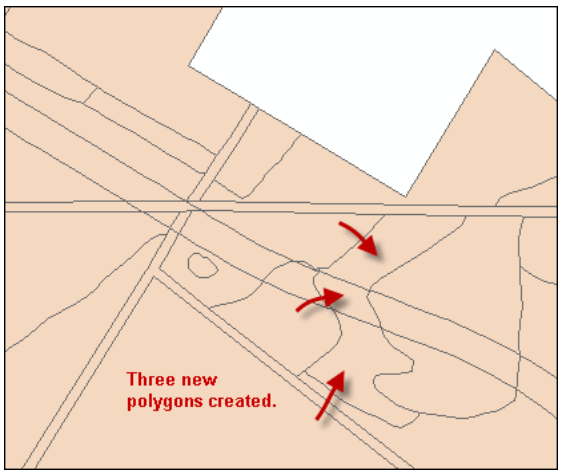


Figure 37. The overlay has created three new polygon features from one original.

4 Using the *Identify* tool , examine the attributes of polygons both inside and outside the right-of-way in *ParkCover*.

Field	Value
OBJECTID	580
Shape	Polygon
FID_ParkROW	1
FID_cover	69
COVER_	70
Stand#	212
Compartment	2
Cover Type	Forested (untreated)
Height Class	12
Crown Closure	Gaps
Material Size	Pulpwood
Age	40
Site Index	0
Total Volume	77.1
Volume Yield	64.4
Shape_Length	187.352911
Shape_Area	1670.897007

Figure 38. Attributes of the portion of stand 212 falling inside the Knowledge Park Drive right-of-way.

You should note a couple of things.

First, where *cover* polygons have been cut into multiple parts, the outside parts are treated as a single feature, a multipart feature retaining all the attributes of the original polygon. Inside parts have also retained the attributes of the originals, although they obviously no longer have those attributes. You'll fix that shortly.

Question 3: *What exactly is a multipart feature, and what purpose does it serve?*

Second, the *FID_ParkROW* field records a 1 for new polygons inside the right-of-way and -1 for those outside. This piece of information becomes very useful a bit later.

In the meantime, get rid of the rounded ends of the right-of-way feature that extend beyond the Woodlot property.

5 Start editing via the *Editor* toolbar.

6 Pan to the western end (left) of the right-of-way and, using the *Editor* pointer, select the rounded polygon feature in *ParkCover*.

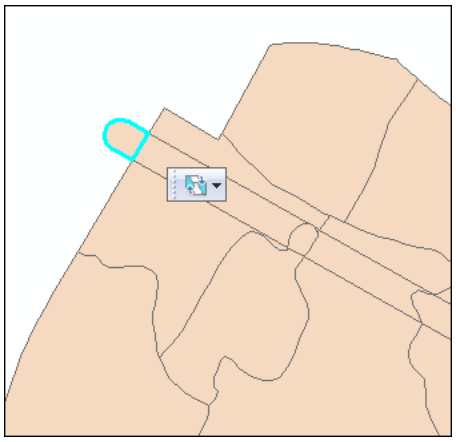


Figure 39. A portion of the Knowledge Park Drive right-of-way falls outside the Woodlot property boundary.

That selects the polygon that lies outside the Woodlot's western boundary as well as the one lying outside the eastern boundary. That happens since these two are one multipart feature.

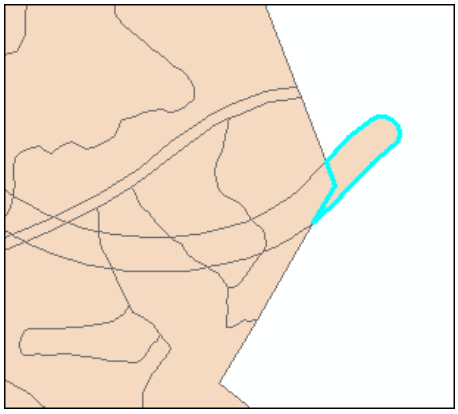


Figure 40. The eastern portion of the right-of-way that falls outside the Woodlot is also selected.

7 Press the Delete key.

That removes the selected polygons, revealing the corresponding ones in original buffer result *ParkRow*.

Now you can remove polygons within the Knowledge Park Drive right-of-way, leaving just a single right-of-way feature. Any idea how you might do that? Hint: Recall the *FID_ParkROW* field in *ParkCover*.

8 Use *Select By Attributes* to select all polygons that lie inside the *ParkCover* feature class, that is, polygons with FID_ParkROW = 1.

As hoped, that selects all polygons inside the right-of-way.

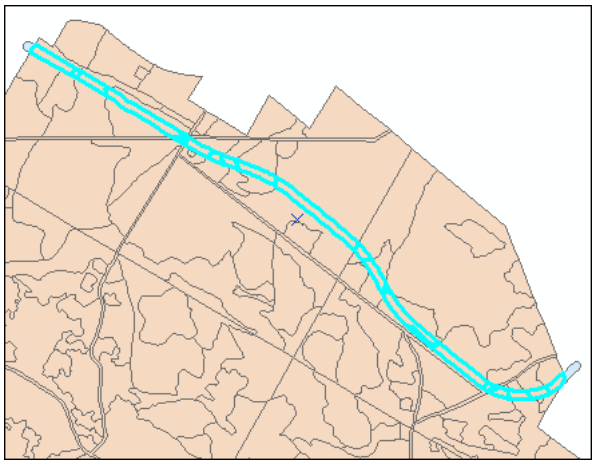


Figure 41. Features selected inside the right-of-way.

9 Select *Merge* from the *Editor* drop-down list. Choose *Main road right-of-way* as the attribute for the result.

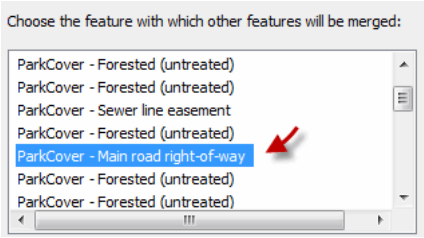


Figure 42. Assign the merged feature the *Main road right-of-way* class.

That leaves you with exactly what you want—a single right-of-way polygon for the new Knowledge Park Drive.

10 Stop editing and save your edits.

Now there's just a little tidying up to do using ArcCatalog.

11 Close ArcMap, then in ArcCatalog, rename *ParkCover* as *cover_update*.

12 Double-click *cover_update* and remove the fields *FID_Bishop_Row* and *FID_cover*. Assign an alias of *Cover Update Knowledge Park Dr.*

13 Delete *ParkROW*.

Question 4*: How would you completely remove the Knowledge Park Drive right-of-way from the cover_update feature class, such that it appeared like the New Maryland Highway right-of-way that divides the Woodlot into left and right parts?*

Conclusion

That was a lot of work, but that's what keeping a forest inventory up to date requires. In fact, what you've experienced here is just the tip of a very large iceberg.

Submit your work

Suggested student deliverables

- Woodlot public roads and cover types feature classes updated with the newly constructed Knowledge Park Drive city street
- Answers to the questions posed in the exercise:
  - How might you avoid the slight dogleg produced in connecting the western endpoint of Knowledge Park Drive to the existing street?
  - What would happen if *Dissolve Type* were left set to the *None* default when using the Buffer tool?
  - What exactly is a multipart feature, and what purpose does it serve?
  - How would you completely remove the Knowledge Park Drive right-of-way from the *cover_update* feature class, such that it appeared like the New Maryland Highway right-of-way that divides the Woodlot into left and right parts?
- If practical, collect a GPS .gpx track that identifies a new linear feature in a forest area for which you have an existing forest inventory (Apply exercise procedures to undertake the necessary updating.)

Credits

Sources of supplied data

Course Data

Data\cover, courtesy of University of New Brunswick Faculty of Forestry and Environmental Management

Data\highway, courtesy of University of New Brunswick Faculty of Forestry and Environmental Management

Data\newprop, courtesy of University of New Brunswick Faculty of Forestry and Environmental Management

Data\tin, courtesy of University of New Brunswick Faculty of Forestry and Environmental Management

Data\Woodlot.mdb, courtesy of University of New Brunswick Faculty of Forestry and Environmental Management

Data\Codes\Woodlot_Codes.xls, courtesy of University of New Brunswick UNB Faculty of Forestry and Environmental Management

Data\Coordinate Systems\ATS 1977 New Brunswick Stereographic.prj, courtesy of ESRI

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Data\GPS\Knowledge.shp, courtesy of University of New Brunswick

Data\GPS\towers.xls, courtesy of University of New Brunswick Faculty of Forestry and Environmental Management

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Data\Layer Files\Air Photo Centre Points.lyr, courtesy of Glen Jordan

Data\Layer Files\Main Roads.lyr, courtesy of Glen Jordan

Data\Layer Files\Mgt Compartments.lyr, courtesy of Glen Jordan

Data\Layer Files\Non-forested.lyr, courtesy of Glen Jordan

Data\Layer Files\Secondary Roads.lyr, courtesy of Glen Jordan

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Data\Models\Forest Values.tbx, courtesy of Glen Jordan

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