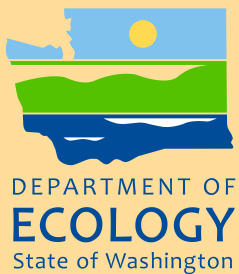


# **The Channel Migration Toolbox**

## **ArcGIS® Tools for Measuring Stream Channel Migration**

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# **The Channel Migration Toolbox**

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## **ArcGIS® Tools for Measuring Stream Channel Migration**

*by*

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# Abstract

Managing for migration (lateral movement) of stream channels reduces risk to communities in floodplains as well as improves floodplain health. A common management tool is a Channel Migration Zone (CMZ). CMZ mapping is required by the Washington State Shoreline Management Act and its implementing administrative code. CMZ mapping projects often require the measurement of lateral migration rates using change in the position of mapped historical channels through time. The Channel Migration Toolbox contains four tools that help automate the measurement of channel migration rates in the geographical information system (GIS) software ESRI® ArcGIS. Practitioners are often interested in average channel migration rates measured along entire channel reaches, and then variability in channel migration rates within reaches. Variability can be evaluated by measuring migration along multiple transects drawn perpendicular to the channel. Accordingly, the tools allow measurement of channel migration rates averaged along reaches and measured directly at multiple transects. The tools include:

- Tool 1. Reach-average channel migration
- Tool 2. Transect generation
- Tool 3. Transect channel migration
- Tool 4. Transect channel width

Tools 1, 3, and 4 perform measurements across multiple time periods within the historical record. Tools 1 and 3 measure channel migration as the change in position of the channel centerlines through time. Tool 2 generates evenly-spaced transects required for Tools 3 and 4.

# Introduction to the Channel Migration Toolbox

Stream channel migration presents hazards to communities in floodplains and valley bottoms. However, it also creates physical habitat important for aquatic organisms such as salmon (Naiman, Bechtold, Beechie, Latterell, & Van Pelt, 2010). Managing for stream channel migration therefore has complementary benefits of risk reduction and improvement of floodplain health. One tool that delineates the hazards and benefits of channel migration on the landscape is a Channel Migration Zone (CMZ) (Rapp & Abbe, 2003). CMZs delineate the areas where channels are reasonably likely to migrate within some future time period. CMZ mapping is required by the Washington State Shoreline Management Act and its implementing administrative code; therefore it has become relatively common practice in the state.

Channel migration studies commonly involve the measurement of lateral channel migration rates. These measurements are often made at many points along a channel, and across multiple time periods throughout the historical record. Given the potentially large number of data points across space and time, manually measuring channel migration can be an onerous and time-consuming process. The Channel Migration Toolbox developed at the Washington Department of Ecology and described here largely automates that process, and was created to facilitate the mapping of CMZs.

The Channel Migration Toolbox contains four tools that help automate the measurement of channel migration rates in the geographical information system (GIS) software ESRI® ArcGIS. Practitioners are often interested in average channel migration rates measured along entire channel reaches, as well as the variability of channel migration rates within reaches. Variability can be evaluated by measuring migration along multiple transects drawn perpendicular to the channel. Accordingly, the tools allow measurement of channel migration rates averaged along reaches, and measured directly at multiple transects. The tools make measurements across multiple time periods within the historical record. They include:

- Tool 1. Reach-average channel migration
- Tool 2. Transect generation
- Tool 3. Transect channel migration
- Tool 4. Transect channel width

The primary inputs are channel centerlines (Tools 1 and 3, see Figure 1) and channel outlines digitized from historical maps and aerial photographs (Tool 4). Tool 2 is the only tool in the toolbox that does not make direct measurements of channel migration or channel width. This document generally describes each tool, its inputs and outputs, and considerations for its use. In addition to general descriptions provided here, help and detailed instructions for running each tool are provided in tool help menus in ESRI® ArcGIS. Instructions for opening the Channel Migration Toolbox in ArcGIS are provided at the end of this document.



# Tool Descriptions

This section describes each tool and general guidelines for use. Each section devoted to a tool outlines (1) a general description, (2) tool inputs and outputs, (3) important steps to run the tool, and (4) preparation and considerations for running the tool.

The tool descriptions often refer to filenames of tool inputs or outputs. Because the tools reference and generate these files for different time periods, the tool names often have in-line variables that reference the period being analyzed. In these cases, % symbols before and after the variable name denote the in-line variable substitutions, which matches the convention used by ArcGIS.

The tool descriptions provide an overview of the function, purpose, and use of each tool. Specific directions for the operation of each tool are provided in the ArcGIS Tool Help menus.

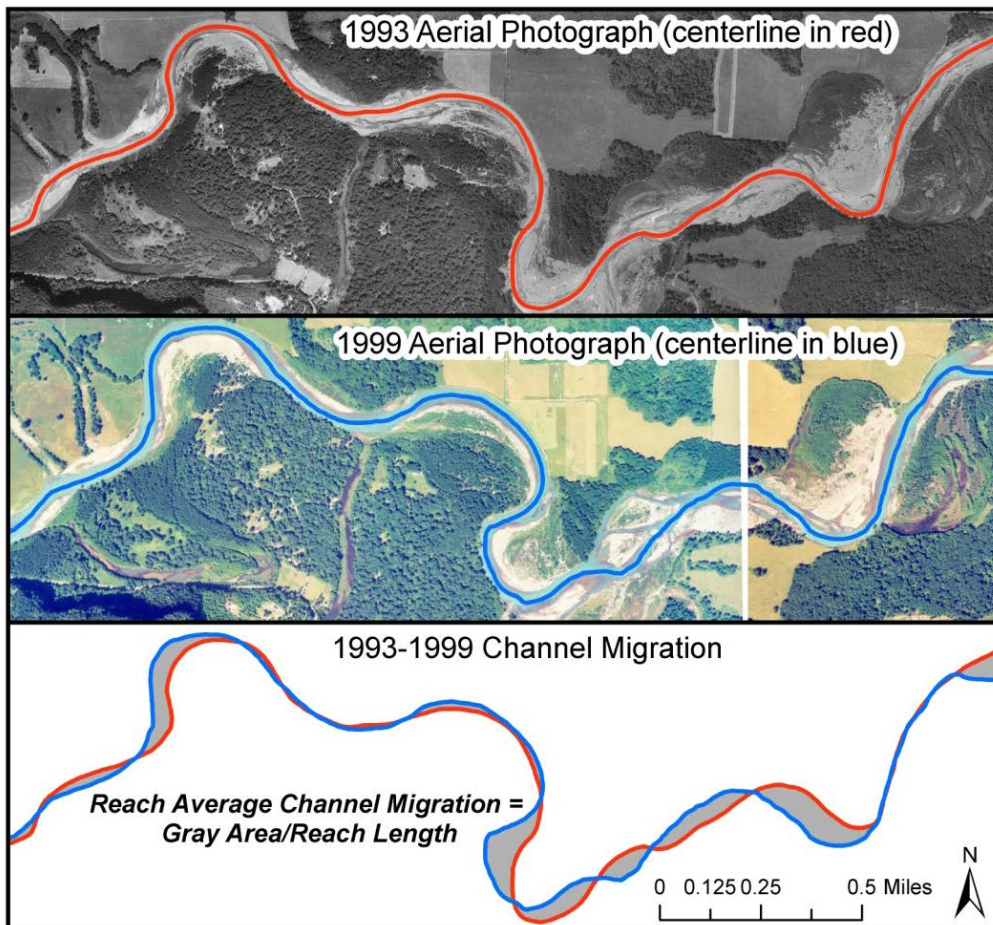


Figure 1. Channel migration example from the Cowlitz River, WA. The example shows low-flow channel centerlines and how reach-average channel migration would be calculated.

# Tool 1: Reach-average channel migration

## General description

Tool 1 measures average channel migration distances along a channel reach for multiple historical time periods. Channel migration is measured as lateral change of channel centerlines (Hooke, 1987). Polygons formed by consecutive channel centerlines are the basis for reach-average channel migration rate calculations (Figure 1). The tool generates (1) a table summarizing migration rates for each analysis period, and (2) polygon feature classes representing centerline migration for each analysis period. The polygon outputs are required inputs for Tool 3. Tool 1 was built in ArcGIS Model Builder and has a nested tool (Tool 1A) which is required for operation.

## Tool Inputs and Outputs

### Inputs

1. Centerline workspace: Geodatabase containing the channel centerlines to be run using the tool. The centerlines should be contained in separate feature classes. Each feature class must:
  - Be named with a common format like 'centerline\_%year%', where %year% corresponds to the year in which the centerline was recorded. Note that additional characters cannot follow the year in the feature class name.
  - Have a field containing the centerline year. The year field must have a common name for all centerline feature classes being analyzed.
2. Centerline years (initial year excluded): A list of unique years that identify the centerlines to be input into the tool. List these years in chronological order and exclude the initial channel centerline (which is specified as a subsequent tool parameter).
3. Centerline filename base: The common portion of centerline feature class-naming convention. In the example used above, the centerline filename base would be 'centerline\_'. Adjust this input according to your naming convention for channel centerline feature classes. The tool uses a combination of the centerline filename base and the centerline years (inputs listed above) to reference the centerline feature classes. Because of this aspect of tool design, centerline feature classes cannot have names that contain characters after the year. For instance, a feature class name of 'centerline\_1977a' would cause the tool to fail.
4. Initial centerline (feature class): The feature class containing the initial channel centerline.
5. Reach length (in units of spatial reference): Valley length is used to calculate reach-averaged migration. Units should match those of the input coordinate system.
6. Reach boundaries: A line feature class containing lines approximately perpendicular to the channel that define the reach ends. These lines must intersect all centerlines being analyzed (Figure 2).
7. Output workspace: The geodatabase to contain the generated output files. NOTE: This database must match the geodatabase specified as the Current and Scratch workspaces in the global Environments settings. See section on '*Important requirements for operation*'.
8. Year field name: The name of the field containing centerline years.

## Outputs

1. Table 'migration\_summary': This table reports migration measurements for each time period measured. The number of rows will correspond to the number of measurement periods. This table contains four fields:
  - [sh\_area]: Migration shape area (in the units of coordinate system)
  - [beg\_year]: The beginning year of the analysis period (in Figure 1, for example, 1993)
  - [end\_year]: The ending year of the analysis period (in Figure 1, for example, 1999)
  - [lngh\_avg\_mig]: Total centerline migration for the analysis period averaged for the reach length. This value is [sh\_area] divided by [reach\_length (user input)]
2. Feature classes 'mig\_%end\_year%': The %end\_year% corresponds to the ending year of each measurement period. The number of feature classes generated therefore corresponds to the number of measurement periods. These feature classes are polygons formed by migrating channel centerlines for each measurement period (representing the grey area in Figure 1). The areas of these polygons are reported in the 'migration\_summary' table. These feature classes are required inputs to Tool 3.
3. Feature classes 'mig\_discrete\_%end\_year%': As above, %end\_year% corresponds to the ending year of each measurement period. These polygon feature classes are nearly identical to the 'mig\_%end\_year%' feature classes, but rather than being combined into a single polygon, the feature classes contain multiple polygons. These feature classes generally can be considered redundant and you can delete them following a run of the tool. However, in certain instances where multiple reaches are being analyzed (discussed below in 'Preparation and considerations'), the discrete feature classes may be useful.

## Important requirements for operation/troubleshooting

Limitations of the ArcGIS system tools used to build Tool 1 require that the following steps be performed prior to running the tool:

1. The user must set the following environments globally in ArcMap:
  - Current Workspace must equal the Output Workspace.
  - Scratch Workspace must equal the Output Workspace.
  - The global Environments menu can be accessed in ArcMap through the Geoprocessing → Environments menu.
2. Two or more measurement periods must be input for the tool to run correctly.
3. The tool uses a nested Model Builder tool (Tool 1A). In some cases, communication between Tool 1 and Tool 1A will break when the Toolbox is transferred between computers. In order to repair the connection, follow these steps:
  - In ArcCatalog or the ArcToolbox, *right click* on Tool 1 and click Edit.
  - Double click on the nested tool within the Model Builder editing view (named: 1A\_Nested Model Polygon CM Tool)
  - Specify the location of Tool 1A on your computer

## Preparation and considerations

### Channel centerline mapping

The primary inputs to Tool 1 are channel centerlines digitized as ArcGIS feature classes from aerial photographs and maps. In order to map channel centerlines, you likely will have to georeference historical aerial photographs or maps to a common reference frame and then digitize the channel centerlines.

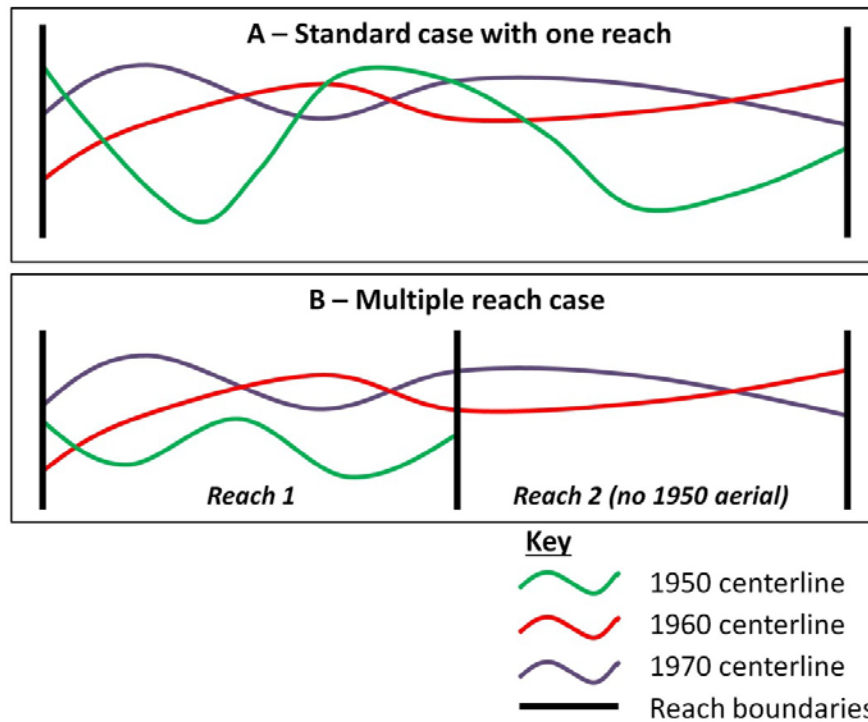
Channel centerlines can be digitized using two general methods. The first method involves directly and manually digitizing the centerline from aerial photographs. The second involves manually digitizing channel banks and then using existing tools to automatically generate the centerline. One such tool is within the Planform Statistics toolset (Lauer, 2006) in the Stream Restoration Toolbox produced at the National Center for Earth Surface Dynamics (<http://www.nced.umn.edu/content/stream-restoration-toolbox>). The first method is best for channels with multiple threads where automated centerline generators are not able to choose the correct channel thread. However, the second provides consistently defined centerlines and can save time when channel banks are being mapped for other purposes.

Prior to digitizing centerlines, consider your definition of a channel centerline. The centerline of the wetted low-flow channel is commonly used in channel migration analyses; however, you also might be interested in migration of the active channel centerline. The *active channel* is typically defined as the wetted low-flow channel plus exposed gravel bars adjacent to the wetted channel (Church, 1992).

### Mapping reach boundaries and defining additional reaches

Tool 1 is designed to perform channel migration measurements along one project reach (Figure 2, panel A). However, with some simple additional steps, you can use the tool to measure channel migration along multiple sub-reaches of a project reach. You may be interested in defining sub-reaches due to different geomorphic or land-use characteristics, or maybe in areas where a historical aerial photograph only extends across a portion of the project reach (Figure 2, Panel B). First, define additional reach boundaries as shown in the Figure 2 multiple-reach example (draw additional line features within the reach boundary feature class). Then, run Tool 1 normally. When using the tool to measure centerline migration along multiple sub-reaches, Tool 1 will not calculate reach-average migration correctly. In order to calculate reach-average migration for each sub-reach, follow these additional steps:

1. Draw reach polygons in a single feature class and assign unique reach\_ID attributes to each feature. Sub-reach boundaries in the polygon feature class should coincide with sub-reach boundaries (lines) input into Tool 1. Polygons should also encompass all migration polygons generated by Tool 1.
2. Use the ArcGIS Spatial join tool (Analysis Tools → Overlay) to join reach\_IDs from the sub-reach polygons to the 'mig\_discrete\_%end\_year%' features generated by Tool 1.
3. Use the Dissolve tool to dissolve the resulting migration polygons (now with reach IDs) by reach ID. This step will create one migration polygon for each analysis period and each sub-reach.
4. In the attribute tables, calculate polygon areas and divide by respective sub-reach lengths to calculate reach-average migration.



**Figure 2. Defining reach boundaries and additional reaches in Tool 1. Panel A shows the standard case in which one project reach is defined for the purposes of Tool 1. Note how the reach boundaries are defined such that channel centerlines extend to, but not beyond, the boundaries. Panel B shows a case where one of the centerlines does not extend the entire project length, and multiple sub-reaches are defined accordingly. Aerial photographs (particularly early ones) are often less extensive and therefore can extend only part of project lengths, so this can be a common problem. In the multiple reach case, sub-reach boundaries (lines) are drawn as needed, and Tool 1 is run as normal. However, post-processing steps (discussed in the main text) are required to measure migration distances for individual sub-reaches.**

## Tool 2: Transect generation tool

### General description

Tool 2 generates evenly-spaced transects to be used by Tools 3 and 4. Transects are generated perpendicular to a user-input centerline at a chosen spacing and length. Tool 2 is the only tool in the toolbox that does not make direct measurements of channel migration or channel width. Tool 2 is run from a Python script called ‘CreatePerpTransects.py’ provided in the zip file with the Channel Migration Toolbox.

### Tool Inputs and Outputs

#### Inputs

1. Input Line: A line feature class containing the centerline of the analysis reach. The valley centerline will be a common choice. However, other centerlines may be appropriate as discussed in the Preparation and Considerations section below. *Prior to running the tool, add fields and corresponding field values to specify the desired transect spacing and transect length.*

2. Distance between Transects: Choose the field name in the Input Line's attribute table containing the desired distance between transects. Because this information is specified in a field, you can specify different transect spacing distances along the project reach by dividing the centerline into multiple features and then specifying different field values for each.
3. Transect Length: In a similar fashion to the input above, choose the field containing desired transect lengths.
4. Output workspace: Define the geodatabase where output files will be generated.
5. Transect points name: Specify the name of the feature class that will contain points. The tool generates points at the intersection of the input line and the generated transects.
6. Transect line name: Specify the name of the feature class that will contain the transect lines.

### **Outputs**

1. Transect points: Feature class containing points located at the intersections of the input line(s) and generated transects. The tool assigns unique IDs to each point.
2. Transect lines: Feature class containing transect lines that intersect the centerline at their midpoint. The tool assigns unique IDs to each transect.

### **Important requirements for operation/troubleshooting**

If the tool does not correctly communicate with the underlying Python script (CreatePerpTransects.py), follow these steps:

1. Right click on the Tool 2 in ArcCatalog or ArcToolbox and select Properties.
2. Under the Source Tab, specify the file location of the CreatePerpTransects.py.

### **Preparation and considerations**

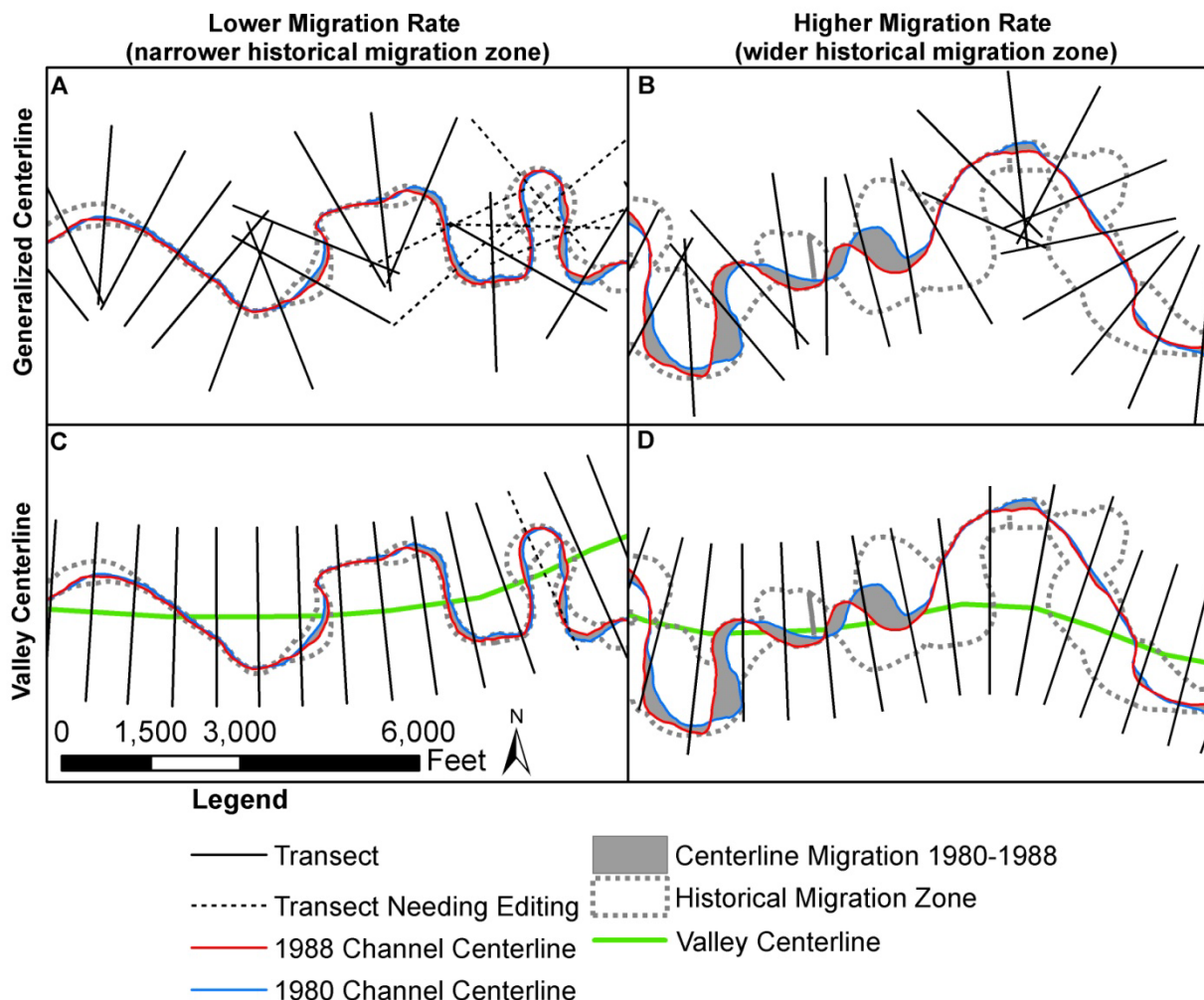
How you draw the transect centerline can influence the measurements of channel migration distances. In cases where channel centerlines are highly sinuous relative to the transect centerline, transects will in many cases intersect migration shapes at high angles (see Figure 3). In these cases, measured migration distances can, on average, be longer than if the transect centerline follows a more sinuous path.

Channel migration studies have traditionally drawn transects perpendicular to the valley centerline. However, these transects often intersect the channel and migration polygons at highly oblique angles. In these cases, measurements can over-estimate channel movement. An alternative to using the valley centerline is a generalized centerline. A generalized centerline approximates the average of the channel centerlines being analyzed (see Figure 3). Generalized channel centerlines will have greater sinuosity than the valley centerline. Therefore transects drawn perpendicular to the generalized centerline will on average intersect migration polygons at angles closer to 90 degrees. The centerline of the historical migration zone of all channels in the historical record is a simple option for a generalized centerline. Figure 3 shows examples of transects drawn from a generalized centerline (Panels A and B) and the valley centerline (Panels C and D) on the Cowlitz River (Washington) to demonstrate the differences discussed above.

The spacing of transects also is an important choice. In general, you should space transects at greater distances on larger streams and at relatively shorter distances on smaller streams. Relative stream size can be measured using channel width or stream discharge. Channel meander



amplitude and wavelength also scale with channel size (Leopold & Wolman, 1960). Because channel migration rates vary along channel meanders (Hickin & Nanson, 1975; Nanson & Hickin, 1986), transects should be spaced a distance less than a typical meander wavelength in order to capture variability within meander bends. Therefore, another possible guide for transect spacing is meander wavelength.



**Figure 3. Techniques for drawing transects.** This figure shows transects drawn perpendicular to a generalized centerline (panels A and B) and the valley centerline (panels C and D) in two reaches of the same stream (Cowlitz River, WA) with differing channel migration rates. The generalized centerline is drawn as the approximate centerline of the historical migration zone (grey dashed outline). Conversely, the valley centerline (green) is drawn solely based on the overall valley trend, resulting in a line that follows little of the channel’s sinuous course. The same period of record was used to map the historical migration zone in each reach, so the width of the historical migration zone reflects average channel migration rate. The generalized centerline results in transects that intersect the migration polygons at angles closer to 90 degrees. Conversely, highly oblique intersection angles can be common when transects are generated using the valley centerline. As a result, channel migration rate measurements along transects will on average be higher in the valley centerline case. The channel migration analyst should consider these differences prior to drawing transects using Tool 2. Dashed transects mark those that would have to be manually edited (prior to running Tool 3) so as to not intersect the historical migration zone more than once. Note that intersecting transects do not cause problems with tool operation.

# Tool 3: Transect channel migration tool

## General description

The transect channel migration tool measures lateral migration of channel centerlines along transects. Tool 2 generates the transects needed to run Tool 3. Like Tool 1, Tool 3 measures lateral movement of channel centerlines across multiple periods. The primary outputs of the tool are a series of tables that summarize channel migration at the input transects. The table named 'trans\_mig\_summary\_all' reports average migration rates at each transect for the analysis period. Tool 3 uses the nested Tool 3A.

## Tool Inputs and Outputs

### Inputs

1. Beginning Year: The year marking the beginning of the entire analysis period.
2. Ending Years of Migration Measurement Periods: A list of years that uniquely identify and reference migration polygons produced using Tool 1. Years must be listed in chronological order.
3. Transect Routes: A line feature class containing linear-referenced lines. Tool 2 creates lines without linear referencing, so prior to running this tool linear-reference transects using the Create Routes Tool (ArcGIS system tools → Linear Referencing).
4. Transect Route ID Field: The field name containing unique route/transect IDs.
5. Migration Polygon Workspace: The geodatabase containing the migration polygons generated using Tool 1.
6. Migration Polygon Filename Base: The base portion of the migration polygons to be referenced by the tool. If you are using the migration polygons generated using Tool 1, input 'mig\_'.
7. Output Workspace: The workspace in which to generate output tables and feature classes. NOTE: This database must match the geodatabase specified as the Current and Scratch workspaces in the global Environments settings. See section below on '*Important requirements for operation*'.
8. Output Filename Base: The base portion of filenames for generated tables. This can be helpful to identify the stream or reach being measured. One helpful convention includes the stream name or stream and reach name – for instance, 'Cowlitz\_' or 'Cowlitz\_R1\_'.

### Outputs

1. Table 'trans\_mig\_summary\_all': This table reports annual average centerline migration rates. The table contains six fields of interest:
  - [RID]: Transect route ID.
  - [Frequency]: The number of measurements used in the calculation of average migration rate.
  - [MAX\_end\_year]: The ending year of the entire analysis period.
  - [SUM\_total\_mig\_dist]: The total distance of centerline migration measured over the analysis period (all measurement periods).
  - [num\_years]: The number of years used to calculate channel migration rate. The number of years is simply calculated as the ending year minus beginning year of the analysis period; therefore, if certain transects have missing migration polygons (for instance, if some aerial photograph years do not cover the entire



study reach), this field will have to be manually edited and the calculation of migration rate will have to be corrected.

- [mig\_rate\_ann]: The time-weighted annual average centerline migration rate. This field is calculated as [SUM\_total\_mig\_dist] divided by [num\_years].
2. Tables ‘%Output Filename Base%\_trans\_mig\_summary\_% end year%’: The number of these tables generated will equal the number of measurement periods. Each table contains four fields of interest:
    - [RID]: Transect route ID.
    - [end\_year]: Measurement period ending year.
    - [Frequency]: The number of migration measurements along the transect for a measurement period. This value will generally equal one, except when the transect intersects a migration polygon at multiple points.
    - [total\_mig\_dist]: The total migration distance along that transect for a measurement period. In cases where a transect intersects the migration polygon at multiple points, the distances are summed.
  3. Table ‘transect\_migration\_merge’: A merged table of the tables entitled ‘%Output Filename Base%\_trans\_mig\_summary\_% end year%’ (described immediately above).
  4. Tables ‘%Output Filename Base%\_trans\_mig\_meas\_%end\_year%’: Tables containing linear measurements of migration along transects. Each table contains the following fields of interest:
    - [RID]: Transect route ID. Note that a transect can be listed multiple times in the table if it intersects a migration polygon more than once.
    - [FMEAS]: A linear measurement along a transect defining one edge of the migration polygon.
    - [TMEAS]: A linear measurement along a transect defining the second edge of the migration polygon. Note that FMEAS and TMEAS do not indicate the direction of channel migration.
    - [end\_year]: Measurement period ending year.
    - [mig\_dist]: The migration distance calculated by subtracting FMEAS from TMEAS.
  5. Feature classes ‘mig\_dis\_%end\_year%’: Dissolved versions of input migration polygons. These are generally redundant versions of the input polygons.

## **Important requirements for operation/troubleshooting**

Limitations of the ArcGIS system tools used to build Tool 3 require that the following steps be performed prior to running the tool:

1. The user must set the following environments globally in ArcMap:
  - Current Workspace must equal the Output Workspace.
  - Scratch Workspace must equal the Output Workspace.
  - The global Environments menu can be accessed in ArcMap through the Geoprocessing → Environments menu.
2. Two or more measurement periods (ending years) must be input for the tool to run correctly.

3. The tool uses a nested Model Builder tool (Tool 3A). In some cases, communication between Tool 3 and Tool 3A will be broken when the Toolbox is transferred between computers. In order to repair the connection, follow these steps:
  - In ArcCatalog or the ArcToolbox, *right click* on Tool 3 and click Edit.
  - Double click on the nested tool within the Model Builder editing view (named: 3A\_Nested Transect Channel Migration Tool).
  - Specify the location of Tool 3A on your computer.

## Preparation and considerations

Prior to running Tool 3, you may need to adjust the lengths of transects generated using Tool 2. Depending on your chosen length, the sinuosity of the channel, and other factors, transects can occasionally intersect migration polygons at undesired points. These situations tend to occur on highly sinuous channel reaches. For example, a transect may intersect a migration polygon twice: once at the desired point; and then a second time at another point up or downstream measured by another transect. In these cases, manually shorten transects to remove these second intersections. To avoid having to compare transects to every migration polygon, instead compare transects to the historical migration zone of channels within the analysis period. The historical migration zone is the area that channels have occupied over the course of the analysis period (Rapp & Abbe, 2003). Figure 3 shows transects drawn using Tool 2. Transects intersecting the historical migration zone twice (drawn as dashed lines) should be manually be shortened prior to running Tool 3.

## Tool 4: Transect channel width tool

### General description

Measuring the planform characteristics of a channel is often required for channel migration studies. Tool 4 measures channel width and the number of channels along transects. For instance, variations in channel width along a channel reach often correlate positively with channel migration rate (Brice, 1982). The number of channels at transect also characterizes channel braiding and may also relate to channel migration rates (Beechie, Liermann, Pollock, Baker, & Davies, 2006). The tool generates tables with records of channel width and number of channels for each transect. Tool 4 uses the nested Tool 4A.

### Tool Inputs and Outputs

#### Inputs

1. Channel Years: The list of years identify, and are used to reference, channel polygons.
2. Transect Routes: A line feature class containing linear-referenced lines. Tool 2 creates lines without linear referencing, so prior to running this tool, transects should be linear-referenced using the Create Routes Tool (ArcGIS system tools → Linear Referencing). Alternatively, transects linear-referenced for input into Tool 3 can also be used.
3. Transect Route ID Field: The field name containing unique route/transect IDs.
4. Channel Workspace: The geodatabase containing the channel polygons.
5. Channel Filename Base: The base portion of the channel polygons to be referenced by the tool.

6. Output Workspace: The workspace in which to generate output tables and feature classes. NOTE: This database must match the geodatabase specified as the Current and Scratch workspaces in the global Environments settings. See section below on *'Important requirements for operation'*.
7. Output Filename Base: The base portion of filenames for generated tables. This can help identify the stream or reach being measured.

## Outputs

1. Table 'chan\_width\_trans\_summary': This table reports annual average centerline migration rates. The table contains six fields of interest:
  - [RID]: Transect route ID.
  - [Frequency]: The number of measurements used in the calculation of mean channel width and number of channel.
  - [MEAN\_chan\_width\_tot]: The arithmetic mean of channel widths for the analysis period.
  - [MEAN\_num\_channels]: The arithmetic mean of the number of channels for the analysis period.
2. Tables '%Output Filename Base%\_summary\_%end\_year%': The number of these tables generated will equal the number of input channels. Each table contains the following fields:
  - [RID]: Transect route ID.
  - [year]: The year of the channel measurement.
  - [chan\_width\_tot]: The sum of widths of all threads of the channel intersecting the given transect.
  - [num\_channels]: The total number of channel threads encountered at the given transect.
3. Table 'channel\_width\_merge': A merged table of the tables entitled '%Output Filename Base%\_summary\_%end\_year%' (described immediately above).
4. Tables '%Output Filename Base%\_%end\_year%': Tables containing linear measurements and positions of channels along transects. Each table contains the following fields of interest:
  - [RID]: Transect route ID. Note that a transect can be listed multiple times in the table if it intersects a channel polygon more than once (e.g. multiple channels are present).
  - [FMEAS]: A linear position along a transect defining the first edge of the channel polygon.
  - [TMEAS]: A linear position along a transect defining the second edge of the channel polygon.
  - [end\_year]: Measurement period ending year.
  - [mig\_dist]: The width of a channel calculated by subtracting FMEAS from TMEAS.
5. Feature classes '%Channel\_Filename\_Base%\_dis\_%end\_year%': Dissolved versions of input channel polygons. These are generally redundant versions of the input polygons.

## Important requirements for operation/troubleshooting

Limitations of the ArcGIS system tools used to build Tool 4 require that the following steps be performed prior to running the tool:

1. The user must set the following environments globally in ArcMap:
  - Current Workspace must equal the Output Workspace.
  - Scratch Workspace must equal the Output Workspace.
  - The global Environments menu can be accessed in ArcMap through the Geoprocessing → Environments menu.
2. Two or more channel years must be input for the tool to run correctly.
3. The tool uses a nested Model Builder tool (Tool 4A). In some cases, communication between Tool 4 and Tool 4A will break when the Toolbox is transferred between computers. Follow these steps to repair the connection:
  - In ArcCatalog or the ArcToolbox, *right click* on Tool 4 and click Edit.
  - Double click on the nested tool within the Model Builder editing view (named: 4A\_Nested\_Transsect Channel Width Tool).
  - Specify the location of Tool 4A on your computer.

## Installation

The Channel Migration Toolbox can be run directly from ArcCatalog by double-clicking on tool icons. The Toolbox can also be added to ArcToolbox by: (1) opening ArcToolbox; (2) right clicking ArcToolbox at the top of the menu; (3) selecting 'Add Toolbox;' navigating to, and selecting the Channel Migration Toolbox.

## Ecology Publications on Channel Migration

Legg, N.T., and Olson, P.O., 2014, Channel Migration Processes and Patterns in Western Washington: A Synthesis for Floodplain Management and Restoration: Ecology Publication 14-06-028.

<https://fortress.wa.gov/ecy/publications/SummaryPages/1406028.html>

Olson, P.O., Legg, N.T, Abbe, T.B., Reinhart, M.A., and Radloff, J.K., 2014, A Methodology for Delineating Planning-Level Channel Migration Zones: Ecology Publication 14-06-025.

<https://fortress.wa.gov/ecy/publications/SummaryPages/1406025.html>

Rapp, C.F., and Abbe, T.B., 2003, A framework for delineating channel migration zones: Ecology Publication 03-06-027.

<https://fortress.wa.gov/ecy/publications/summarypages/0306027.html>

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