ALCES Online User Guide

ALCES Online General Overview – What is it?

Why?

Societies, and the landscapes on which they depend and affect, are dynamic. As populations grow, land uses expand, and landscapes become increasingly busy, planners are challenged to devise management strategies that maximize benefits, minimize liabilities, and achieve a holistic balance. To complicate their mandate further, the natural dynamics of climate change, insect outbreaks, plant succession, and wildlife populations are also major architects of human-shaped landscapes. Clearly, striking an acceptable balance between competing economic, social and environmental objectives is the most challenging of planning goals. That is why we created ALCES Online.

What?

ALCES Online is a powerful, fully integrated, web-delivered GIS and land use simulator. It provides unprecedented capability for today's planners. By adopting the most advanced spatial programming technologies, ALCES provides stakeholders with the ability to visualize current landscapes, to understand the historical back-casts that built our contemporary settings, and can rapidly assess alternative future land use trajectories.

Where?

The ALCES Simulator can be rapidly deployed on a diversity of spatial scales, ranging from small towns, large cities, suburbs, municipalities, regions, or entire countries. Its highly customizable interface allows planners to understand spatial patterns, view and manipulate an exceptional diversity of pre-loaded mapping strata, or to quickly build their own indicators.

Who?

The ALCES Group has worked hard to understand the evolving priorities of planners, whether their professions are based in urban design, industrial sectors, hydrology, carbon pool dynamics, or wildlife biology. The Alces Group provides customized training sessions to all users of ALCES Online.

1 Basic Navigation

The black stripe at the top contains the highest level navigation tools. Starting from the left:

The **Home** button will take the user back to the default web page for the current project, displaying the default map.

The **Map** button takes the user to the main mapping window. This is the primary workspace where most simulations will be built and viewed.

The **Charts** button takes the user to the Charts and Dashboards tool.
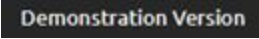
The **Scatterplot** button takes the user to the Scatterplots and Magnitude Map tools.

The **Information** button takes the user to the help section.

The **Data Library** button takes the user to the Data Library tool that is used to upload new data layers.

The **Mapper** button takes the user to the Mapper tool that is used to build and simulate landscape scenarios.

The **PopDyn** button takes the user to the Population Dynamics tool that is used to simulate population dynamics.

The **Account name (e.g.,** Demonstration Version **)** will bring up a list of all projects to which a user has permissions. Users will select one and ALCES Online will go the home page of that project, displaying the default map screen.

The **Head and Shoulders** symbol with a user name beside it will take the user into a screen where their contact info and passwords can be changed.

The **Log Out** button will allow users to safely and cleanly exit the web session.

2 Spatial Data Repository

The enabling feature of ALCES Online is the highly customized professional spatial database at its core. PostgreSQL and PostGIS are used to manage, store, and manipulate very large volumes of data. The ALCES Online Graphical User Interface shields the user from complexities and enables users untrained in GIS to do GIS tasks.

2.1 Data Structure

ALCES Online requires users to bring various forms of data into the server based data repository. All projects start with a default database (e.g., current landscape composition). Users may subsequently load additional data layers and/or calculate and create new data layers from existing ones within the ALCES Online environment.

This section introduces the types of data in ALCES Online. A section describing how to use the data library to upload data is forthcoming.

2.1.1 Indicator Data

Indicators are area based knowledge brought into ALCES Online as polygon or raster data. They represent a numeric value tied to spatial coordinates. In other words, they indicate something about places in space and time. Examples include land cover types, human footprint types, climate data, etc. Indicator data are cell based, for example the portion of a cell covered by a land cover type or the mean temperature of a cell. Indicators are prepared using a cell size of 100 m, and can be viewed lower resolution depending on the size of the study area. Indicator data is not raster in that an indicator's value for a cell is not limited to 0 and 1. For example, if five land cover types are present in a cell the value of each land cover indicator will be greater than 0 but less than the size of the cell.

Indicators may be loaded from a source data set or calculated and created within ALCES Online.

Indicators may be loaded or calculated for user defined time steps. Typically, projects will contain indicators that have values for past, present, and future time frames.

2.1.1.1 Indicators - Unity

Area based indicators in ALCES Online are loaded into a high resolution raster data format. A special set of indicators are produced for each project. These indicators combined, represent the state of the surface of the earth within the study area as described by a defined list of Landscape Types(LT) and Footprint Types(FT). The value of a unity indicator reflects the portion of a cell that is covered by a given LT or FT. No overlaps are allowed. The combined area of all LT & FT areas in a cell must equal the cell area. The concept is that a given unit of area cannot be both a natural natural land use type and a human footprint type at the same time – it is one or the other.

Unity data are prepared using the server-based unity-builder. With the Unity Builder Spec Sheet, the user provides a list of land cover attributes that, when integrated, will comprise the unity layer. The user enters the priority of each dataset, which dictates the likelihood of that attribute being used to cover the landscape over those with lower priority. Once populated, the Unity Builder Spec Sheet is used by ALCES Online to prepare the unity layer. (Note: passing the Unity Builder Spec Sheet to ALCES Online is currently done via command line, and can only be done by ALCES Online developers. This will be changing so that any user can prepare a unity layer).

Other general information about the unity builder:
1. Datasets may be vector or raster files.
2. A single vector or raster file may be used for multiple landscape/footprint types, whereby the attribute field (vector files) and an attribute value (vector or raster) dictates presence on the landscape. Attribute values for rasters are the pixel values.
3. Many datasets can be used for a single landscape/footprint type, simply include them more than once, with the appropriate data source. This method is beneficial for selective use of a data source (i.e. split it up if it has higher priority in one location over another).
4. Line and point vector datasets must have a corresponding buffer value (if not, an error message will result). This buffer will polygonize the dataset appropriately. Buffer values should be in metres, which will be approximated by the region coordinate system.
5. It may be necessary to reclassify one or more land cover types based on the composition of a cell. For example, one of the cover types may be an Unknown type (e.g., due to cloud cover). Once an initial unity layer is prepared, if may be desirable to reclassify the Unknown type to equal each cell's dominant cover type. This is reclassification is defined using the "2nd pass" worksheet. The cover type to be reclassified is entered into the "Type mdb name" column. The criterion to use when performing the reclassification is entered in the "Condition" column, and the eligible cover types for the reclassification is entered in the "Query List mdb name" column. For example, reclassifying an Unknown type based on the maximum value of three forest types would be directed using Unknown in the Type mdb column; Max in the Condition column; and a semi-colon delineated list of the 3 forest types in the Query List mdb name column.
6. The value in the "Pixelation" field is a raster cell size that will be used to approximate the geometry of a polygon on the landscape when calculating area. Narrow or spatially complex polygons will warrant a smaller pixelation value, whereas a large well-rounded or square polygon may be approximated by a larger size. For example, a road that is (on average) 4 metres wide could be approximated by a 4 metre "Pixelation" value. The boundary of a medium-sized municipality may be approximated appropriately by a 100 metre "Pixelation". In the future this will be replaced by an algorithm that evaluates the relationship between geometry area and the number of intersecting pixels.
7. A note of caution: a raster dataset with a high priority, and a resolution exceeding that of the final unity dataset cell size may result in large "sqares" on the landscape. Use vectors or high-resolution rasters as much as possible.

8. When selecting layers to include in the unity builder, care should be taken to ensure that all portions of the study area are covered by at least one of the layers. Functionality will be added in the future to deal with classification gaps, but such functionality is not yet available.

2.1.1.2 Indicators – Non-Unity

Most projects will have many spatial data layers that are area based originating from polygons and rasters but they will not be part of the unity dataset. Two examples that are associated with the unity dataset are age (i.e., time since disturbance) and origin (cut, fire, pest). Other examples include climate data and census data.

2.1.2 Region Data

Regions are spatial polygon entities that are used for grouping, selections and calculations. They are entered into ALCES Online as polygon shapefiles. They allow users to make sub selections from the entire dataset.

ALCES Online provides simple tools that allow users to combine multiple regions in complex ways for creative data exploration. Examples of regions stored in typical ALCES Online projects include administrative boundaries (like counties, First Nations Reserves, electoral districts, census divisions), physical conditions (like elevation ranges, climate zones), geographical features (like watersheds).

ALCES Online provides a simple tool that allows users to draw their own regions.

2.1.3 Feature Data

Feature layers (also called overlays) are spatial map layers that can be used on map products to represent spatial features. They can be thought of as 'graphic pictures' to enhance data viewing.

Feature layers may be polygons, lines, or points. All of these may be uploaded by users. ALCES Online provides tools for creating points in the Touring feature.

Typical ALCES Online projects include features like roads, infrastructure, and human footprint features. All regions can also be used as features.

3 Maps Tool

ALCES Online contains a large volume of time sequenced area based cell data, regions, lines, and point data. The Maps Tool allows the user to create customized maps of these data and combine data to create new data layers. The Maps Tool has three panels: the Mapping Options panel on the left, the Map Panel in the middle, and the Graph panel on the left. These panels are now described, with emphasis on the Mapping Options panel that is used to define a map and create new indicators.
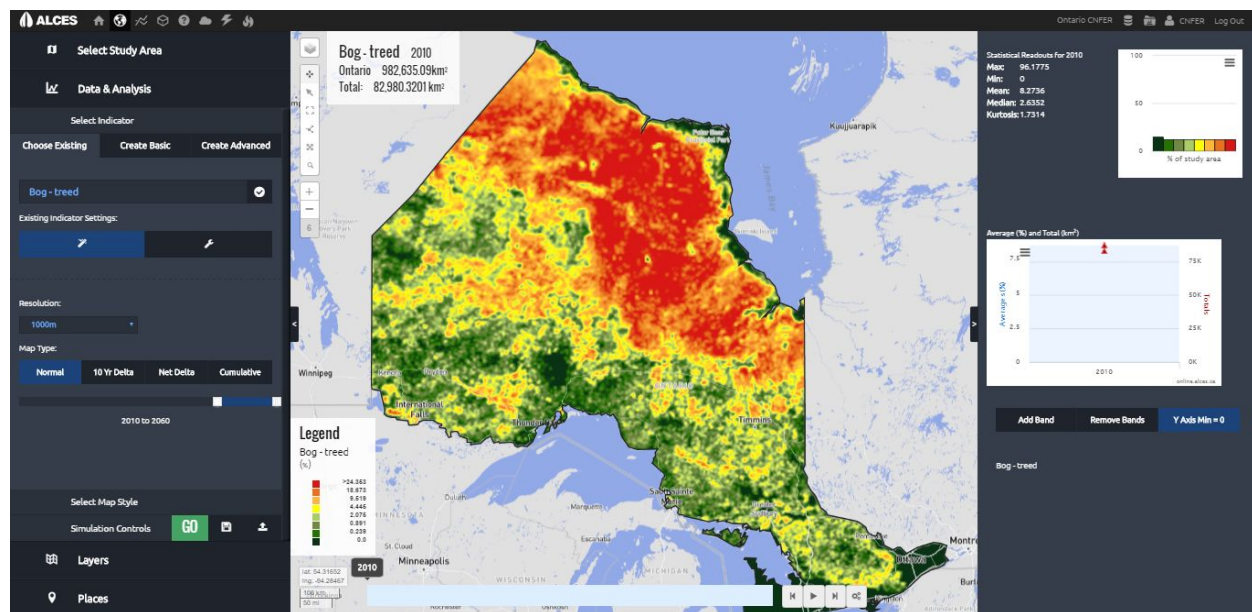
3.1 Mapping Options

The Panel on the left side of the Maps screen provides the user with several tools to view and create spatial data. The following sections briefly describe some of these options.

3.1.1 Select Study Area

Three options are available to select a study area:

1. Single - select a region from the list
2. Complex - combine multiple regions using Add, Subtract, Intersect, or Exclude options
3. Draw a new region to use as a study area
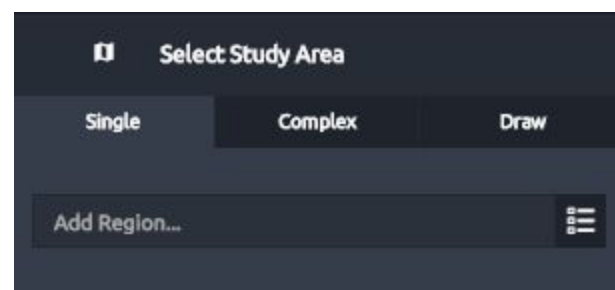
3.1.2 Data & Analysis

3.1.2.1 Select Indicator

3.1.2.1.1 Choose Existing

The Choose Existing option allows the user to select an indicator from the existing list. These are organized into user defined groupings. The text entry boxes also employ smart searching for ease of finding the desired indicator. Each existing indicator has a default scenario (if temporal data exist). The scenario can be changed by clicking the wrench symbol located under the Choose Existing box.
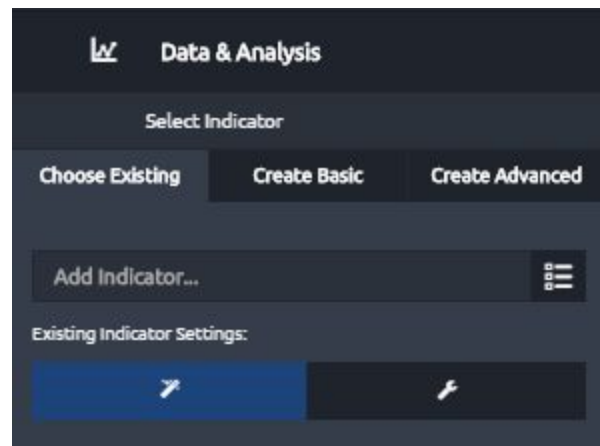
3.1.2.1.2 Create Basic

Create basic provides a straight-forward approach to combine two or more existing indicators (or saved simulations) to create a new integrated measure. The first step is to enter the title and indicator description. Next, select the first existing indicator to be included. Once an existing indicator is selected, two sliders appear. The first is used to indicate whether low or high values of the existing indicator are favoured. The second slider is used to indicate the relative weighting of the existing indicator, or how important it is to the new indicator. Additional existing indicators can then be added and the sliders used to identify relative weighting and whether low or high values are preferred. The combining method can be set as additive or multiplicative. The resulting indicator will range in value from 0 to 1, and reflect the combined result of the component indicators and associated settings (weights, preference of low or high values, and combination methods). The Create Basic panel is also used to select the forecast, backcast, and RNV
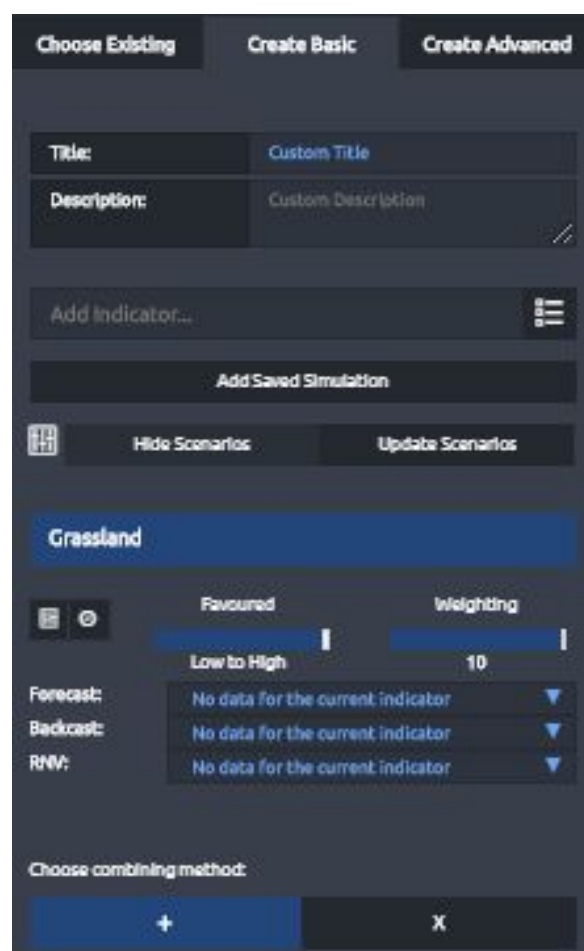
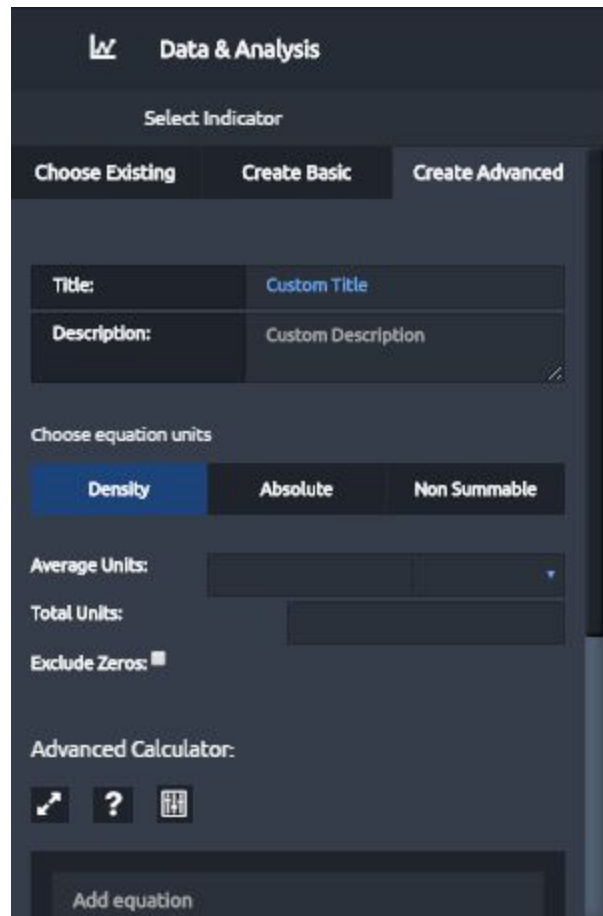scenarios (if they exist) that should be used when running the new indicator.

3.1.2.1.3 Create Advanced

The capacity of ALCES Online to explore the consequences of land use can be expanded through the development of custom indicators using Create Basic and Create Advanced.

With Create Advanced, a new indicator is defined using an equation to combine existing indicators. A wide range of modifiers as well as mathematical and logical functions are available when creating the equation, providing a flexible tool that allows for the development of complex indicators.

When Create Advanced is selected, the user first enters the Title of the indicator and has the option of entering a Description.

The user selects the equation units. It is very important that proper unit is selected or else outputs will be incorrect. The user must select the type of unit (Density, Absolute, or Non Summable) and enter the unit.

- Density is appropriate if the equation calculates percent coverage of a cell (which is the default format in ALCES Online for landscape composition indicators) or number per unit area (km2, ha, or m2). If density is selected, the Average Units must be entered as a density.
- Absolute is appropriate if the equation calculates the total amount per cell (e.g., km2, people) in a unit that can be summed across cells. If Absolute is selected, the Total Units must be entered.
- Non Summable is appropriate if the equation calculates a value that is not a density and is not summable. Examples include age (e.g., years) and indices such as a habitat suitability index. If Non Summable is selected, the Average Units must be entered (but not as a density).

The user has the option to Exclude Zeros. If Exclude Zeros is selected, cells with zero values will be excluded when the average value for a study area or region is calculated. This is useful if a the average value should not be influenced by zeros. For example, an approach for calculating average forest age involves applying a value of 0 to cells without forest. Average forest age should not be affected by the zero's, so Exclude Zeros should be selected.

To enter an equation, the user selects existing indicators, previously saved simulations, numbers, and functions to generate a customized output.

- You can type numbers or type **coefficient** to trigger a prompt.
- You can type an existing indicator name or type **variable** to trigger a prompt.
- Add, subtract, divide, and multiply functions can be typed
- More advanced functions can be typed. For a complete list, click the ? above the equation box in Create Advanced and then click See Full List. A summary of the more commonly used functions is provided in the table below. More details on the functions is available in section 7 Advanced Functions.
- Indicators that were previously created with Create Advanced can be included in another indicator's equation. To do so, click **saved simulation** to trigger a dialogue for selecting the indicator. The dialogue box asks the user to select the saved simulation and to specify whether the saved simulation should be Linked or Copied. Link means that future changes to the previously created indicator (i.e., saved simulation) will affect the equation that you are building. Copy means that future changes to the previously created indicator will not affect the equation that you are building.

Function	Description
If	Logical statement of the form: If … then… else. Comparisons (<, >, >=, <=, !=, ==) and adjoining functions (and, or) are used to define the condition to be assessed by the If statement.
Status	A dialogue box appears when the Status function is selected that requests the user to enter the Status Indicator (e.g., Forest Origin), the Scenario, the Operator (!= or ==), and the Status (fire vs pest vs harvest origin). A 1 is returned if the condition is met by the origin indicator, 0 otherwise.
Buffer	A dialogue box appears when the Buffer function is selected that requests the user to enter an expression and a Distance. If the Include type is selected, the buffer function returns a 1 if a cell is within the buffer distance of cells with a non-zero result for the expression, and 0 otherwise. If the Exclude type is selected, the buffer function returns a 0 if a cell is within the buffer distance of cells with a non-zero result for the expression, and 1 otherwise.
Proximity	A dialogue box appears when the Proximity function is selected that requests the user to enter an expression. The function returns the distance from each cell to the nearest location of a cell with a non-zero value for the expression.
Patches	A dialogue box appears when the Patches function is selected that requests the user to enter the summary method and an expression. The

	function identifies patches of contiguous cells with a non-zero result for the expression, and returns the patch area (Patch Areas (m2)) or the sum of the expression's value across cells within a patch (Patch Sums).
max	Returns the maximum value for a series
min	Returns the minimum value for a series
pow	Applies an exponent to an expression
exp	Returns the exponential of an expression

Once an existing indicator or saved simulation is included in the equation, the existing indicator or saved simulation can be right-clicked for options. The options include Edit, Copy, Comment (to add explanatory text), and Delete.

Clicking Edit to an existing indicator results in a dialogue box (shown below) with the following options:

1. Choose Variable. The user can select which indicator and which scenario to use, and whether the variable should be expressed as a Density or Absolute when calculating the equation. For example, for a landscape composition variable, choose Density if the variable should be included as % or choose Absolute if the variable should be included as km2. If scenarios have been run that affect the indicator, the user also selects the forecast, backcast, and RNV scenario to be used.
2. Average or Sum by Region. Clicking the + symbol allows the user to summarize a variable by a region for the purpose of the equation. For example, if a wildlife indicator is to be calculated at the scale of a watershed, then explanatory variables such as footprint or forest age should be averaged or summed by watershed for the purpose of calculating the wildlife indicator. Region Category should be selected if the intent is to summarize a variable for each of a type of region (for example, by watershed). Total should be selected if the variable is to be summed across cells within each region, and average selected if the variable is to be averaged across cells within each region.
3. Time-Shift Data. Clicking the + symbol allows the user to apply results from another timestep than the reporting timestep. This can be achieved using Shift, if the intent is to implement a lag, or Static, if the intent is to always apply a variable's value from the same timestep (e.g., current or predisturbance).
4. Add Modifiers. Five types of modifiers can be applied to variables.
   a. Univariate. The user defines a curve that converts the variable's value (x-axis) to other values (y-axis). Univariate modifiers are useful for dose-response relationships such as a habitat quality metric that is determined by road density.
   b. Bivariate. The user selects a second variable to be used to define a coefficient that is then multiplied against the original variable. The user defines a curve that converts the secondary variable (x-axis) to the coefficient (y-axis). Bivariate

modifiers are useful when the influence of a variable (e.g., coniferous forest as wildlife habitat) is affected by a secondary attribute (e.g., forest age).

c. Decadal. Allows the user to apply a coefficient that varies by decade (i.e., over time). The coefficient can be Compound, in which case the coefficient is multiplied by the variable, or Override, in which the coefficient replaces the variable. Decadal modifiers can differ across regions by using Add a Regional Decadal Modifier. Decadal modifiers are useful when the influence of a variable changes over time (e.g., mine footprint releasing less effluent after a future improvement in mining practices).

d. Monthly. Allows the user to distribute a variable's value across months. This is useful when it is important to understand monthly status of an indicator, for example by distributing annual stream flow across months.

e. Regional. A regional modifier allows the user to apply a coefficient that differs by region (e.g., forest management unit, watershed, etc.). Typically, the Full Value option is used to apply the modifier to every cell in a region. Alternatively, the modifier can be Distributed across the cells occurring in a region. When applied to a variable, the regional modifier is multiplied against the variable. When applied to a constant (e.g., 10), the regional modifier replaces the constant. A regional modifier is useful when the influence of a variable differs by region; for example, a reduced effect of roads on wildlife habitat within management units where access management is being applied. Regional modifiers are also useful in Mapper for defining filters that include or exclude a portion of the landscape from receiving a simulation action (e.g., excluding protected areas from development).

5. The format of a variable can be changed from Normal (i.e., the value of a variable in a given year) to 10 Yr Delta (change in value by decade), Net Delta (change in value between two reporting intervals defined by the user), or Cumulative (sum of a variable's value across reporting intervals). Typically, however, the Normal format should be used.

Clicking Edit to a saved simulation results in a dialogue box (shown below) with the following options:

1. Edit expression will modify the previously created indicator's (i.e., saved simulation) equation. If the saved simulation was Linked, then edited the expression will also modify the original saved simulation.
2. Average or Sum by Region. See above description.
3. Time-Shift Date. See above description.
4. Add modifiers. See above description.

If the user wants to change the scenario that is selected for all of the variables in a Create

Advanced equation, they can do so by clicking the Update Scenarios button located above the equation box.

3.1.2.1.4 Resolution

The Resolution used when mapping and/or analyzing data can be specified. The default resolution is very coarse and most users will want to increase the resolution. Higher resolution data require more time to render and calculate, but result with more detailed mapping.

3.1.2.1.5 Map Type

The user may select data to be returned as Years or Decades. Years should be used if trying to view an annual data set.

The user may select from 4 broad types of maps. They all display the same data in a different way:
- Normal – the value of the indicator at a point in time
- 10 Year Delta – The amount that the indicator has changed in the past 10 years for different points in time
- Net Delta – the amount that the indicator has changed during a user defined time interval
- Cumulative – The cumulative change that the indicator has experienced between two user defined time points

The reporting intervals (typically decades) to include when preparing a map series is specified using the year slider located below the Map Type options.
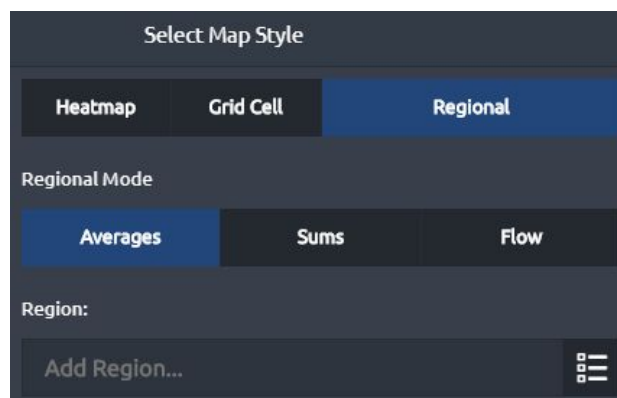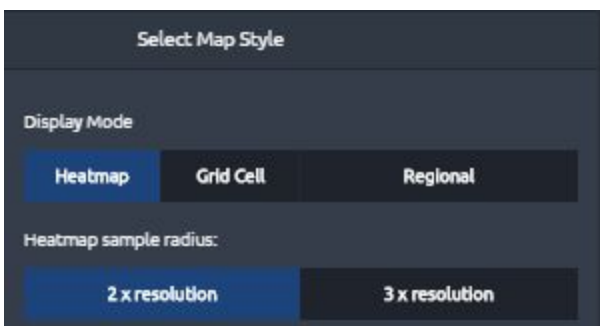
2010 to 2060
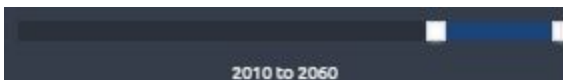
3.1.2.2 Select Map Style

This panel allows the user to customize mapping settings such as the display mode and break points.

3.1.2.2.1 Display Mode

Three display modes are available:
1. Heatmap (default). With a heat map, the mapped value for a cell is influenced not only by the cell's value but the value of its surrounding cells. The user may select 2X resolution or 3X resolution sample radius depending on how 'fuzzy' one wants the generalized colors to appear. This a generalized map style that shows trends across large areas.
2. Grid Cell. Displays individual cell values.
3. Regional. The user may summarize an indicator at a regional scale (e.g., by watershed). ALCES Online will retrieve the selected indicator values for each cell and then compile it up to the region level selected. The returned map provides one value for each polygon in the selected region. If this option is selected, the user can specify whether the indicator should be summarized by calculating the average value across cells within each region or by summing the value across cells within each region. The Flow Regional Mode is not currently operational. The user must also specify the region category to use when preparing the summary.

Select Map Style

Display Mode

Heatmap | Grid Cell | Regional

Heatmap sample radius:

2 x resolution | 3 x resolution

Select Map Style

Heatmap | Grid Cell | Regional

Regional Mode

Averages | Sums | Flow

Region:

Add Region...

3.1.2.2.2 Breakpoints and Color Scheme options

By clicking the wrench symbol, the user can select the method used to define breakpoints and the colour scheme.
- Maps can either be Continuous or Discrete. With Continuous, mapping occurs across a spectrum of colours and each breakpoint

Breakpoints and Color Scheme options:

Quantification
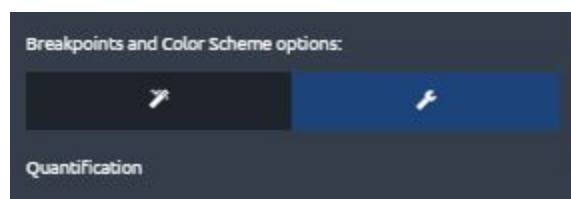
defines values associated with colours located along that spectrum. With Discrete, one colour is associated with each breakpoint category.

- The default option for defining breakpoints is Equal Quantiles whereby breakpoints are automatically set by ALCES Online so that an equal proportion of the study area is within each category in year 2010 (i.e., current). Other options for automatically generated breakpoints are Exponential Increase, Exponential Decrease, Linear, and Binary. Alternatively, Custom breakpoints can be created by clicking the wrench symbol and entering values into the boxes that appear.
- The user can select from a variety of colour palettes.

### 3.1.2.3 Simulation Controls
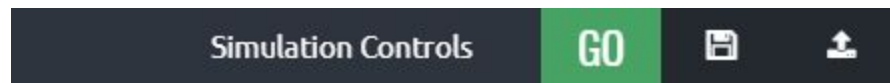
3.1.2.3.1 Run Simulation

The GO button ( ) on the Simulation Controls panel will render the map or map series defined by the Study Area, Indicator, and Map Style settings.

3.1.2.3.2 Export Current Simulation

The arrow symbol ( ) on the Simulation Controls panel provides the user with options for downloading the rendered maps. Options (formats) are CSV, JPG, and TIFF.

3.1.2.3.3 Saved Current Simulation

The disk symbol ( ) on the Simulation Controls panel provides the user with options for saving an indicator created using the Basic or Advanced calculators. A saved indicator is called a Saved Simulation in reference to both the equation and the temporal data (e.g., simulated landscape dynamics) that are incorporated in the equation. There are two save options. Save as New will create a new saved simulation which can be accessed at a later time from the Saved Simulation folder in the top right menu bar. Overwrite Last Loaded will replace the most recently opened saved simulation. To access a saved simulation at a later time, click the folder ( ) in the top right corner of the page. A dialogue box will open asking you to Load a Saved Simulation. Clicking the play button ( ) to the right of a Saved Simulation will open it in the Maps page where it can be run by clicking Go from the Simulation Controls. Other options in the Saved Simulation folder are to edit a saved simulation's name or description ( ) and to create/update an indicator from saved simulation ( ). See the next section for details on creating an indicator from a saved simulation.

3.1.2.3.4 Creating an Indicator Equation from a Saved Simulation

If a saved simulation is to be shared with other users or applied to multiple Mapper scenarios, the saved simulation should be converted to an indicator equation. Once a saved simulation exists as an equation, it is available from Choose Existing in the Maps tool for viewing by other users with access to your user group. A saved simulation is converted to an indicator equation

by opening your Saved Simulations folder in the Maps tool and clicking the [icon] icon to the right of the saved simulation of interest. You will be prompted to choose the Scenario for Data. If the indicator is to be applied to a single scenario, select the scenario from the dropdown box. If the indicator is to be applied to multiple scenarios using the Mapper module (section 6.4 Applying Derived Indicators), choose "Default general" from the dropdown box. You will also be prompted to choose the Indicator Category. The Indicator Category refers to the folder where the indicator will be located when selecting an indicator from Choose Existing in the Maps module. Use the dropdown box to select the indicator category. Contact ALCES if a new Indicator Category is required.

3.1.3 Layers
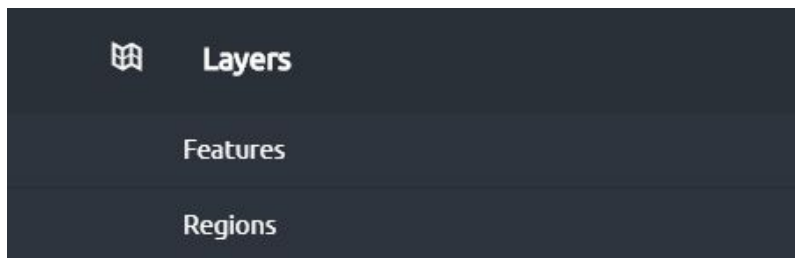
The layers panel allows the user to select Features and Regions to include in a map as overlays.

3.1.4 Places
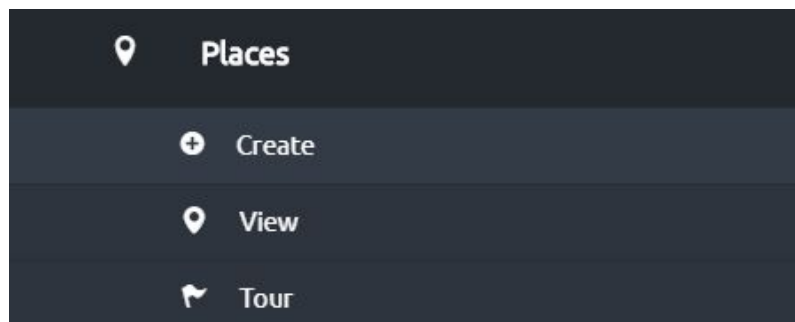
Point locations can be stored and named as sets. The user can then define how they want to virtually tour those locations. Responding to a set of user defined parameters, ALCES Online changes the scene on the map window in a sequence determined by the user defined inputs. The scene changes will zoom in to desired levels and pause and then zoom out and move the next sequential point location. Used in conjunction with the detailed base maps, it provides

users the opportunity to get a quick view of actual landscape conditions at pertinent features' locations.

Click Create to create a new place. Places can be manually digitized by clicking "Add places on the map!," and using your mouse to located the place on the map. You will be asked to enter the place name, and choose which place folder it should be stored in (or create a new folder). Alternatively, a place can be created by entering X,Y, coordinates.

Once places are created, they can be accessed by clicking View. Places that you have prepared can be selected by clicking the box next to the appropriate place or places folder. The "With selected" dropdown box is then used to add places to a tour or a folder. A tour is a collection of points that can be saved as named Tours for collaboration and later re-use. The order in which points are toured and the zoom level with which they are viewed can be set with a variety of options using the View tool.

To view a tour, click Tour.

3.2 Map Window

The Map Window in the central portion of the page displays maps of data as requested by the user. The Map Window can be expanded to the left and right by clicking the arrow buttons. The title in the top left of the map window identifies the name of the mapped indicator, the year or decade that is being viewed, the study area and it's size, and the indicator's total (if the indicator is summable) or average value across the study area. The legend in the left hand corner conveys the meaning of the map's colours. Other components of the Map Window include the layers, map tools, and the time slider.

3.2.1 Layers

A variety of basemaps are available by clicking the layers button ( ) in the top left corner of the Map Window. The menu that appears can also be used to select other options including: showing the simulation and feature legends, clipping the map to the study area, showing the study area border, including streets and labels in the base map, to the map including whether the legend is shown, the map is clipped to the study area, the study area border is shown, the opacity of the simulated indicator, including map tool and time slider controls, and showing markers. Sliders are also available to change the opacity of the simulation (i.e., mapped indicator), features, regions, and places.

3.2.2 Map Tools

The Map Tools sidebar at the left of the map window includes buttons to change the zoom level and the mouse function (pan the map , select a layer , fit map to the current study area , and measure a layer). The sidebar can also be used to search for a location .

3.2.3 Time Slider
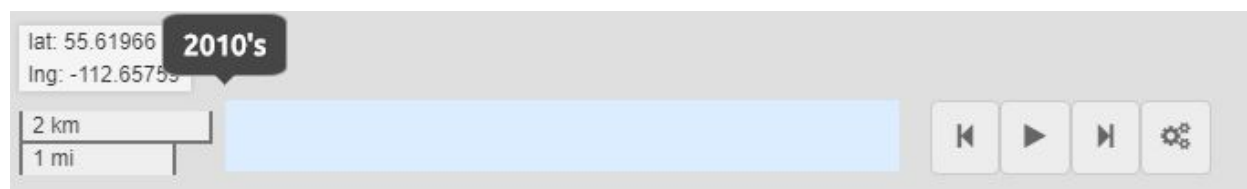
Indicator data is always assumed to be capable of having time series values. Data may be loaded that way (for example historic climate data) or it may be calculated within ALCES Online (advanced calculator or simulation engine). The time slider bar on the map window allows users to view the time series values.

A given scenario is set up with a current year. The display then shows a historic range and a future range relative to the defined current period.

Users may select the period by left clicking on the number line or moving one period by clicking the arrow buttons. Alternatively, the user may press the middle play button and the map window will automatically change the indicator map display period by period. Settings for the slider are available by clicking ⚙ .

3.3 Graph Window

The graph window on the righthand portion of the page displaces two types of graphs that summarize the indicator output for the study area. A histogram displays the percent of the study area within each of the breakpoint classes for the indicator. A line graph display average and total (if the indicator is summable) status of the indicator across the requested time period. Options available for modifying the line graph include whether or not the y axis should include 0, and adding coloured bands that can be used to convey levels of performance. The histogram and line graph can be exported by clicking ☰ . The graph window also includes a statistical summary of the indicator including maximum, minimum, mean, and median values of the indicator across all cells in the study area, as well as kurtosis (i.e., prevalence of outliers).

4 Charts and Dashboard Tool

The Charts tool allows the user to create dashboards that contain one or more customized graphs and maps of Indicator data. The graphs and maps are temporally dynamic, and indicator change over time to be viewed using the Time Slider at the bottom of the Charts page. In addition to maps, the following types of charts are available: line, horizontal bar, column, gauge, stacked area, pie chart, table, and timeseries table.

To create a dashboard using Charts tool, first use the panel in the top left corner to Select the Study Area. Next, click Data & Analysis (located directly below Select the Study Area). The indicator to be mapped or charted is selected from Choose Existing by typing the indicator name or selecting from the list of available indicators by clicking the View List icon (🔳). Once an indicator is selected, the scenario is selected by clicking the wrench button located below the Choose Existing box. (Note: It is recommended that dashboards be created with existing indicators as opposed creating new indicators with Create Basic or Create Advanced because Choose Existing will ensure that dashboards are saved properly and available for sharing. Guidance on how to convert a Saved Simulation to an Existing Indicator is available in section 3.1.2.3.4 Creating an Indicator Equation from a Saved Simulation. The resolution can be specified using the dropdown box. The reporting intervals (typically decades) to include when preparing a map or chart is specified using the year slider located below the Chart Type options. Chart Type options are as described in section 3.1.2.1.5 Map Type.

When the indicator and associated settings have been specified, click the green GO button to create the chart or map. By default, a Line chart is created. The line chart will appear in the Chart Dashboard portion of the page. To change the chart type, click the Choose Chart Type icon (〜) located in the top right corner of the line chart. For the Map type, the Display Mode and the Breakpoints and Color Scheme options can be selected by clicking "Select Chart Style" on the left panel (details on setting these options are available in section 3.1.2.2 Select Map Style).

To add another indicator to a chart, follow the same steps as above to select and run an indicator. To add the same indicator but a different scenario, change the Scenario in Indicator Settings on the left panel and click Run. Chart types that are able to present multiple indicators/scenarios (referred to as Series) are Line, Horizontal Bar, Column, Stacked Area, Pie Chart, Table, and Timeseries Table. If multiple scenarios are applied to a Map or Gauge, the most recently run series will be displayed. Clicking an indicator name at the bottom of a Chart will open a box that can be used to Hide, Rename, or Remove the series, change the color, or view metadata. Clicking the information symbol (ⓘ) on a Map will display metadata.

To add a new chart or map to a dashboard, click the button in the bottom left corner of the Chart Dashboard and follow the steps described above. Once multiple charts or maps occur on a dashboard, you can add series (i.e., indicators/scenarios) to a chart created previously by clicking the circle to the left of the chart title (the circle will be green once it is clicked) and

following the steps described previously. Charts and Maps can be resized by clicking and dragging the bottom right corner of the Chart or Map. A Chart or Map can be moved by clicking and dragging the top of a Chart or Map. Other buttons in the bottom left corner of the Chart Dashboard can be used to delete a chart/map, save a dashboard, or open a previously saved dashboard. If you would like to share a saved dashboard with other users in your user group, please contact ALCES.

There are multiple options for exporting the chart, which can be accessed by clicking the ≡ icon in the top left hand corner of a chart.

5 Scatterplots Tool

Scatterplots allow the user to visually explore relationships between multiple data indicators. The user selects Region, Scenario, and Chart Style. The user then selects Indicators to use as variables on the scatterplot. One may use 2 or 3 or 4 variables and choose to ignore zero values. The result is a scatterplot that can be rotated on all axes and sequenced through time periods.
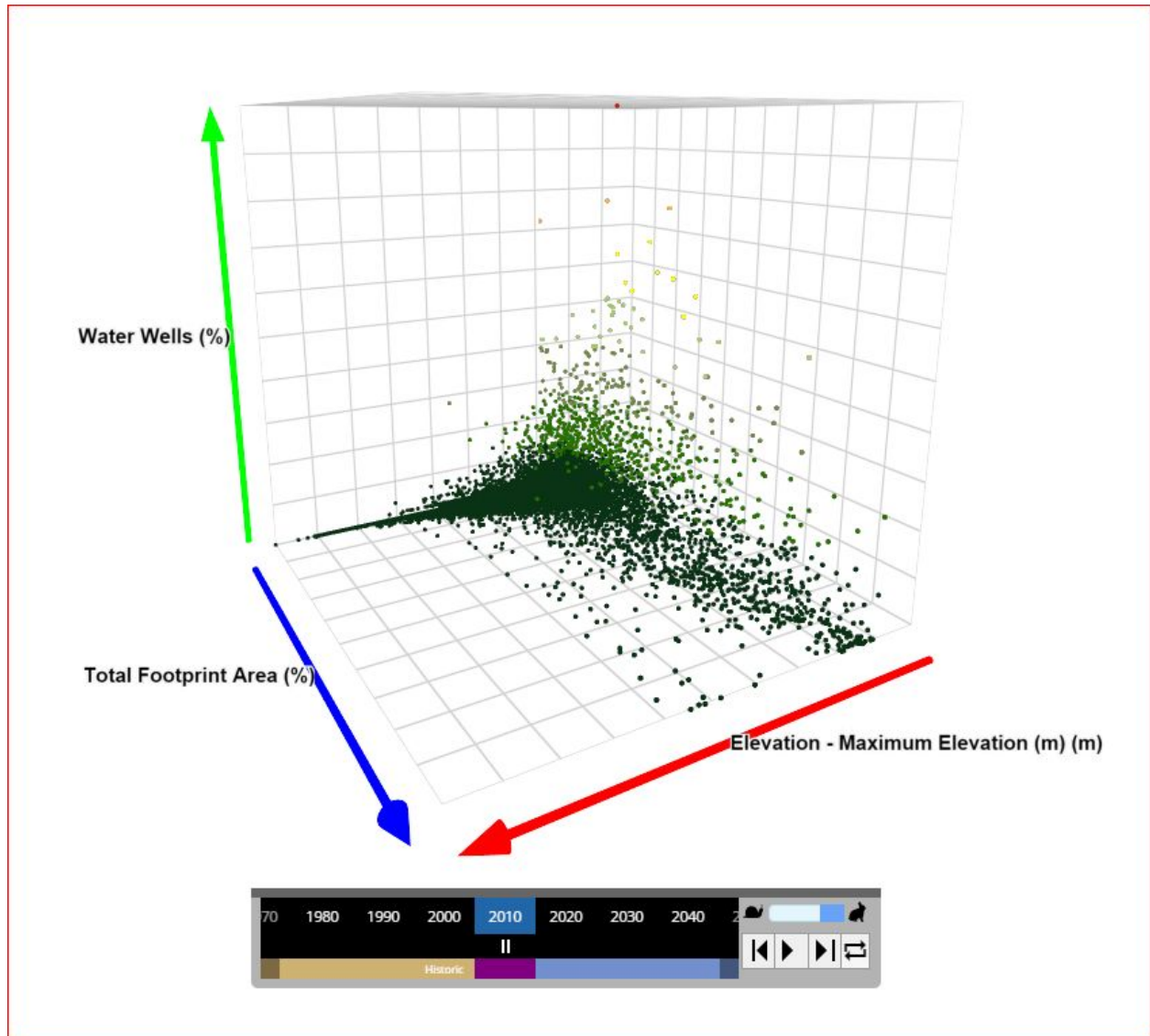
By selecting regional averages, ALCES Online returns one dot for each unique region polygon in the selected region.
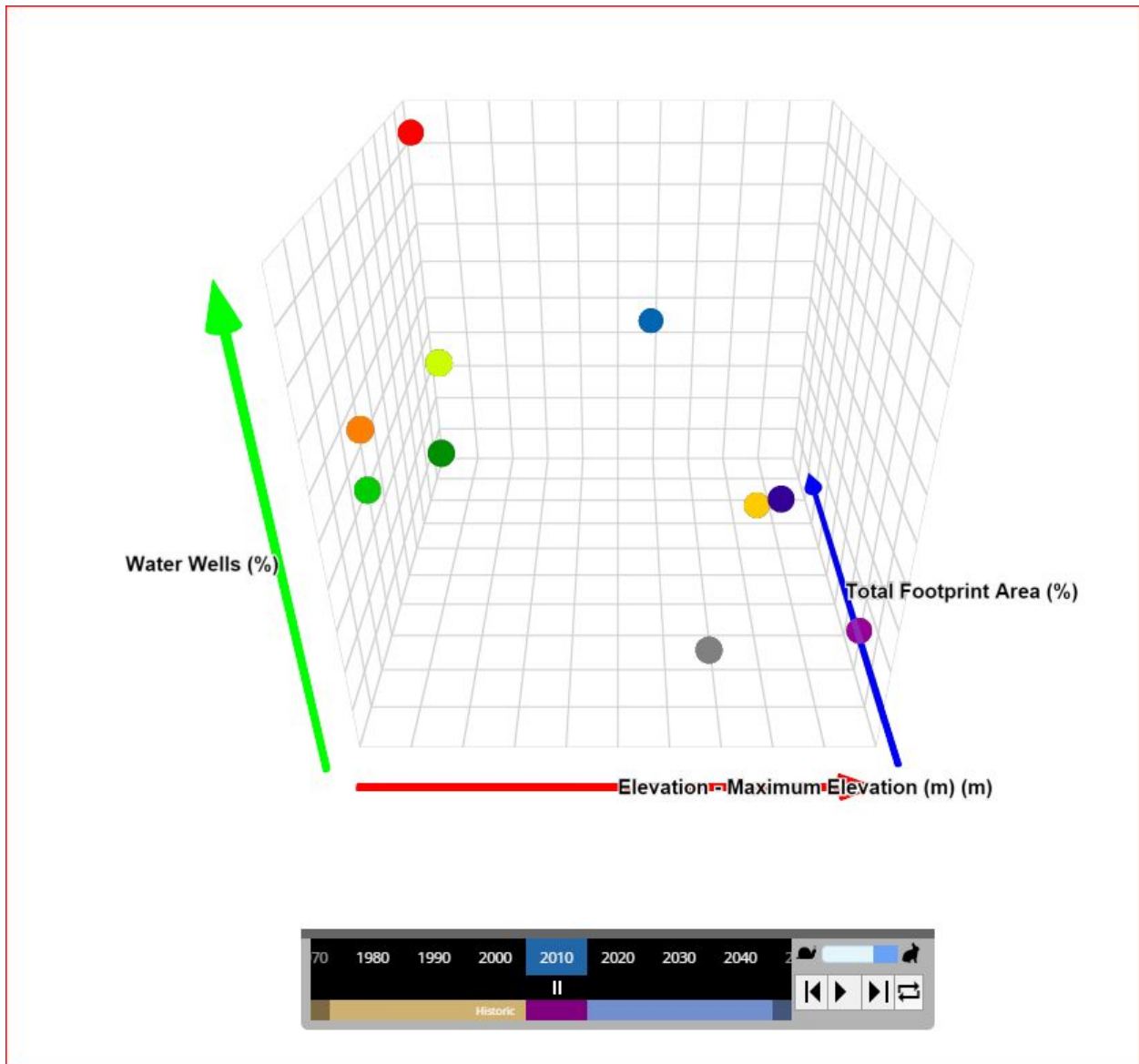
Users may select a magnitude map under the scatterplot tab. With this tool, two horizontal axes are supplied (by ALCES Online)with Latitude and Longitude. The Y axis is supplied with the selected indicator values. A three dimensional plot is returned. Colors and visual preferences can be adjusted in the chart style tab. The end product is a 3-D plot that can be rotated on all axes.
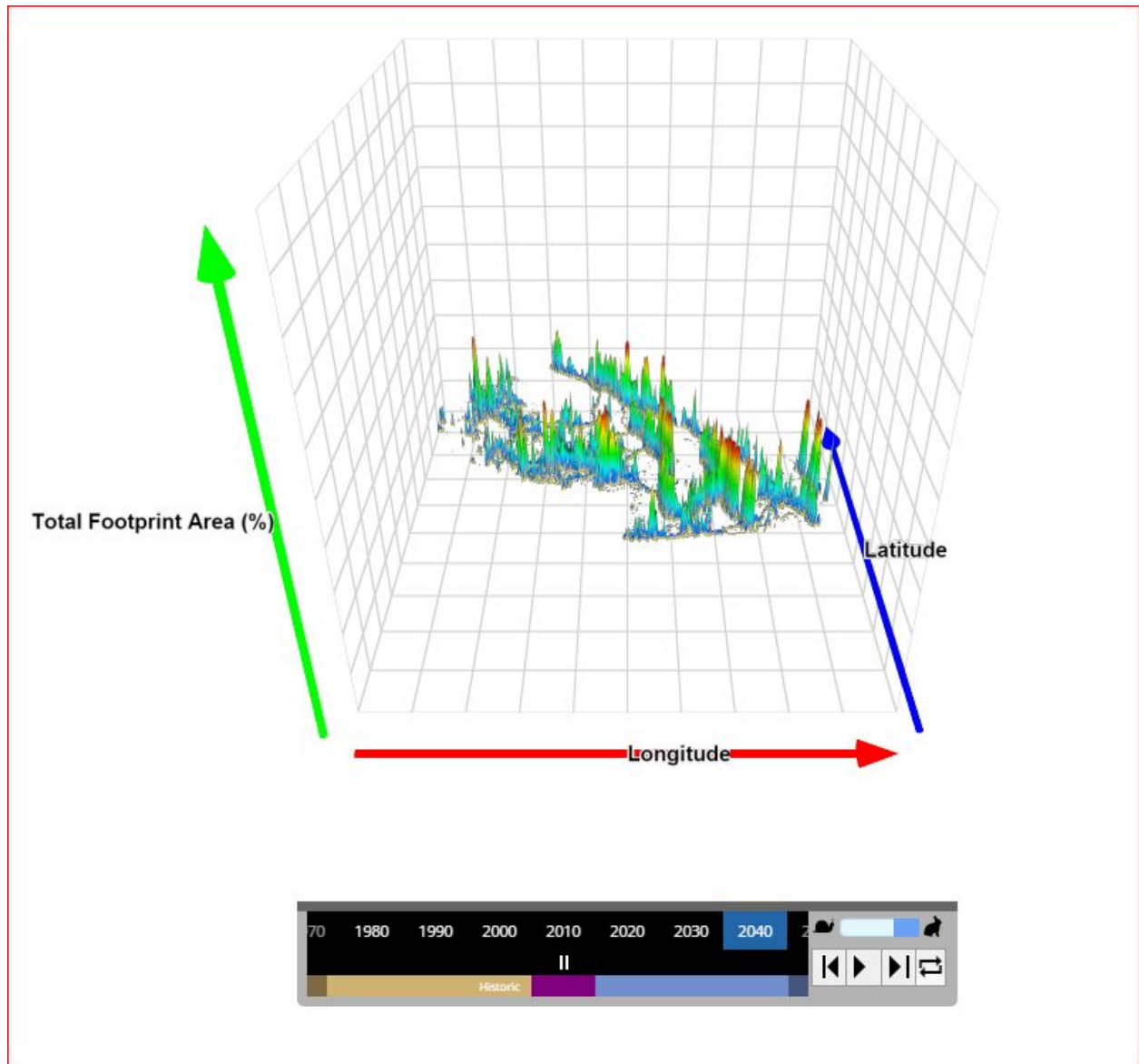
6 Mapper

Mapper is ALCES Online's spatial simulation engine. Users are able to build simple to complex models that will simulate natural processes and landscape change over time. Simulations can backcast or forecast values (i.e., reconstruct historical landscape change or project future landscape change). The tool allows users to formulate any dynamic change process affecting indicators within ALCES Online. Typically, however, a simulation effects landscape composition (i.e., the unity data set), age (e.g., forest age), and/or origin (e.g., fire origin).

Mapper is designed to support flexible and transparent simulation of cumulative effects. A range of scenarios can be efficiently prepared and simulated to allow users to compare the consequences of alternative potential futures. Mapper is intended for scenario analysis as opposed to prediction. Scenario analysis is the process of analyzing possible events and strategies by considering alternative futures. Scenario analysis should assess multiple scenarios. Each scenario should be logical and transparent, but is not a prediction.

Using Mapper, a scenario is built by defining a series of actions, each of which causes one or more transitions to landscape composition, age, and/or origin. Each action represents a process that alters the study area. Examples include settlement expansion, forest harvest, road construction, fire, succession, and mine reclamation. Mapper simulates the cumulative effect of a set of actions.

6.1 Creating a Project

A Project is a collection of scenarios that use the same timeline, study area, resolution, simulation and output increments, and predisturbance indicators. If reclamation will be included in a scenario, it is necessary to identify predisturbance indicators that define the composition of the landscape prior to disturbance. This can be done by clicking Add Multiple Predisturbance Indicators and selecting natural landcover types.

6.2 Creating a Scenario

Once a project is created, one or more scenarios can be defined within the project. There are multiple types to choose from when defining a scenario. A forecast scenario simulates changes caused by potential future actions. A backcast scenario reconstructs changes caused by past actions to transition a landscape from its current composition back to its predisturbance composition. A RNV (range of natural variation) scenario applies stochastic natural disturbance (e.g., fire) to the predisturbance landscape in order to simulate natural landscape dynamics.
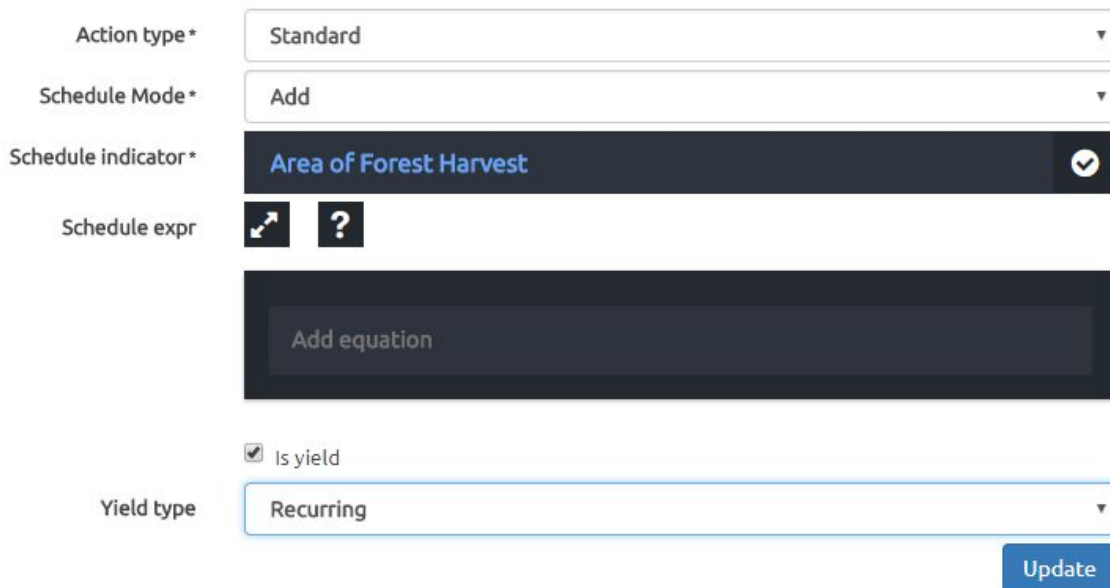
6.3 Creating Actions

To review, an action represents a process that changes landscape composition, age, and/or origin. To set up an action, the following components are specified:

- Scheduled indicator - the indicator (e.g., footprint type) that is used to track where the action occurs
- Type - whether the amount of the action is fixed or derived from other variables
- Mode - whether the action adds or subtracts the scheduled indicator from the landscape
- Thematic filter - where the action is allowed to occur)
- Transition - the effect of the action which can include conversion or reclamation of landscape types, change to landscape age, and change to landscape origin
- Allocation - an action's more detailed spatial pattern
- Eligible indicators - which indicators, such as land cover types, can be affected by the action
- Schedule - the total amount of the action to occur within each simulation interval

Details on these components are provided below.

6.3.1 Action Type, Mode and Indicator

Action Type

There are two types of actions: standard and natural dynamics. Standard actions require the user to specify the rate of occurrence (6.3.6 Schedule), such as the area disturbed per year or decade. Filters (6.3.2 Thematic Filters), allocation methods (6.3.4 Allocations), and a list of eligible indicators (6.3.5 Eligible Indicators) are used to define how the scheduled area should be spatially allocated. Natural dynamics actions are triggered by a condition (e.g., reclamation of road when it is 20 years old) that is defined by a filter. A schedule, allocation method, and list of eligible indicators are not required for a natural dynamics action because the action's amount and location are an outcome of the filter.

Schedule Mode

The Add mode results in the scheduled indicator being added to the landscape (e.g., road development). The Subtract mode results in the scheduled indicator being removed from the landscape (e.g., road reclamation).

Schedule Indicator
The landscape indicator representing the action (e.g., a type of road).

Schedule Expr
The user has the option of entering an equation that will affect the action's schedule (see 6.3.6 Schedule for details).

Is yield
A yield action is identified by clicking the "Is yield" box. A yield action results in changes to landscape age and/or origin, but does not cause a change to composition. For example, fire could modify forest age and origin but not forest type. If the Is yield box is checked, a non-unity indicator should be selected as the schedule indicator (e.g., Harvest area).

Yield type
If the Is yield box is checked, the user defines the yield type as Recurring or Cumulative. Recurring means that the schedule indicator is recalculated each simulation interval (e.g., Harvest area within a simulation interval). Cumulative means that the schedule indicator accumulates across simulation intervals (e.g., cumulative harvest area).

6.3.2 Thematic Filters

Filters define what cells are eligible or ineligible for use in the action. In essence, filters can be used to identify cells that are not available for the action. To create a filter, click

. A dialogue box that appears is used to enter the Title, Description (optional), Data Type, and the equation. The equation can contain variables, coefficients, operators, functions, and saved simulations. Cells for which the equation returns a non-zero value are eligible for the action, and cells with a zero value are ineligible. Selecting the Static data type means that the equation is only calculated at the start of the simulation. Selecting the Dynamic data type means that the equation is recalculated each simulation interval such that the filter responds to simulated landscape dynamics (e.g., changes in landscape composition, age, and status).
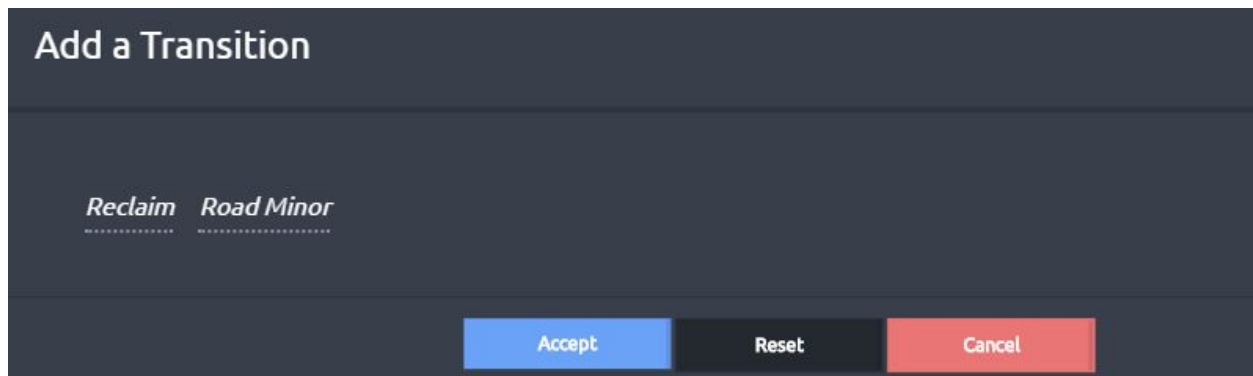
Filters are not required. If no filter is set, all cells are available for analysis and potential allocation.

Multiple filters are allowed. If multiple filters are defined, the results are **multiplied** together as 1's and 0's. Eligible cells are 1's and ineligible cells are 0's. A cell that is flagged ineligible by one filter can not be reversed by another filter (two falses will not make a positive).

6.3.3 Transitions
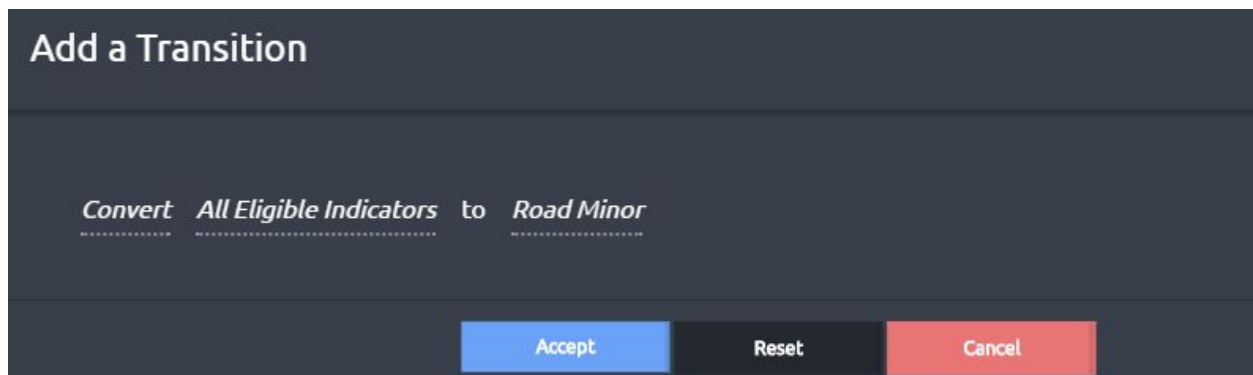
Transitions are instructions identifying the effect of the action in terms of changes to landscape composition, age, and status. Available transitions are described below.

Reclaim removes the schedule indicator and replaces with natural land cover based on the predisturbance composition (as defined for the project - 6.1 Creating a Project). The syntax is demonstrated in the example transition below, which is set to reclaim the Road Minor footprint type. The action's schedule mode must be set to subtract (6.3.1 Action Type, Mode and Indicator) if the reclaim transition is used.
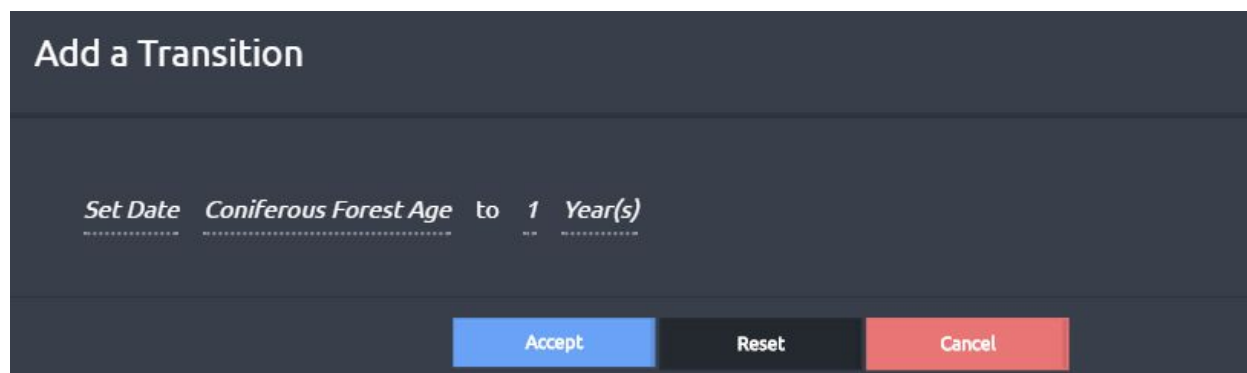
Convert replaces eligible indicators (6.3.5 Eligible Indicators) with the scheduled indicator. The syntax is demonstrated in the example transition below, which is set to convert all eligible indicators to the Road Minor footprint type.

Set Date changes the age of an age indicator. The syntax is demonstrated in the example transition below, which is set to change Coniferous Forest Age to 1 year. Years, months, or days can be used as the unit of time. Years should be used if your simulation uses yearly or decadal time steps.

Update changes a status indicator (e.g., forest origin). The syntax is demonstrated in the example transition below, which is set to update the status indicator "Forest Origin Status" to Cut. In addition to Cut, other types of status are Fire and Pest.

6.3.4 Allocations

There are six types of allocation methods, each of which represents a different type of spatial pattern. **Pre-schedule** is a deterministic allocation whereby the action is applied to regions identified by the user. Pre-schedule is useful when the future spatial pattern of an action is known (e.g., cutblock layout). **Raster mask** is a deterministic allocation whereby the action is distributed across cells based on the relative value of an expression. **Random** is a stochastic allocation whereby the relative likelihood of each cell receiving the action is dictated by a region layer or expression. Random is useful for processes that are dispersed with small individual events (e.g., well sites or acreages). **Clustered** is the same as Random except that cells are selected in clusters. Clustered is useful for processes that are dispersed with large individual events (e.g., cutblocks or fires). **Radial** also has a stochastic component, but allocates outwards from one or more points. Radial is useful for processes that are aggregated (e.g., urban expansion). **Linear** has a stochastic component, but allocates so as to link user-defined source and target cells. Linear is useful when simulating the expansion of networks such as roads, pipelines, and transmission lines.

The inputs that are required for each type of allocation are now described.

6.3.4.1 Pre-Schedule

Pre-schedule is a deterministic allocation whereby the action is applied to regions identified by the user. Pre-schedule is useful when the future spatial pattern of an action is known (e.g., cutblock layout).

Max per pixel
The maximum amount in the base unit of the schedule indicator that can be allocated in a given cell. This is typically in m for any area based indicator.

Preschedule Regions
Polygons with dates defining where, when and how much allocation will occur. Preschedule actions happen independently of schedules, but they do count towards the specified schedule. Even if a schedule is 0, the preschedule polygons will be filled as specified. During allocation, preschedule allocation amounts will reduce the overall schedule amount. If there is remaining schedule amount left over after pre-schedule, then other allocation methods must be specified and will be used to allocate the rest of the schedule.

6.3.4.2 Raster Mask

Raster mask is a deterministic allocation whereby the action is distributed across cells based on the relative value of an expression.

Max per pixel
The maximum amount in the base unit of the schedule indicator that can be allocated in a given cell. This is typically in m for any area based indicator.

Raster Mask
The user must enter an equation that defines how the schedule amount should be distributed across cells allowed by the thematic filter. The schedule amount is distributed in proportion to the relative value of the equation across cells. The equation can contain variables, coefficients, operators, functions, and saved simulations. If the raster mask type is Static, the raster mask is calculated once at the start of the simulation. If the raster mask is Dynamic, the raster mask is calculated each simulation interval such that it can respond to simulated changes in indicator values (e.g., landscape composition/age/status, climate).

6.3.4.3 Random Allocation

Random is a stochastic allocation whereby the relative likelihood of each cell receiving the action is dictated by a region layer or expression. Random is useful for processes that are dispersed with small individual events (e.g., well sites or acreages). Random allocations can be in size classes less than or equal to the max amount for a single cell. In other words, random allocation should be used to allocate features that are smaller than a single cell.

Proportion

The amount of the schedule that should be applied to this allocation method. Proportions are calculated relative to each other. Numbers can be anything non-negative. For example, proportions could make a 3:1 ratio between two allocation methods by entering a 3 for the first method, and a 1 for the second. The same effect could also be achieved by entering a 75 and a 25, or by entering a 0.75 and a 0.25.

Max per pixel
The maximum amount in the base unit of the schedule indicator that can be allocated in a given cell. This is typically in m for any area based indicator.

Size Classes *(At least 1 Size Class is Required)*
A variety of size classes are allowed for allocation. All sizes should be <= to the max per pixel value (i.e., for an area based indicator in m, a 100m resolution cell should not have size classes greater than 10,000).
- **Size**
  The size of the size class in the base unit of the schedule indicator (usually m)
- **Proportion**
  The relative proportion to allocate to this size class compared to other size classes. Proportions are calculated relative to each other. Numbers can be anything non-negative. For example, proportions could make a 3:1 ratio between two size classes by entering a 3 for the first size, and a 1 for the second. The same effect could also be achieved by entering a 75 and a 25, or by entering a 0.75 and a 0.25.

Vector Masks
A vector mask is a region layer that describes the relative likelihood of cells receiving the action. To add a vector mask, click "Add a Region Scheme" and type the name of the region layer in the "Region Scheme" box. A map and tabular representation of the region layer will appear. To define the relative likelihood of the action occurring in cells belonging to each region, click the Add a value column tab at the top of the region table. If the relative likelihood is represented by a column in the table, select the column from the "from column" dropdown box and click Accept. Alternatively, to enter the relative likelihood of each region, type the default value (typically 0) in the "or initial value" box and click Accept. A column with the default value is then added to the table; the relative likelihood of each region can be modified by changing the appropriate row in the column. Values are relative and can be anything 0 or greater. Values of 0 mean probability is 0 (i.e., allocation is not allowed in those cells). Masks can have multiple values for different time periods. This is achieved by adding multiple value columns, and entering dates for each column in the "date time" box. The system looks for the closest mask in time either current or previous.

Raster Masks
A raster mask is an equation that describes the relative likelihood of cells receiving the action. The equation can contain variables, coefficients, operators, functions, and saved simulations. If the raster mask type is Static, the raster mask is calculated once at the start of the simulation. If the raster mask is Dynamic, the raster mask is calculated each simulation interval such that it

can respond to simulated changes in indicator values (e.g., landscape composition/age/status, climate).

Masks are optional. If no mask, all cells are treated as equal probability. If multiple masks are defined, they are combined in an additive fashion (i.e., values are added together where cells have overlapping vector or raster mask values).

6.3.4.4 Clustered Allocation

Random is a stochastic allocation whereby the relative likelihood of each cell receiving the action is dictated by a region layer or expression, and cells are selected in clusters. Clustered is useful for processes that are dispersed with large individual events (e.g., cutblocks or fires). Allocations can be in size classes greater than or equal to the max amount for a single cell. In other words, clustered allocation should be used to allocate features that are greater than a single cell.

Proportion
The amount of the schedule that should be applied to this allocation method. Proportions are calculated relative to each other. Numbers can be anything non-negative. For example, proportions could make a 3:1 ratio between two allocation methods by entering a 3 for the first method, and a 1 for the second. The same effect could also be achieved by entering a 75 and a 25, or by entering a 0.75 and a 0.25.

Max per pixel
The maximum amount in the base unit of the schedule indicator that can be allocated in a given cell. This is typically in m for any area based indicator.

Size Classes *(At least 1 Size Class is Required)*
A variety of size classes are allowed for allocation. All sizes should be >= to the max allowed for a single cell.
- **Size**
  The size of the size class in the base unit of the schedule indicator (usually m)
- **Proportion**
  The relative proportion to allocate to this size class compared to other size classes. Proportions are calculated relative to each other. Numbers can be anything non-negative. For example, proportions could make a 3:1 ratio between two size classes by entering a 3 for the first size, and a 1 for the second. The same effect could also be achieved by entering a 75 and a 25, or by entering a 0.75 and a 0.25.

Vector Masks
A vector mask is a region layer that describes the relative likelihood of cells receiving the action. To add a vector mask, click "Add a Region Scheme" and type the name of the region layer in the "Region Scheme" box. A map and tabular representation of the region layer will appear. To define the relative likelihood of the action occurring in cells belonging to each region, click the Add a value column tab at the top of the region table. If the relative likelihood is represented by a column in the table, select the column from the "from column" dropdown box and click

Accept. Alternatively, to enter the relative likelihood of each region, type the default value (typically 0) in the "or initial value" box and click Accept. A column with the default value is then added to the table; the relative likelihood of each region can be modified by changing the appropriate row in the column. Values are relative and can be anything 0 or greater. Values of 0 mean probability is 0 (i.e., allocation is not allowed in those cells). Masks can have multiple values for different time periods. This is achieved by adding multiple value columns, and entering dates for each column in the "date time" box. The system looks for the closest mask in time either current or previous.

Raster Masks
A raster mask is an equation that describes the relative likelihood of cells receiving the action. The equation can contain variables, coefficients, operators, functions, and saved simulations. If the raster mask type is Static, the raster mask is calculated once at the start of the simulation. If the raster mask is Dynamic, the raster mask is calculated each simulation interval such that it can respond to simulated changes in indicator values (e.g., landscape composition/age/status, climate).

Masks are optional. If no mask, all cells are treated as equal probability. If multiple masks are defined, they are combined in an additive fashion (i.e., values are added together where cells have overlapping vector or raster mask values).

6.3.4.5 Radial Allocation

Radial allocates outwards from one or more points. Radial is useful for processes that are aggregated (e.g., urban expansion).

Proportion
The amount of the schedule that should be applied to this allocation method. Proportions are calculated relative to each other. Numbers can be anything non-negative. For example, proportions could make a 3:1 ratio between two allocation methods by entering a 3 for the first method, and a 1 for the second. The same effect could also be achieved by entering a 75 and a 25, or by entering a 0.75 and a 0.25.

Max per pixel
The maximum amount in the base unit of the schedule indicator that can be allocated in a given cell. This is typically in m for any area based indicator.

Growth Centroids
Collection of centroids from which growth should occur. Growth centroids can be defined by creating a Places folder in the maps page (3.1.4 Places). Pay careful attention to make sure any places you create are actually within the region that is available to be used in the allocation method.

Centroid Distance Coefficient

Controls whether growth occurs preferentially as a result of the *vector or raster mask*, or the *max distance* from centroids. Higher number means the algorithm grows to the max distance and ignores the probability mask. Lower number means the algorithm grows to the probability mask and ignores the max distance. A higher number typically results in more uniform outward growth.

Max Distance
The maximum distance in m that the algorithm is allowed to grow.

Vector Masks
A vector mask is a region layer that describes the relative likelihood of cells receiving the action. To add a vector mask, click "Add a Region Scheme" and type the name of the region layer in the "Region Scheme" box. A map and tabular representation of the region layer will appear. To define the relative likelihood of the action occurring in cells belonging to each region, click the Add a value column tab at the top of the region table. If the relative likelihood is represented by a column in the table, select the column from the "from column" dropdown box and click Accept. Alternatively, to enter the relative likelihood of each region, type the default value (typically 0) in the "or initial value" box and click Accept. A column with the default value is then added to the table; the relative likelihood of each region can be modified by changing the appropriate row in the column. Values are relative and can be anything 0 or greater. Values of 0 mean probability is 0 (i.e., allocation is not allowed in those cells). Masks can have multiple values for different time periods. This is achieved by adding multiple value columns, and entering dates for each column in the "date time" box. The system looks for the closest mask in time either current or previous.

Raster Masks
A raster mask is an equation that describes the relative likelihood of cells receiving the action. The equation can contain variables, coefficients, operators, functions, and saved simulations. If the raster mask type is Static, the raster mask is calculated once at the start of the simulation. If the raster mask is Dynamic, the raster mask is calculated each simulation interval such that it can respond to simulated changes in indicator values (e.g., landscape composition/age/status, climate).

Masks are optional. If no mask, all cells are treated as equal probability. If multiple masks are defined, they are combined in an additive fashion (i.e., values are added together where cells have overlapping vector or raster mask values).

6.3.4.6 Linear Allocation

Linear allocates so as to link user-defined source and target cells. Linear is useful when simulating the expansion of networks such as roads, pipelines, and transmission lines.

Proportion
The amount of the schedule that should be applied to this allocation method. Proportions are calculated relative to each other. Numbers can be anything non-negative. For example, proportions could make a 3:1 ratio between two allocation methods by entering a 3 for the first

method, and a 1 for the second. The same effect could also be achieved by entering a 75 and a 25, or by entering a 0.75 and a 0.25.

Source Equation

This equation defines the existing network of linear features that you want to grow from. For example, if growing new roads to newly formed cutblocks, the source equation would be the calculator equation that could identify cells that have existing roads. An example equation might simply be "Minor Roads".

Target Equation

This equation defines the existing network of linear feature end points that you want to grow to. For example, if growing new roads to newly formed cutblocks, the target equation would be the calculator equation that could identify cells that have new cutblocks that need roads. An example equation might be:

If: Cutblock Age == 1
Then: 1
Else: 0

Allocate To

- **Schedule**
  If schedule is selected, the algorithm will generate paths until it runs out of available schedule area. Area is calculated as length of all paths x specified width
- **Paths**
  If paths is selected, the algorithm will make sure there are paths generated to connect all points in the target equation to the linear network in the source equation. It will continue creating paths until all points are connected even if it has surpassed the specified schedule. Area is calculated as length of all paths x specified width

Independent Routes

The default (No) should be used if a network is being simulated (e.g., road, pipeline, etc.). Yes should be selected if using the linear allocation method to simulate travel routes from a source point (e.g., a city) to multiple targets (e.g., parks), and it is necessary for each target to be connected with the source by an independent route.

Width

The width in metres of the new feature being created.

Distance Coefficient

Controls algorithm preference for growth at a minimum distance. If a short path is preferred, a high coefficient should be used (the max is 1). A high coefficient value can result in bridging low or 0 weight values in the combined thematic filter and vector or raster masks.

Aspect Coefficient

Controls algorithm preference for growth at a direct path. If a direct path is preferred, a high coefficient should be used (the max is 1). A high coefficient value can result in bridging low or 0 weight values in the combined thematic filter and vector probability masks.

Vector Masks

A vector mask is a region layer that describes the relative likelihood of cells receiving the action. To add a vector mask, click "Add a Region Scheme" and type the name of the region layer in the "Region Scheme" box. A map and tabular representation of the region layer will appear. To define the relative likelihood of the action occurring in cells belonging to each region, click the Add a value column tab at the top of the region table. If the relative likelihood is represented by a column in the table, select the column from the "from column" dropdown box and click Accept. Alternatively, to enter the relative likelihood of each region, type the default value (typically 0) in the "or initial value" box and click Accept. A column with the default value is then added to the table; the relative likelihood of each region can be modified by changing the appropriate row in the column. Values are relative and can be anything 0 or greater. Values of 0 mean probability is 0 (i.e., allocation is not allowed in those cells). Masks can have multiple values for different time periods. This is achieved by adding multiple value columns, and entering dates for each column in the "date time" box. The system looks for the closest mask in time either current or previous.

Raster Masks

A raster mask is an equation that describes the relative likelihood of cells receiving the action. The equation can contain variables, coefficients, operators, functions, and saved simulations. If the raster mask type is Static, the raster mask is calculated once at the start of the simulation. If the raster mask is Dynamic, the raster mask is calculated each simulation interval such that it can respond to simulated changes in indicator values (e.g., landscape composition/age/status, climate).

Masks are optional. If no mask, all cells are treated as equal probability. If multiple masks are defined, they are combined in an additive fashion (i.e., values are added together where cells have overlapping vector or raster mask values).

6.3.5 Eligible Indicators

Eligible indicators are indicators that can be affected by the action. Examples:
- Set of forest types that are eligible for forest harvest
- Set of landscape and footprint types that are eligible to be converted into road

6.3.6 Schedule

The schedule defines the amount to allocate in a given time period to the scheduled indicator identified in the action. The units are m2. If a yearly simulation increment is used for the scenario, the schedule is per year. If a decadal simulation increment is used, the schedule is per decade.

A dynamic schedule can be prepared by defining a Schedule expr (located near the top of the action page beneath the Schedule indicator. A schedule expr is an equation that is calculated each simulation interval and multiplied against the schedule to define the amount to allocate that time period. The average value of the equation across all cells is used when multiplying against the schedule. The equation can include variables, coefficients, operators, functions, and saved simulations. Because an equation can respond to simulated changes in variables such as landscape composition and climate, the schedule expr provides a way to incorporate feedback loops in an action's schedule. As an example, a schedule expr could be used to adjust the area of forest fires during a simulation in response to changes in forest area.

6.4 Applying Derived Indicators

To assess how indicators (e.g., wildlife habitat, ecosystem services, etc.) respond to a Mapper scenario, indicators can be added as Derived Indicators to a Mapper project and then applied to scenarios within that project. To be added as a Derived Indicator, an indicator must first be created using Advanced Calculator in the Maps tool (section 3.1.2.1.3 Create Advanced) and converted to an indicator equation (section 3.1.2.3.4 Creating an Indicator Equation from a Saved Simulation). Then, once viewing the Project of interest in the Mapper module, the indicator can be added by clicking the Add Derived Indicator button located towards the bottom of the page. Clicking the Add Derived Indicator button will open a dialogue box that allows the user to select the indicator. The name of the indicator can either be typed in or selected by clicking the View List icon ( ). Only indicators that have been converted to an indicator equation will be available from list. Once a derived indicator has been added to a project, it can be applied to any scenario within the project. To run the Mapper scenario and all derived indicators, click the Run Scenario and Derived Indicators button at the top of a Scenario's page. To apply one or more Derived Indicators to a Scenario that has already been run, scroll to the bottom of the Scenario page, check off the derived indicators that are to be run, and click the Run Selected Derived Indicators button. Once a Derived Indicator has been run against a scenario, output can be viewed in the Maps module by selecting the indicator from Choose Existing and selecting the scenario by clicking the wrench symbol located under the Choose Existing box.

7 Advanced Functions

Equations are frequently used when creating customized indicators in the Maps tool (i.e., with advanced calculator) and scenarios in the Mapper tool (i.e., for filters and raster masks). This section describes some of the more commonly used functions that can be applied to build simple to complex equations.

The following information is presented for each type of function: summary; syntax; units; and example.

7.1 IF

An IF statement is a logical statement of the form: If … then… else. Comparisons (<, >, >=, <=, !=, ==) and adjoining functions (and, or) are used to define the condition to be assessed by the If statement.

Selecting the If function will bring up a dialogue box in the equation box that provides boxes to enter the TEST, and what value to return if the test is true (IF TRUE) or false (IF FALSE). The TEST is a statement that uses comparisons (<, >, >=, <=, !=, ==) to define the condition to be assessed. Adjoining functions (and, or) can be used to include multiple conditions in the TEST. The TEST function can also contain variables, operators, coefficients, and functions. The IF TRUE and IF FALSE statements can contain variables, operators, coefficients, and functions. When preparing a TEST, IF TRUE, and IF FALSE statement, each component (i.e., variable, operator, coefficient, function, comparison) must be entered (i.e., by pressing return on your keyboard) individually.

When creating an indicator equation with the IF function, the type of equation units (see section 3.1.2.1.3 Create Advanced) should be determined by the variable that is returned by IF TRUE and/or IF FALSE (e.g., Density (%) for land cover or footprint variables).

In the example below, the TEST will identify cells for which the mean elevation is less than 250 m and the coverage of Total Footprint equals 0%. If a cell meets this condition, then the function will return the cell's coverage by Total Forest. If a cell does not meet the condition, the function will return a 0.
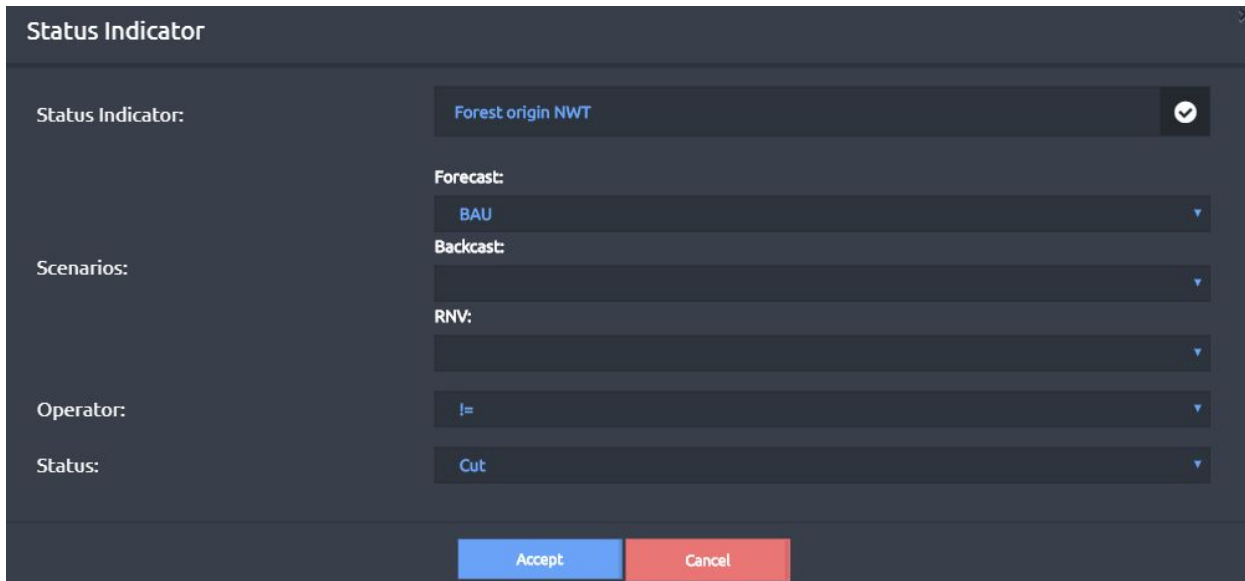
7.2 Status

The status function is used to return a status indicator that (typically) tracks whether a cell's most recent disturbance was fire, forestry, or pest.

When the Status function is selected, a dialogue box will appear that requests the user to enter the Status Indicator (e.g., Forest Origin), the Scenario, the Operator (!= or ==), and the Status (Fire vs Pest vs Cut). A 1 is returned if the condition is met by the origin indicator for the selected scenarios, 0 otherwise. The operator != means "does not equal" while the operator == mean "equals".

A Status function is typically multiplied by another variable in order to return the variable's value for cells that are (or are not) of a certain status type. In such cases, the type of equation units (see section 3.1.2.1.3 Create Advanced) should be determined by the variable that the status function is multiplied against (e.g., Density (%) for land cover or footprint variables).

In the example below, a 1 will be applied to cells for which the status indicator "Forest origin NWT" under the BAU forecast scenario does not equal Cut (i.e., harvest).

In the example below, the status function shown above is multiplied by Total Forest to return the coverage of a cell by Total Forest if a cell is not of Cut (i.e., timber harvest) origin.
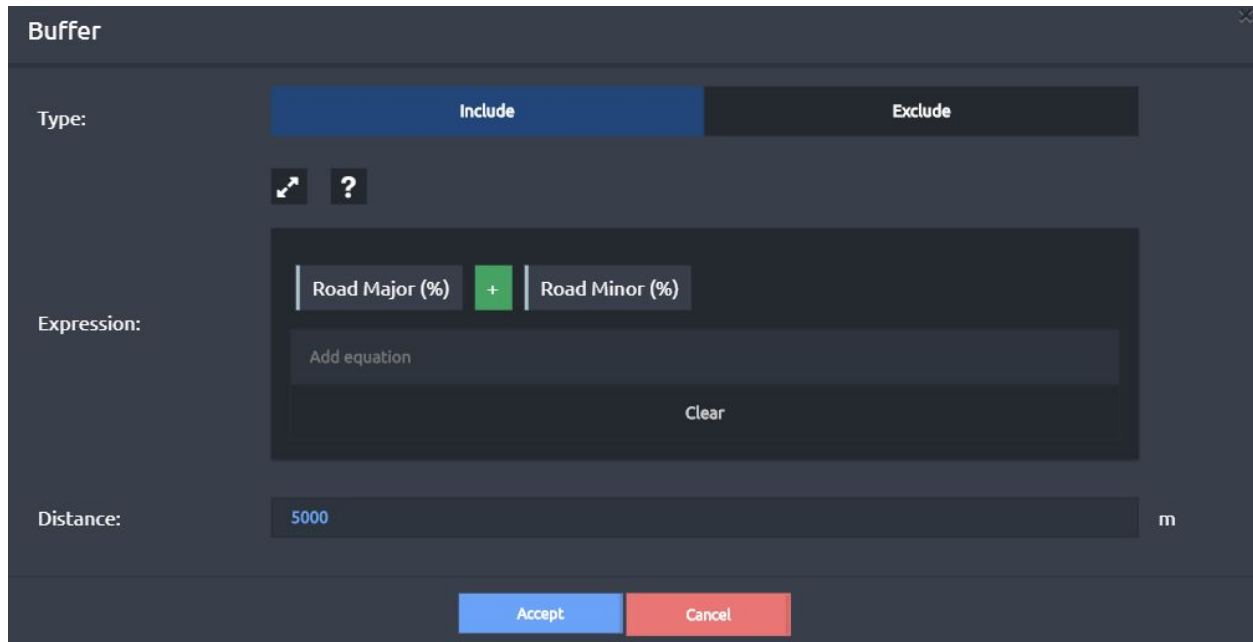

7.3 Buffer

The buffer function is used to place an inclusionary or exclusionary buffer around cells that have a non-zero value for a user-defined expression.

A dialogue box appears when the Buffer function is selected that requests the user to enter an expression and a Distance. The expression can contain variables, coefficients, operators, and functions. If the Include type is selected, the buffer function returns a 1 if a cell is within the buffer distance of cells with a non-zero result for the expression, and 0 otherwise. If the Exclude type is selected, the buffer function returns a 0 if a cell is within the buffer distance of cells with a non-zero result for the expression, and 1 otherwise.

A Buffer function is typically multiplied by another variable in order to return the variable's value for cells that are within (inclusionary) or outside (exclusionary) the buffer. In such cases, the type of equation units (see section 3.1.2.1.3 Create Advanced) should be determined by the variable that the buffer function is multiplied against (e.g., Density (%) for land cover or footprint variables).

In the example below, a value of 1 will be applied to all cells within 5000 m of cells for which the sum of the coverage by Road Major and Road Minor footprint types is greater than 0.
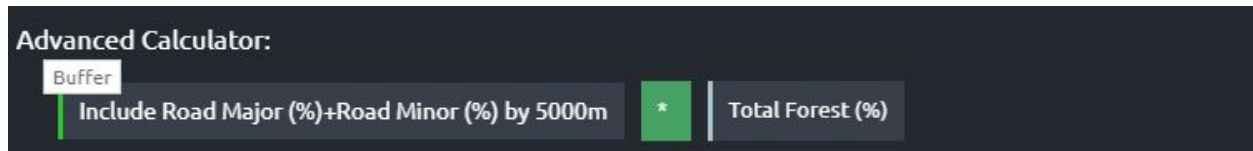
In the example below, the buffer function shown above is multiplied by Total Forest to return the coverage of a cell by Total Forest if the cell is within 5000 m of cells with major or minor road.
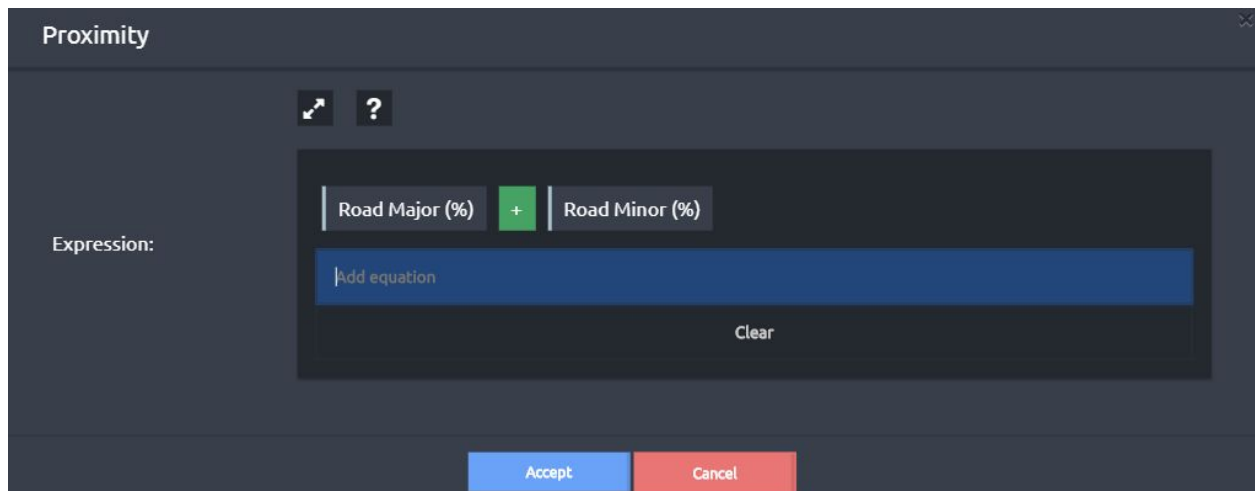

7.4 Proximity

The proximity function is used to calculate each cell's minimum distance to a cell that has a non-zero value for a user-defined expression.

A dialogue box appears when the Proximity function is selected that requests the user to enter an expression. The function returns the distance from the centre point of each cell to the centre point of the nearest cell with a non-zero value for the expression. The expression can contain variables, coefficients, operators, and functions.

When creating an indicator equation with the Proximity function, the type of equation units (see section 3.1.2.1.3 Create Advanced) should typically be set as Absolute because distance is an absolute value as opposed to a density.

In the example below, the value returned to a cell will be the minimum distance (in metres) from the cell to the closest example of a cell with non-zero coverage by the Road Major and Road Minor footprint types.
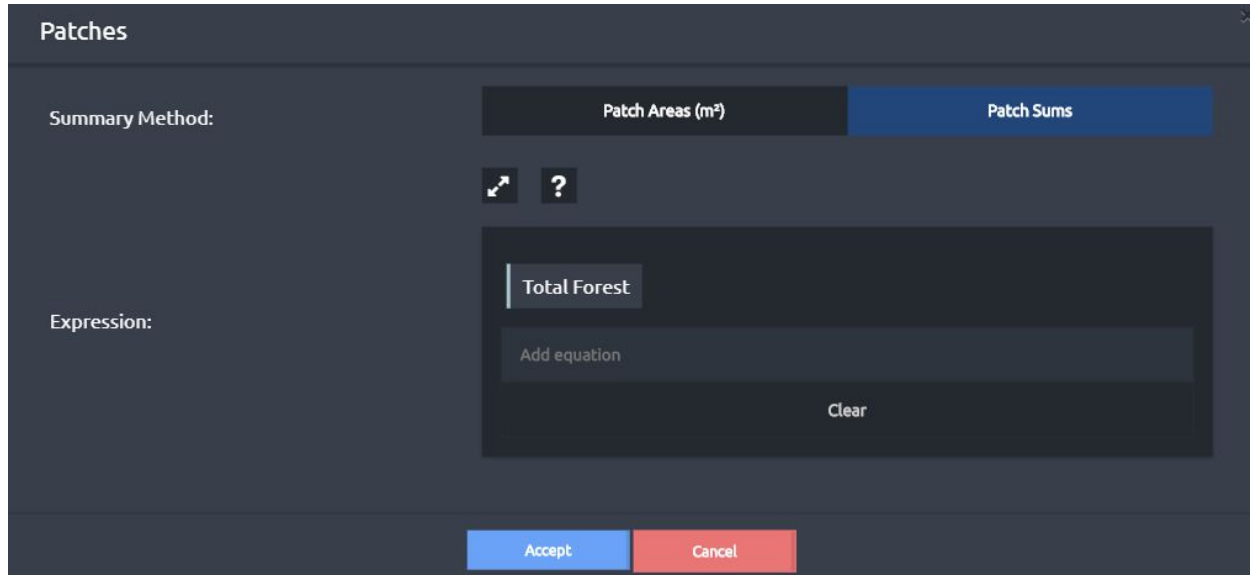
7.5 Patches

The patches function is used to calculate the size of patches of adjacent cells that have a non-zero value for a user-defined expression.

A dialogue box appears when the Patches function is selected that requests the user to enter the summary method and an expression. The function identifies patches of contiguous cells with a non-zero result for the expression, and returns the patch area (Patch Areas (m2)) or the sum of the expression's value across cells within a patch (Patch Sums). The expression can contain variables, coefficients, operators, and functions.

When creating an indicator equation with the Patches function, the equation units (section 3.1.2.1.3 Create Advanced) should typically be set as Non Summable because the function returns the patch size to each cell within the patch (i.e., the function is already summing across cells).

In the example below, the value returned to a cell will be sum of Total Forest across a contiguous patch of cells (to which the cell belongs) having a Total Forest value greater than 0. For example, if a cell has a Total Forest value of 0, the function will return 0; if a cell has a Total Forest value greater than 0 but is not adjacent to other cells with a Total Forest value greater than 0, the function will return the cell's Total Forest value; if a cell has a Total Forest value greater than 0 and the cell is adjacent to one or more cells with a Total Forest value greater than 0, the function will return the sum of Total Forest across cells within the contiguous patch.
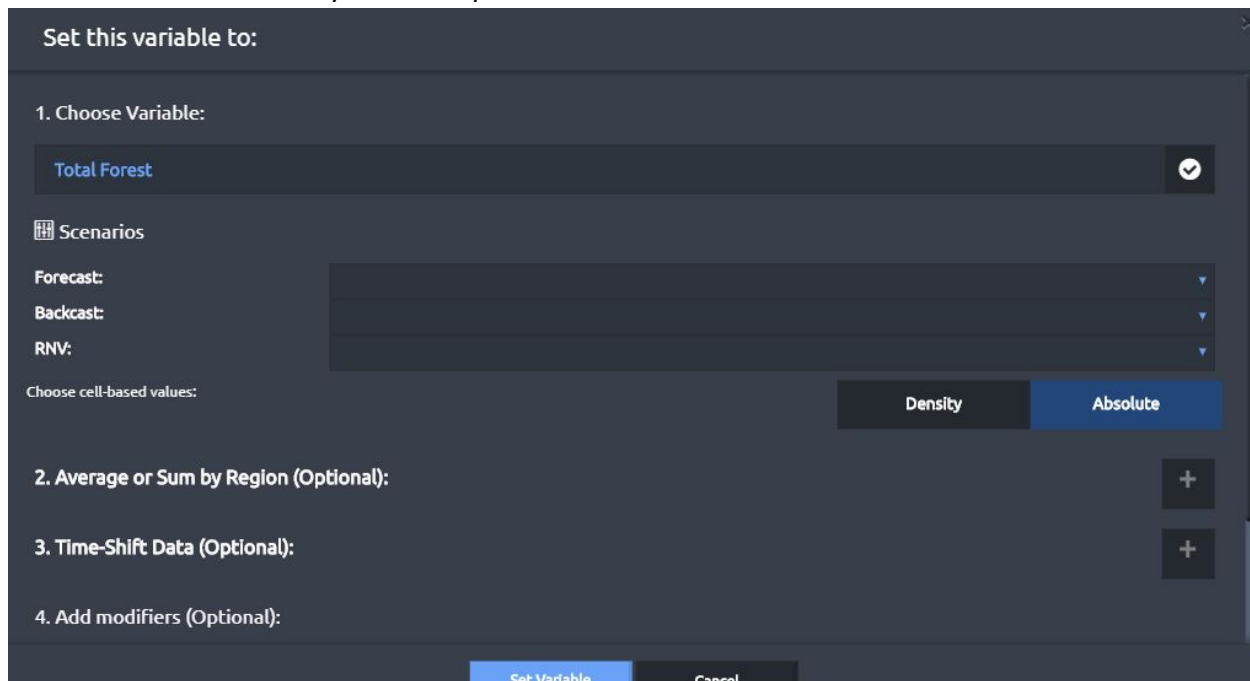
If, as in the example, you are using Patches to calculate the sum of a variable within a patch (e.g., area, length, abundance, etc.), it is important to set the variable's cell-based value to Absolute. This is done by right-clicking the variable (e.g., Total Forest) and clicking Absolute (instead of Density) as the cell-based value in the dialogue box that appears (see 2nd screen capture below). Because the Absolute value for land cover types (e.g., Total Forest) is km2, the value returned to a cell by the example is in km2.
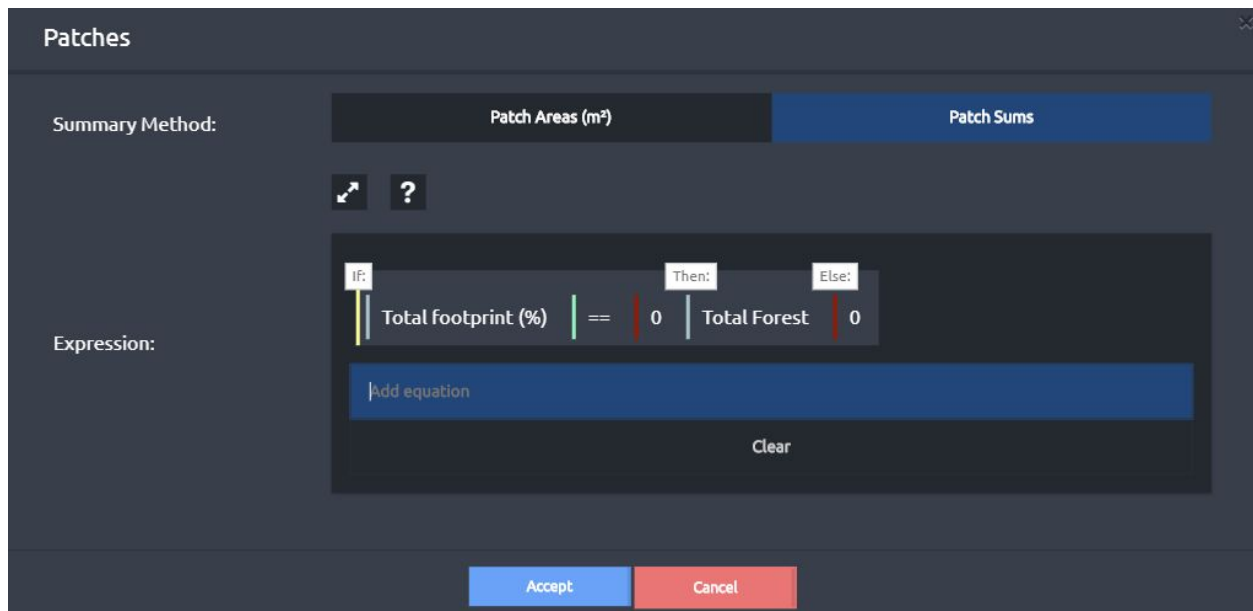
A slightly more complicated example is to use the patches function to calculate the area of Total Forest in patches of cells that do not have footprint. This is done by incorporating and If statement in the expression (see below).
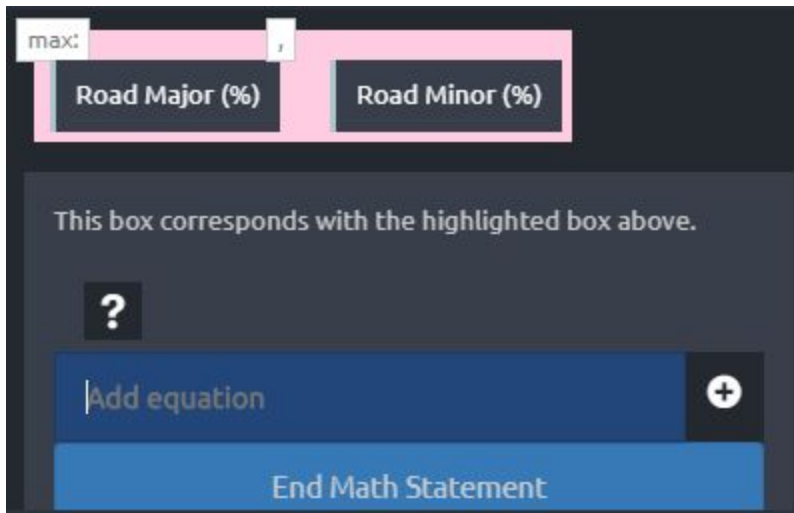
7.6 Max

The max function is used to return the maximum value for a series.

A dialogue box appears when the Max function is selected that is used to enter the series of expressions that should be compared. Each expression can contain variables, coefficients, operators, and functions. To identify the end of one expression and the start of the next, click the ⊕ symbol. Doing so will result in a comma appearing in the equation to separate the expressions. For a given cell, the function will calculate each expression and return the value for the expression with the largest value.

When creating an indicator equation with the MAX function, the type of equation units (see section 3.1.2.1.3 Create Advanced) should be determined by the expressions (e.g., Density (%) for land cover or footprint variables).

In the example below, the value returned to a cell will be the larger of coverage by Road Major or Road Minor footprint types.

7.7 Min

The max function is used to return the minimum value for a series.

A dialogue box appears when the Min function is selected that is used to enter the series of expressions that should be compared. Each expression can contain variables, coefficients, operators, and functions. To identify the end of one expression and the start of the next, click

the symbol. Doing so will result in a comma appearing in the equation to separate the expressions. For a given cell, the function will calculate each expression and return the value for the expression with the smallest value.

When creating an indicator equation with the MIN function, the type of equation units (see section 3.1.2.1.3 Create Advanced) should be determined by the expressions (e.g., Density (%) for land cover or footprint variables).

In the example below, the value returned to a cell will be the smaller of coverage by Road Major or Road Minor footprint types.

7.8 Pow (Power)

The pow function is used to apply an exponent to an expression.

A dialogue box appears when the Pow function is selected that is used to enter expressions for the base and the exponent. The base and the exponent expressions can contain variables, coefficients, operators, and functions. To identify the end of the base expression and the start

of the exponent expression, click the symbol. Doing so will result in a comma appearing in the equation to separate the base and exponent expressions.

When creating an indicator equation with the MIN function, the type of equation units (see section 3.1.2.1.3 Create Advanced) will typically be Non Summable because the sum across cells of the exponent of a variable is often not meaningful.

In the example below, the value returned to a cell will be the square of Mean Elevation.
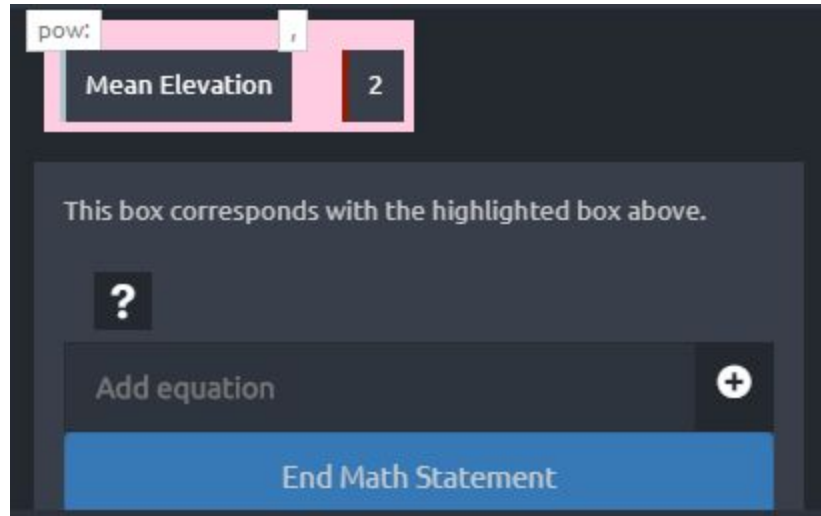
7.9 Math Functions

A number of math operations are available that return the value of the function applied to a user-defined expression. Math functions that are available are: exp (exponential); abs (absolute value), ceil (the smallest integer value that is greater than or equal to the expression); floor (the largest integer value that is less than or equal to the expression); round (the expression rounded to an integer value); sqrt (square root); log (natural logarithm); log10 (logarithm to the base 10); cos (cosine); acos (inverse cosine); sin (sine); asin (inverse sine); tan (tangent); and atan (inverse tangent); A dialogue box appears when the one of these functions is selected that is used to enter expression, which can contain variables, coefficients, operators, and functions.

In the example below, the value returned to a cell will the exponential of Mean Elevation.