Mammoth Game

Abstract

Mammoth Game is an introductory experience designed to teach the basics of dynamic systems modeling and simulation through a prehistoric narrative. This simple model captures the population dynamics of a mammoth herd using two core flows: births and deaths. By visualizing these flows, learners can understand how rates influence the growth or extinction of a population over time. This article offers a step-by-step guide to building the model, providing hands-on and visual learning through an online simulator. It's ideal for beginners exploring systems thinking and looking to engage with living, intuitive simulations.

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Keywords

population dynamics, births, deaths, mammoths, dynamic system, basic model, systems thinking, online simulation, active learning.

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Introduction

Can a story as old as the mammoths help us understand the behavior of living systems? In this introduction to online modeling and simulation, we use a simple yet powerful metaphor: a mammoth herd in a prehistoric ecosystem. Through the **Mammoth Game**, we invite students, professionals, and systems thinking enthusiasts to take their first steps into the world of dynamic modeling.

This basic model includes a single stock (the mammoth population) and two flows (births and deaths), each governed by a respective rate. Its simplicity is its strength: it allows learners to grasp the internal mechanics of systems without distractions. With each simulation, users not only observe changes but explore causes, interpret curves, and experiment with scenarios. This narrative and visual approach transforms learning into an active and meaningful experience.

MODEL REGISTRATION

This section captures the model's key metadata: title, short description, and tags. This information allows the model to be categorized, searched, and shared within the online simulator, supporting educational and collaborative use.

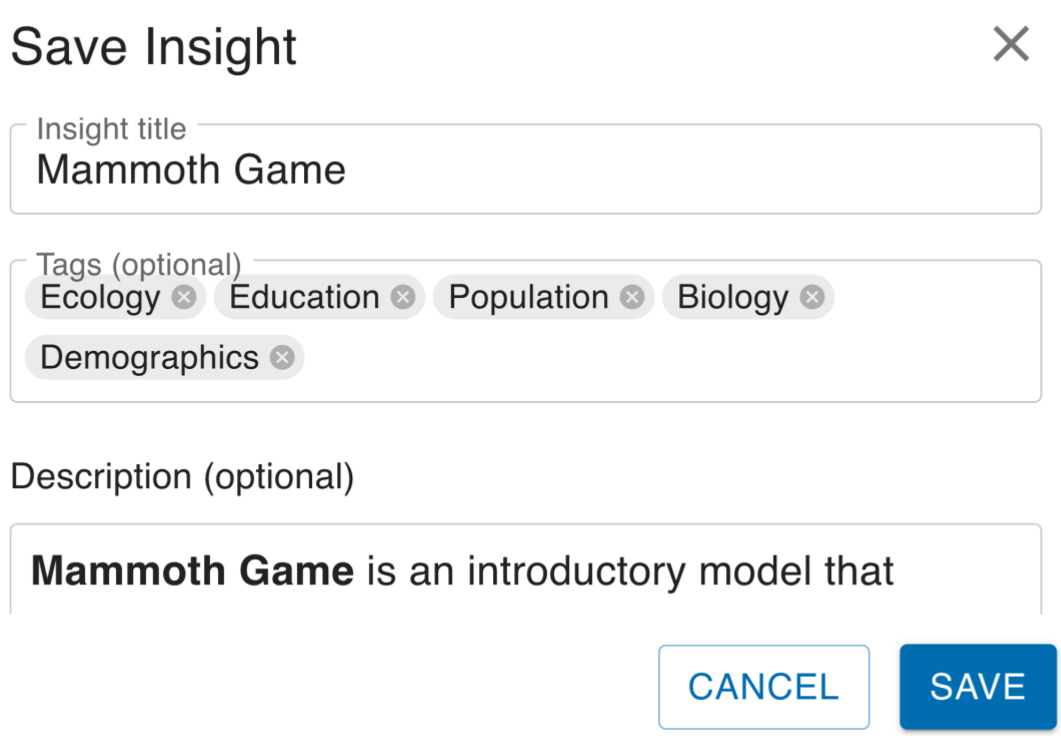


Figure 1: Model registration for "Mammoth Game".

✅ Title

Mamooth Game

✅ Tags sugeridos *(en ambos idiomas)*:

#población #mamuts #simulación #modeloBásico #sistemasDinámicos #nacimientos #muertes #educación #introductorio #modelado #pensamiento Sistémico #simulación Online	#population #mammoths #simulation #basicModel #dynamicSystems #births #deaths #education #introductory #modeling #systemsThinking #onlineSimulation

📝 Model short description

Mammoth Game is an introductory model that simulates the population dynamics of a mammoth herd. Using a simple yet powerful approach, it shows the effects of births and deaths on the total population. Perfect for beginners exploring systems thinking and dynamic modeling.

MODEL SETTINGS

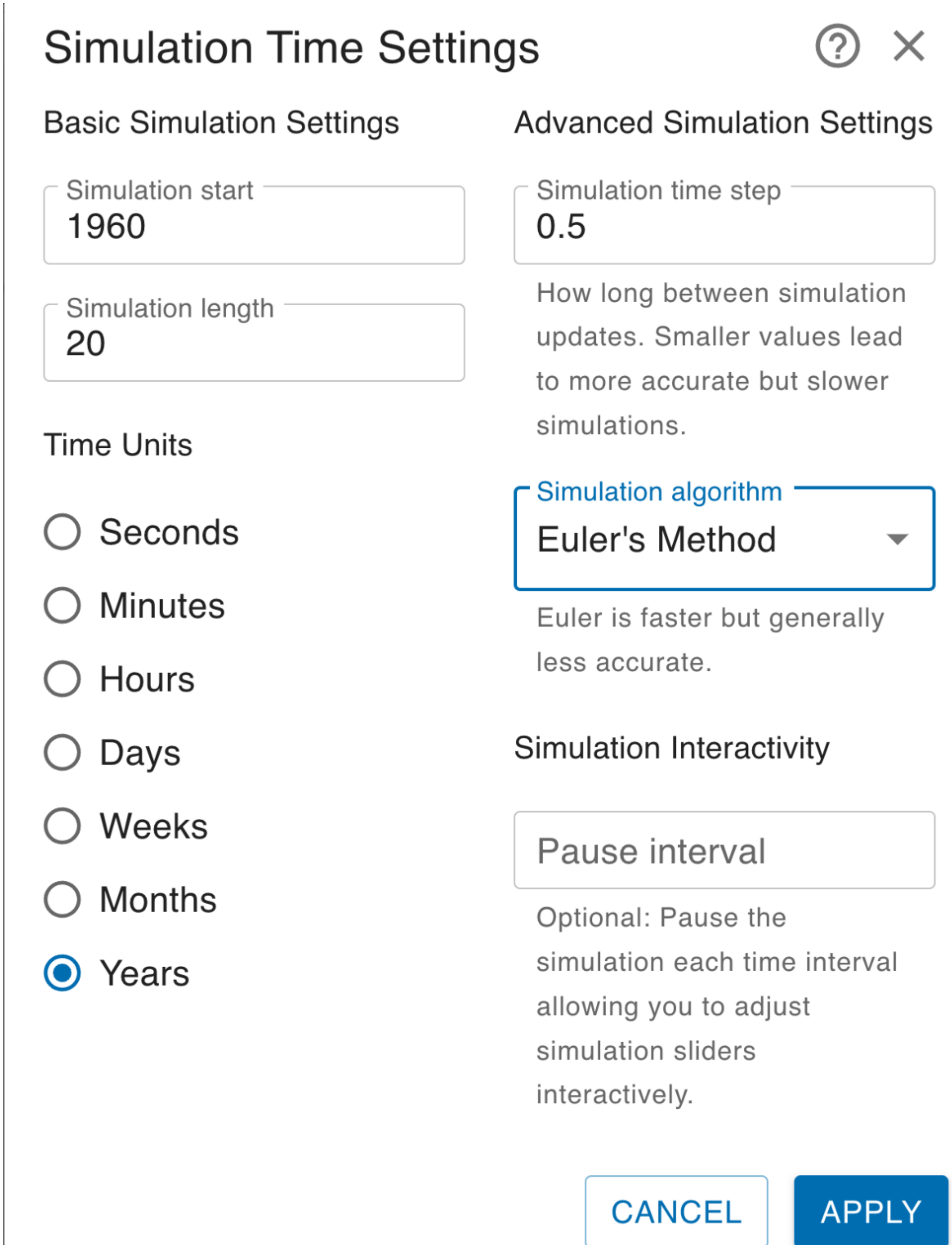


Figure 2: Simulation settings for the "Mammoth Game" model.

Simulation settings for the “Mammoth Game” model.
This section defines the temporal and computational parameters that govern the simulation behavior. It includes the simulation start (e.g., 1960), total length in time units (e.g., 20 years), time unit labels, time step, integration algorithm, and interactivity options. These settings control the model’s accuracy and execution dynamics.

1. Configuración básica de la simulación

Basic Simulation Settings

Simulation Start

Sets the initial time value when the simulation starts. Usually set to 0.

Sets the initial time value when the simulation starts. In this model, we recommend starting at the year **1960**, which serves as a symbolic or educational starting point for observing mammoth population dynamics.

Value: 1960

Simulation Length

Defines how many time units the simulation will run for.

Defines how many time units the simulation will run. For this introductory model, we suggest a duration of **20 years**, which provides enough time to observe trends clearly without making the simulation too long.

Value: 20 (simulating from 1960 to 1980)

Time Units

Describes the time unit used in the simulation (e.g., years, months, days). This is for labeling purposes only and does not affect calculations.

Value: Years

2. Advanced Simulation Settings

Simulation Time Step

Determines the interval between simulation updates. Smaller values (e.g., 0.25, 0.5) yield more accurate but slower simulations.

Value: 0.5

◈ Simulation Algorithm

Selects the numerical integration method. *Euler* is faster but less accurate; methods like *Runge-Kutta* are more accurate but slower.

Value: Euler

◈ Simulation Interactivity

Allows the simulation to pause automatically at defined intervals so that sliders can be adjusted interactively in real-time.

◈ *Pause Interval (opcional)*

Specifies how often (in simulation time units) the simulation pauses if interactivity is enabled.

Value: None

Nota:

Estas configuraciones no alteran la estructura lógica del modelo, pero son cruciales para su ejecución, precisión, y experiencia de aprendizaje.

Model Structure

The “Mammoth Game” model illustrates a simple population dynamic and serves as an introductory exercise in online modeling and simulation. It consists of a single stock (mammoths), two flows (births and deaths), and their corresponding rates. This minimal structure is sufficient to observe how a population changes over time and how rate adjustments influence its behavior. Below, we describe the components that make up the model.

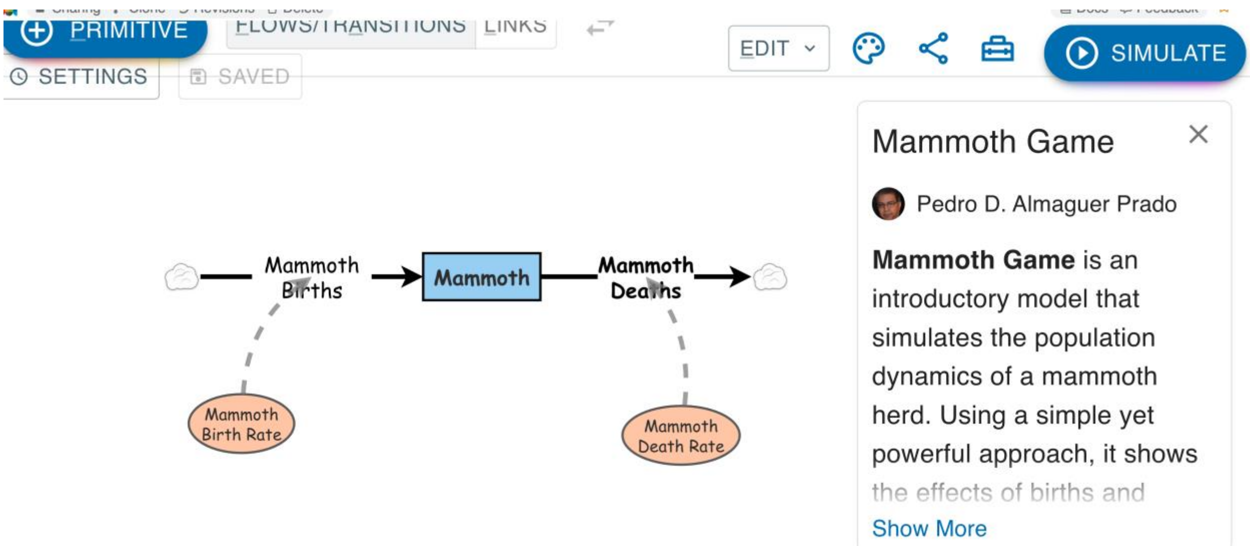


Figure 3: “Mammoth Game” model diagram and visual/data customization elements.

This figure displays the graphical structure of the model, including the mammoth stock, birth and death flows, and their corresponding rates. In addition to building the model logic, the simulation environment allows for full visual customization: changing icon and arrow colors, modifying label font sizes, adjusting line thickness, and choosing between solid or dotted lines to highlight causal relationships. Users can also define slider ranges for real-time data input, assign measurement units to each variable, and set initial values and equations that govern system behavior.

Inserting Primitives into the Model

To begin building the model, the user places the cursor in the center of the canvas (workspace) where the diagram will be displayed. Right-clicking opens a contextual menu that allows the selection and insertion of various **primitives**—the basic building blocks of simulation models. These include:

- **Stocks:** Accumulators representing quantities or populations, such as mammoths.

- **Auxiliary Variables:** Elements that compute intermediate values based on other variables (e.g., change rates).
- **Converters:** Components that transform or scale values (e.g., from percentage to absolute values).
- **States (Checkboxes):** Switches used to enable or disable conditions or policies during the simulation.
- **Text box:** Text containers used to annotate, title, or explain elements of the model directly on the canvas.
- **Picture:** Inserted images to enhance visual understanding, provide context, or decorate the model.
- **Interactive buttons:** Buttons that perform specific actions such as resetting or pausing the simulation.

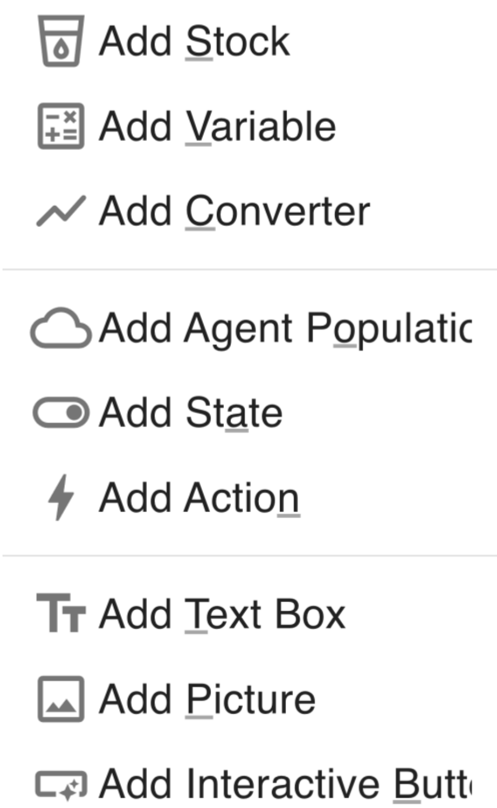


Figure 4: Contextual menu for inserting primitives into the canvas.

Right-clicking on the workspace displays a dialog box that allows the user to insert the model's fundamental elements, including stocks, flows, auxiliary variables, converters, interactive states (checkboxes), text boxes, images, and interactive buttons. This feature supports both the visual and functional construction of the model.

Primitive: Stock - Mammoth (in English)

- Stock name: **Mammoth**
- Unit of measure: **Mammoths**
- Initial value: **50**
- Value slider:

  - Show slider: ✅ Enabled
  - Minimum value: **0**
  - Maximum value: **100**
  - Adjustable during simulation: ✅ Yes

- Short description:

Represents the accumulated population of mammoths in the ecosystem. This value can be adjusted to explore different starting scenarios and analyze their impact on the system's dynamics.

Primitive: Variable – Mammoth Birth Rate

- **Variable name: Mammoth Birth Rate**
- **Unit of measure: 1/Year**
- **Value: 0.3**
- **Value slider:**
  - Show slider: ✅ Enabled
  - Minimum value: **0**
  - Maximum value: **1**
  - Adjustable during simulation: ✅ Yes
- **Short description:**

Defines the fraction of the mammoth population that is born each year. A value of 0.3 means that 30% of the current population is added annually. This rate allows us to observe population growth based on reproduction dynamics.

Primitive: Variable – Mammoth Death Rate

- **Variable name: Mammoth Death Rate**
- **Unit of measure: 1/Year**
- **Initial value: 0.3**
- **Value slider:**
  - Show slider: ✅ Enabled
  - Minimum value: **0**
  - Maximum value: **1**
  - Adjustable during simulation: ✅ Yes
- **Short description:**

Defines the fraction of the mammoth population that dies each year. A value of 0.3 means that 30% of the current population dies annually. This rate allows us to observe how the stock decreases due to natural or environmental causes.

Primitive: Flow – Mammoth Births

- **Flow name: Mammoth Births**
- **Type: Flow**
- **Formula: [Mammoth]*[Mammoth Birth Rate]**
- **Unit of measure: Mammoths/Year**
- **Short description:**

This flow represents the number of mammoths born each year, calculated as the product of the current mammoth population and the birth rate. It feeds directly into the *Mammoth* stock and models natural population growth.

Figure 5: Top canvas menu to activate flows, draw links, and change their direction.

How to add flows to the model (in English)

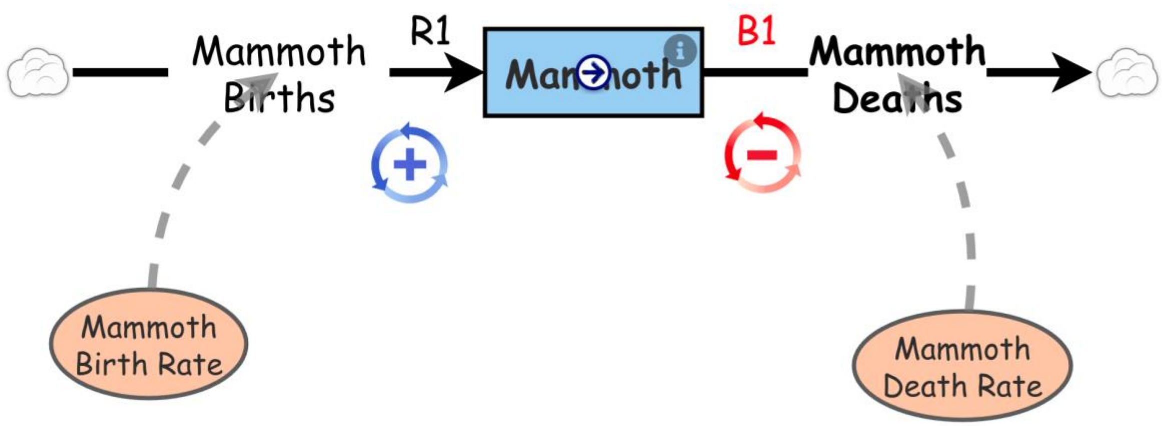


Figure 6: How to draw flows from a stock by enabling "Flows" mode and dragging from the stock's center circle.

It is important to note that **flows** are not an independent type of primitive like stocks, variables, or converters. Instead, flows are integrated directly into the diagram using tools from the menu.

To add a flow to the model:

1. Go to the top of the *canvas* and select the **Flows** option.
2. A small **white circle** will appear inside the rectangle representing a stock.
3. Place your cursor on that circle, **click and drag with the mouse** in any direction from the stock's border.
4. When you release the mouse, the flow will be added to the model.

To **change the direction** of the flow (e.g., inflow or outflow), select the **arrows icon** located on the right side of the top menu.

This process helps build clear population dynamics, such as mammoth births and deaths, which directly modify the population stock.

When and how to define a biflow?

Sometimes, a flow may represent both inflows and outflows depending on model conditions. These are called **bidirectional flows**.
To allow a flow to take negative values (i.e., to subtract from the stock), you must **uncheck** the **"Only positive rate"** option located on the right side of the canvas.
This enables the flow direction to change during the simulation, making the model better suited to represent reversible or compensatory processes.

Primitive: Flow – Mammoth Deaths

- **Flow name: Mammoth Deaths**

- **Type: Flow**

- **Formula: [Mammoth]*[Mammoth Death Rate]**

- **Unit of measure: Mammoths/Year**

- **Short description:**

This flow represents the number of mammoths dying each year. It is calculated by multiplying the current mammoth population by the death rate. It directly decreases the *Mammoth* stock, allowing the simulation of natural or environmental population loss.

How to create and edit links between primitives

To represent causal or functional relationships between model components, we use **links**. Here's how to create and customize them step-by-step:

Figure 7: Top canvas menu for creating links between model primitives. The arrow icons allow you to adjust the direction of links and flows.

➤ STEPS TO CREATE A LINK

1. **Select the Links tool**
   From the top of the canvas, click on the **“Links”** icon (an arrow). This activates link creation mode.
2. **Hover over the source primitive**
   Move your cursor over the primitive you want to start the link from (e.g., **Mammoth Birth Rate**). A **small circle with an arrow** will appear inside the box.
3. **Drag to the destination**
   Click on the circle and **drag** your mouse to the destination primitive (e.g., **Mammoth Births**). A link will appear automatically.
4. **Name the link (optional)**
   Double-click the link to give it a label, or leave it unnamed if preferred.

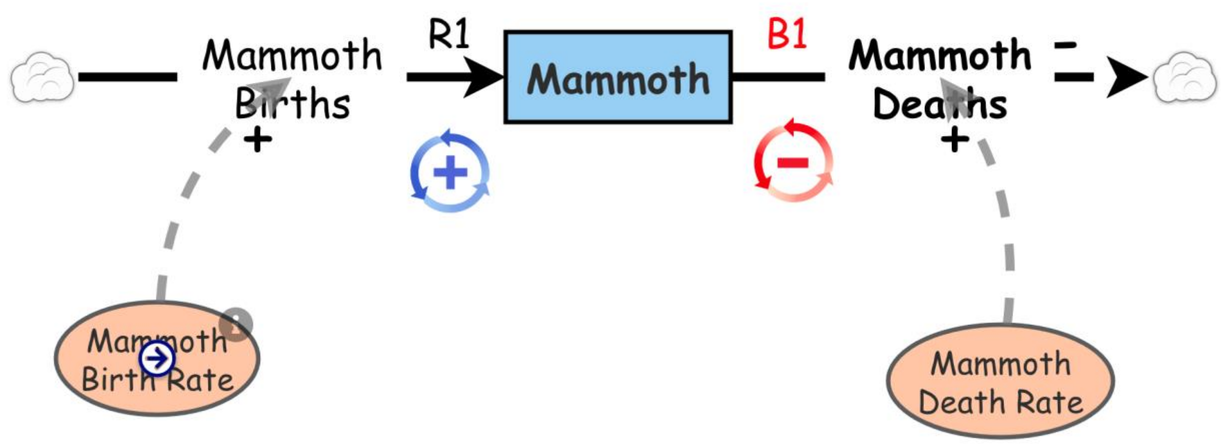


Figure 8: Creating a link from a variable to another model component. After selecting “Links” from the top menu, a small arrowed circle appears from which the link can be dragged to the target element.

➤ CUSTOMIZING THE LINK

- **Color and line style**: You can change the color, make it solid or dashed.
- **Line width**: Adjust to make it thinner or thicker.
- **Add a note**: Right-click the link and choose “Add Note” to explain its role.
- **Change the curvature**:
  - Hold down the **Shift** key.
  - Click on the link to add a **control point**.
  - Then **drag** that point to create a curve.

- You can add multiple points for complex curves or delete them by Shift + clicking on them.

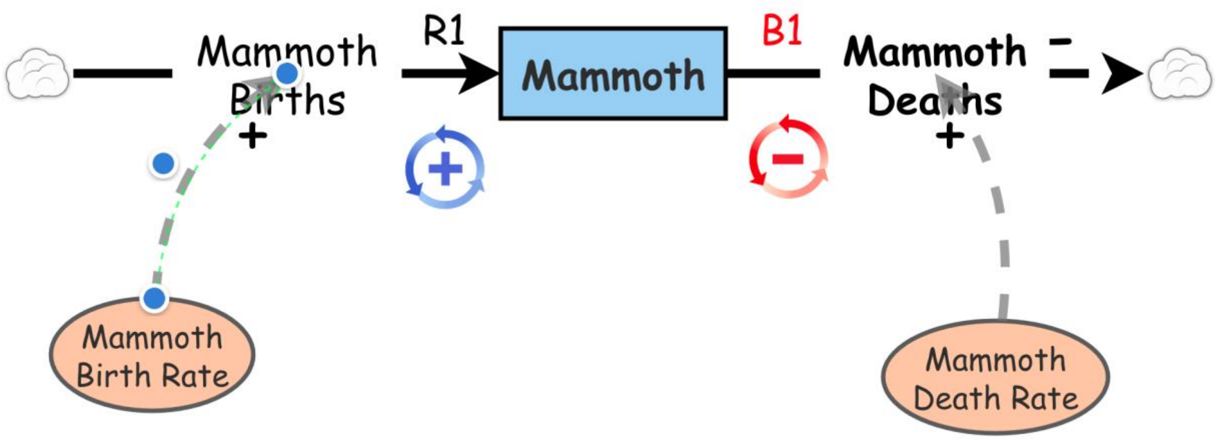


Figure 9: Modifying the curvature of a link. By hovering over the link and pressing the Shift key, a control point appears, allowing you to shape the curve. Multiple points can be added or removed to define the desired path.

◈ Bilingual explanatory text:

To add text to the model canvas, use the **Text Box** primitive. This allows you to include explanations within the diagram, name feedback loops, indicate the signs of causal relationships (**+** for reinforcing, **–** for balancing), and provide visual context to model components. It's a helpful tool for enhancing interpretation and communication, especially during learning or collaborative review processes.

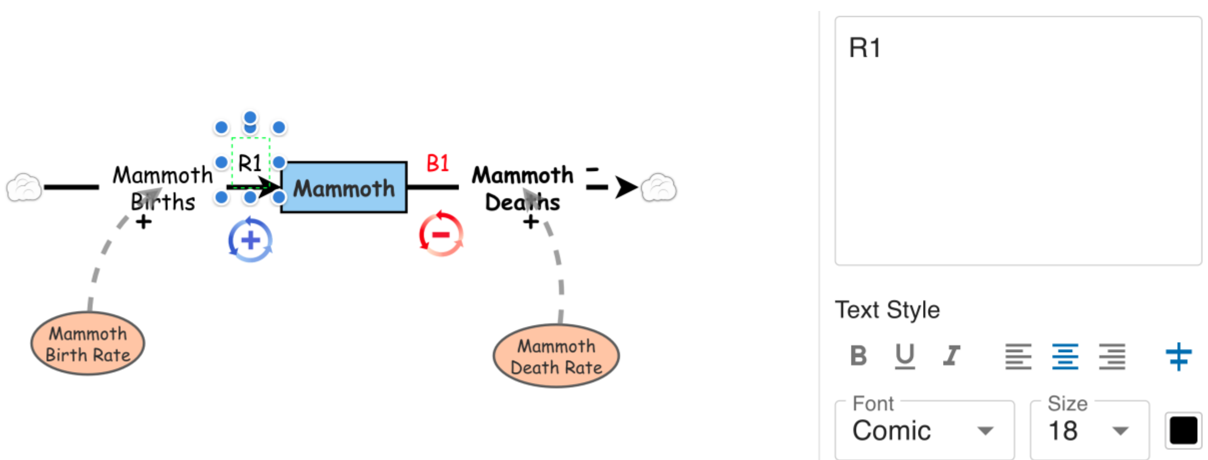


Figure 10: Using the Text Box primitive to add explanatory text to the model canvas. It allows naming loops, describing causal relationships, and enhancing diagram clarity.

Comunicación visual efectiva con Picture

Adding an image to the canvas using the **Picture** primitive is an effective way to visually communicate key ideas in the model. A wide range of figures, icons, and emojis can be used to represent components, highlight loops, or clarify relationships without lengthy text. This feature is especially helpful for making models more accessible and intuitive, particularly in educational or collaborative settings.

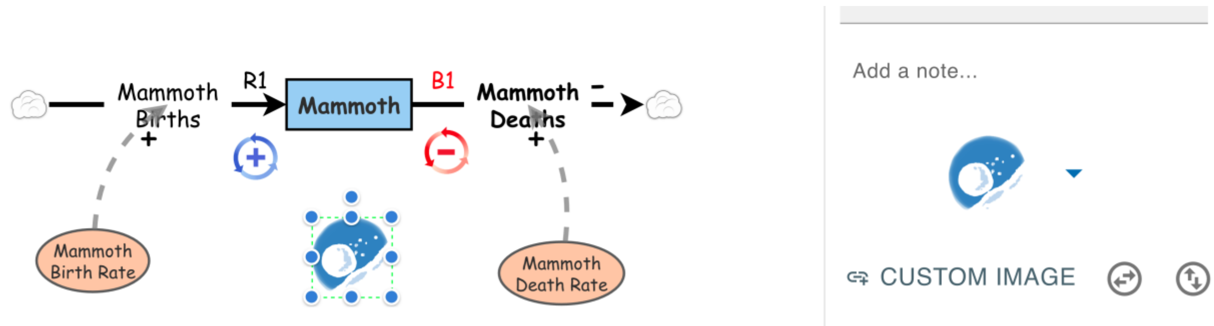


Figure 11: Selecting and inserting an image using the Picture primitive. Clicking the primitive icon opens a right-side panel with a gallery of images and emojis ready to be added to the model.

Image and emoji gallery accessible via the *Picture* primitive. Users can select the graphic that best fits their model, supporting a more visual and understandable representation.

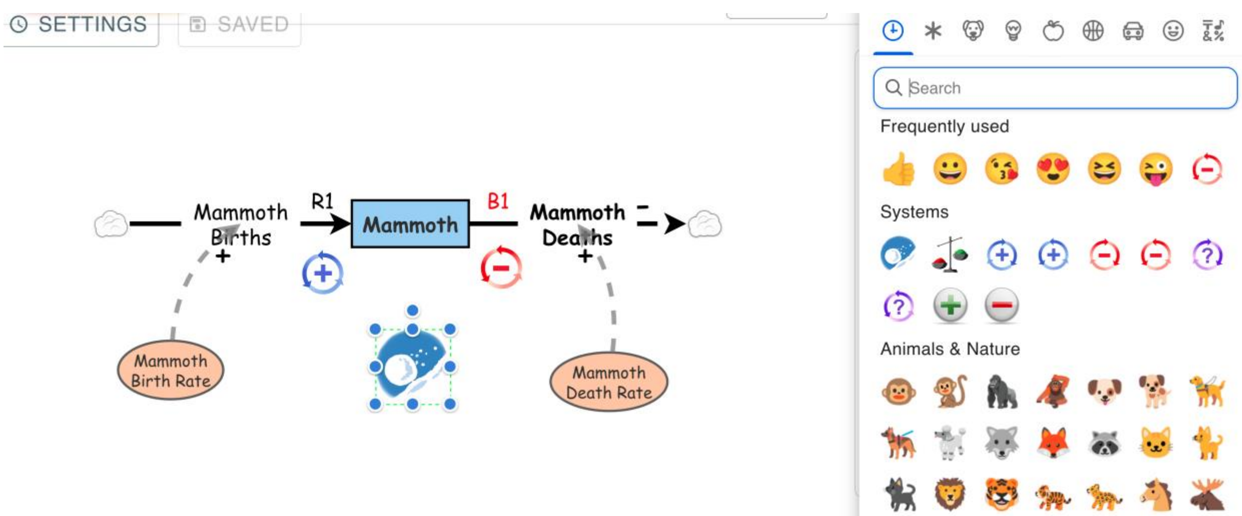


Figure 12: Picture primitive's image and emoji gallery to illustrate the model.

Model Customization with the Design Palette

All aspects of the model's appearance can be customized by accessing the **design palette icon** located in the top menu. This panel allows users to:

- Change **font type**, **size**, and **format**
- Adjust the **colors** and **shapes** of primitives
- Modify **line thickness** and **line colors**

- Switch between **solid** or **dashed** lines
- Redefine the overall **layout and style** of the diagram

This tool is essential for enhancing clarity, improving visual communication, and tailoring the diagram's aesthetics for presentations, teaching, or collaborative modeling.

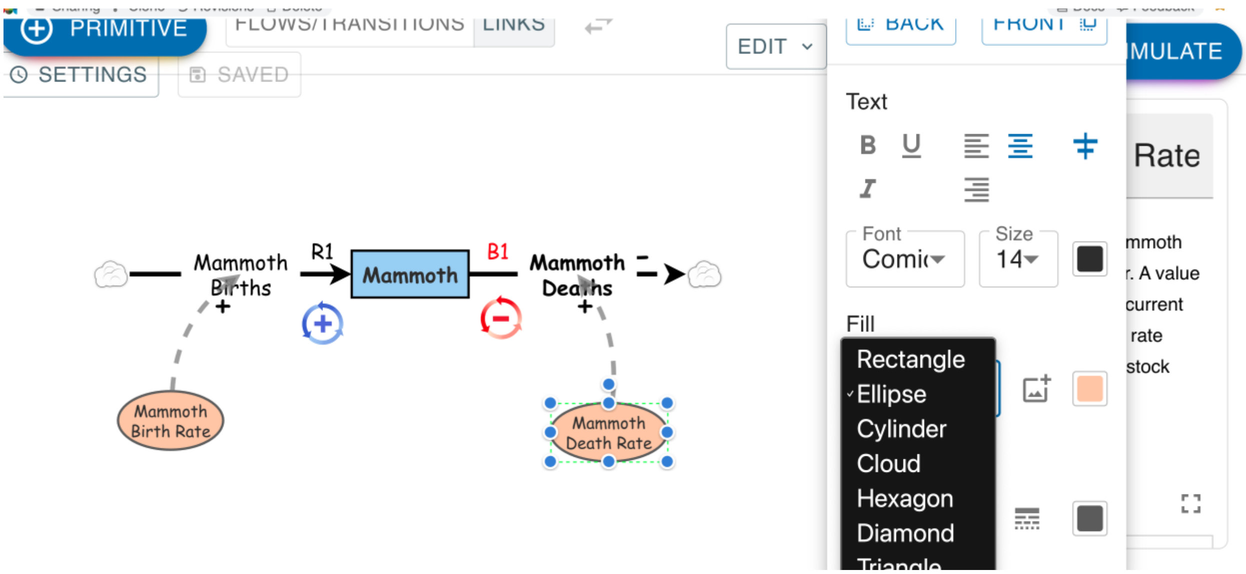


Figure 13: Design palette for modifying visual attributes of primitives in the model.

Complete Mammoth Game Model

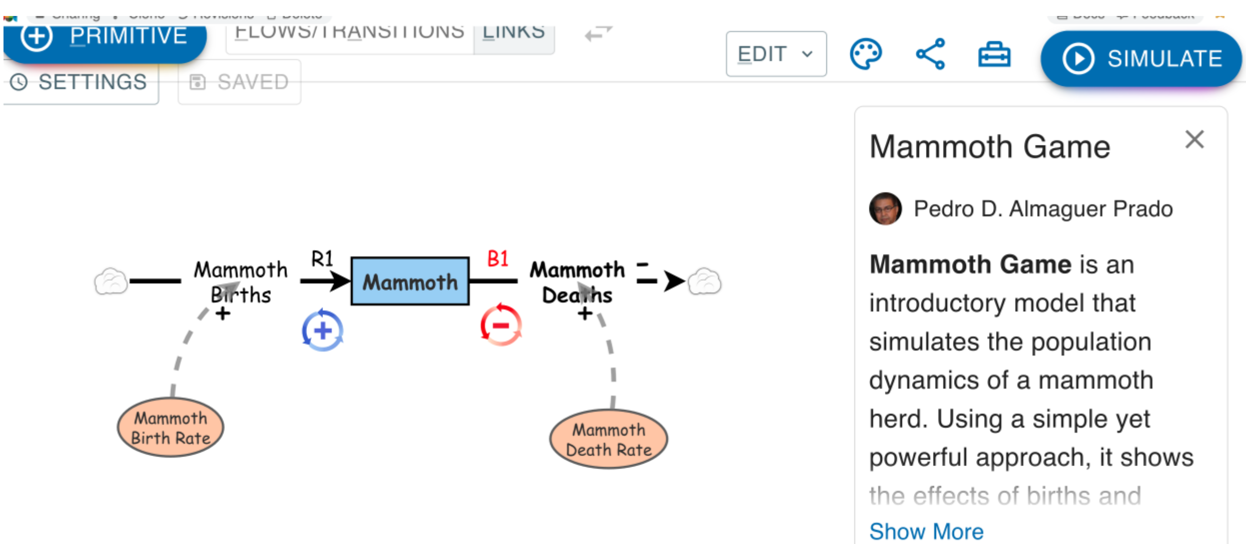


Figure 14: Full view of the complete model with components, links, and visual customization.

Mammoth Game Model Simulation

Once the model is built and customized, we can run it to observe how the mammoth population evolves over time. By clicking the **Simulate** button in the top menu, a chart is automatically generated showing the changes in the mammoth stock, births, and deaths over the simulation period.

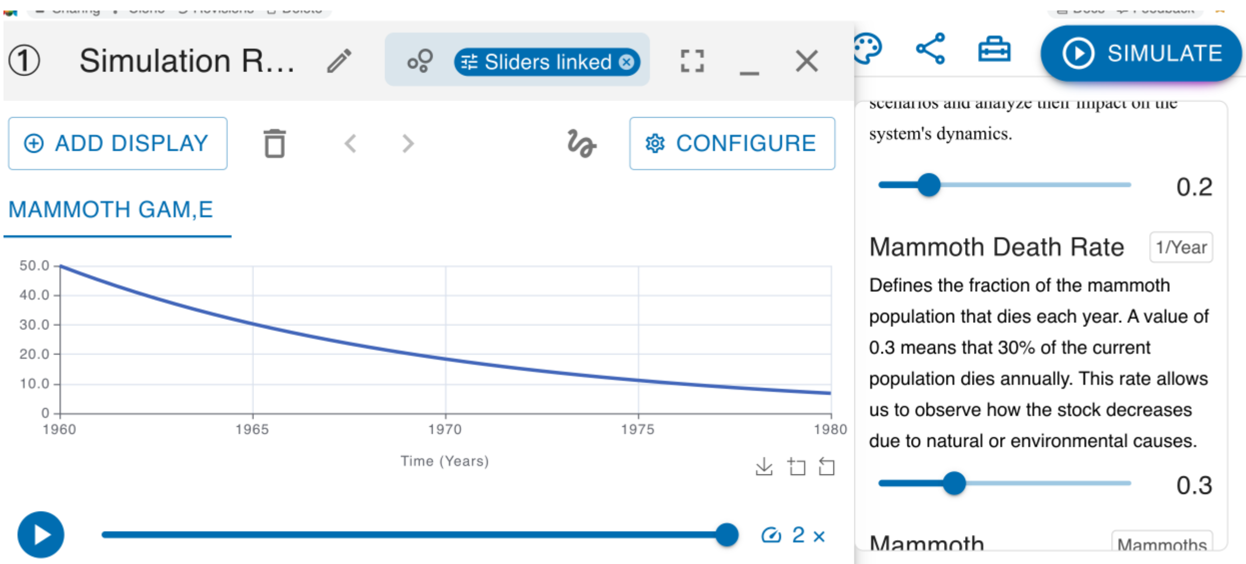


Figure 15: Simulation results of the mammoth model.

Exploring Scenarios with the Model

One of the main advantages of using simulation models is the ability to **test different decisions before implementing them in the real world**. For instance, you can change the **birth rate to 0.37** and keep the **death rate at 0.20**, and then observe how these changes affect the mammoth population dynamics over time.

This process allows you to **see both the intended and unintended consequences** of your decisions, helping you make more informed and systemic choices — **without taking real-world risks**.

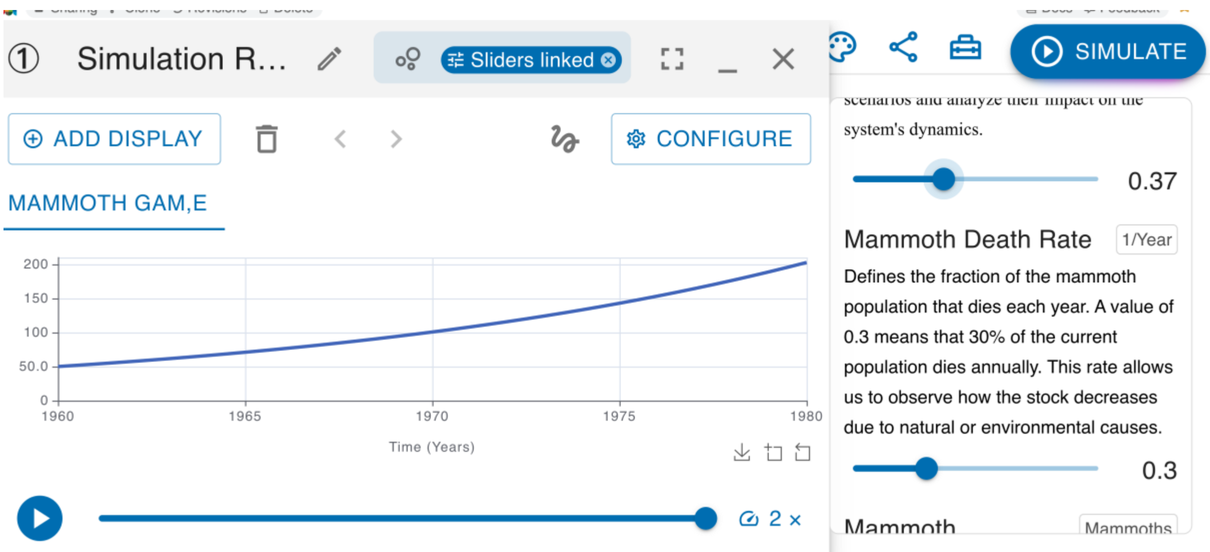


Figure 16: Scenario comparison after adjusting birth rate.

Advanced Chart Configuration

After running the simulation, the **Configure** button allows for detailed customization of how the results chart is displayed. This option opens a panel with multiple settings to tailor the visual output to your analytical needs.
The menu lets you choose from the following types of displays:

- **Time Series**
- **Scatter Plot**
- **Table**
- **Agent Map**

Each chart can be configured independently, using the same parameters as the primary chart (title, variables, axes, labels, format, etc.).
The **Scatter Plot** is particularly impactful for visual analysis across two dimensions. For instance, plotting **Economic Legitimacy** on the X-axis and **Ecosystem Health**, **Reputation**, or **Freedom** on the Y-axis enables you to evaluate policies visually in four quadrants. This reveals whether a policy was **sustainable**, **unstable**, **moderately successful**, or **catastrophically failed**, based on its position on the chart.

Available configuration options include:

- **Chart Title**: Modify the main title of the chart.
- **Y-Axis Variables**: Select which primitives to display on the left Y-axis.
- **Chart Settings**: Choose how the data will be presented using *Show points*, *Show lines*, or *Use areas*.
- **X-Axis Label**: By default, it appears as *(Time (%u))*, where %u reflects the simulation's unit of time.
- **Y-Axis Label**: If set to *(%o)*, the label will show the name of the first primitive listed, or you can define a custom label.

- **Secondary Y-Axis (optional)**: Use this to graph additional primitives on a different scale shown on the right side of the chart. First, select the primitives to be plotted on this secondary axis, then define the label (using *(%o)* to display the name of the first listed primitive).

These flexible options make it easier to analyze relationships between variables, especially when dealing with different units or scales, and to interpret model outcomes more effectively.

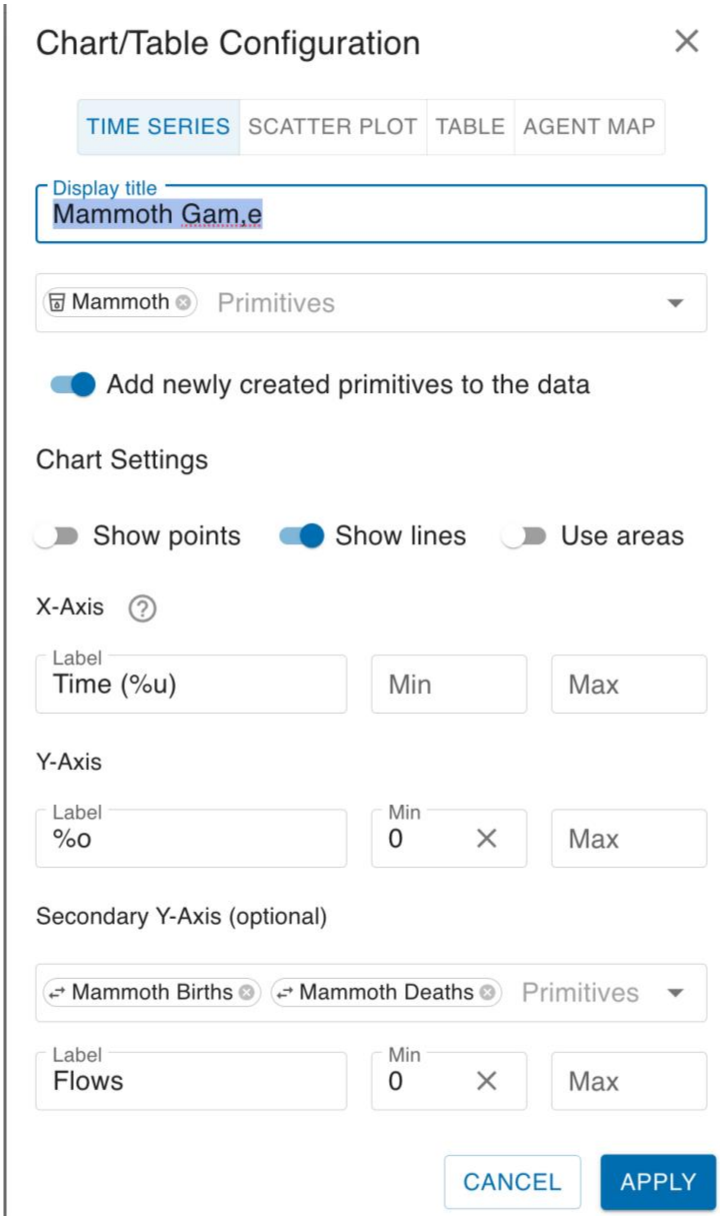


Figure 17: Chart settings to customize axes, title, and visualization style.

📌 Finally, you can **add new charts** using the **Add Display** button, and **delete them** using the trash icon located to the right of that same button.

This graph allows simultaneous visualization of the total mammoth population and the birth and death flows over time. As the population increases or decreases, vital flows respond with fluctuations that reflect the internal dynamics of the system. The overlap of these elements helps to understand the feedback effects that regulate the model's behavior.

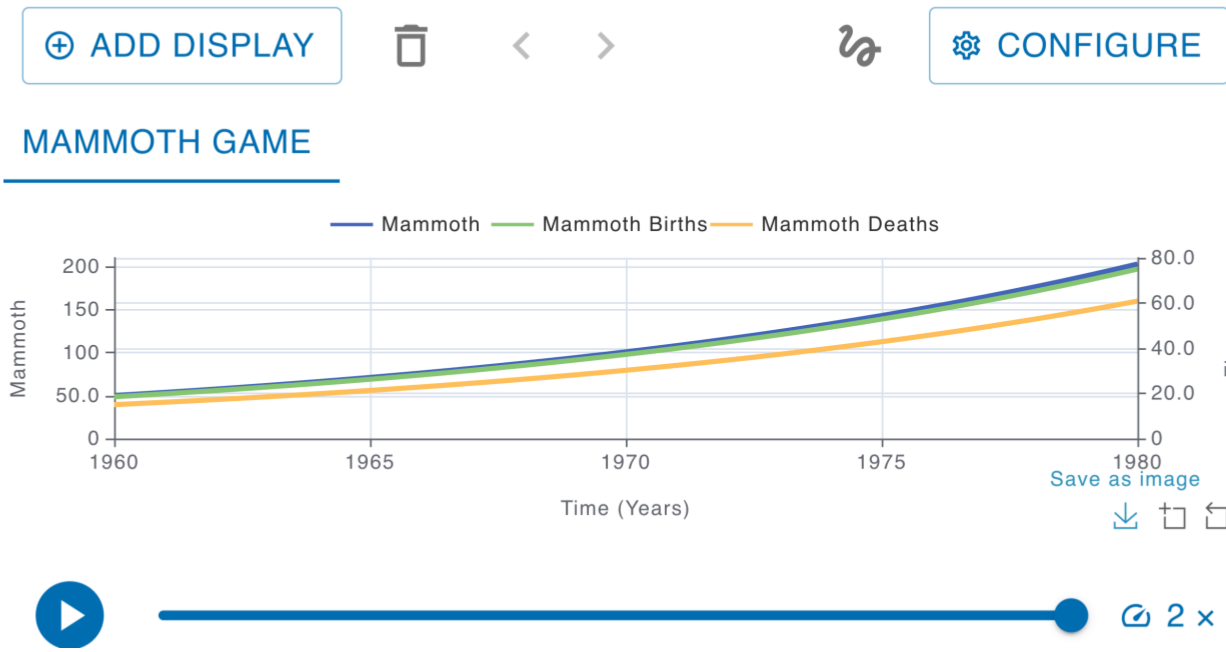


Figure 18: Population and vital flows in the MAMMOTH GAME.

Grouping model elements with *Make Folder*

To improve organization and clarity in a complex model, you can **group multiple elements** (primitives, flows, links, etc.) into a **folder or sector**.

Steps to use Make Folder:

1. Select the model elements you want to group (hold Shift to multi-select).
2. Right-click on one of the selected elements.
3. From the context menu, choose **Make Folder**.
4. Rename the folder to something descriptive.
5. The grouped elements will be visually encapsulated, as shown in the next figure.

This tool is ideal for representing **submodels**, **system sectors**, or **functional blocks** of your model.

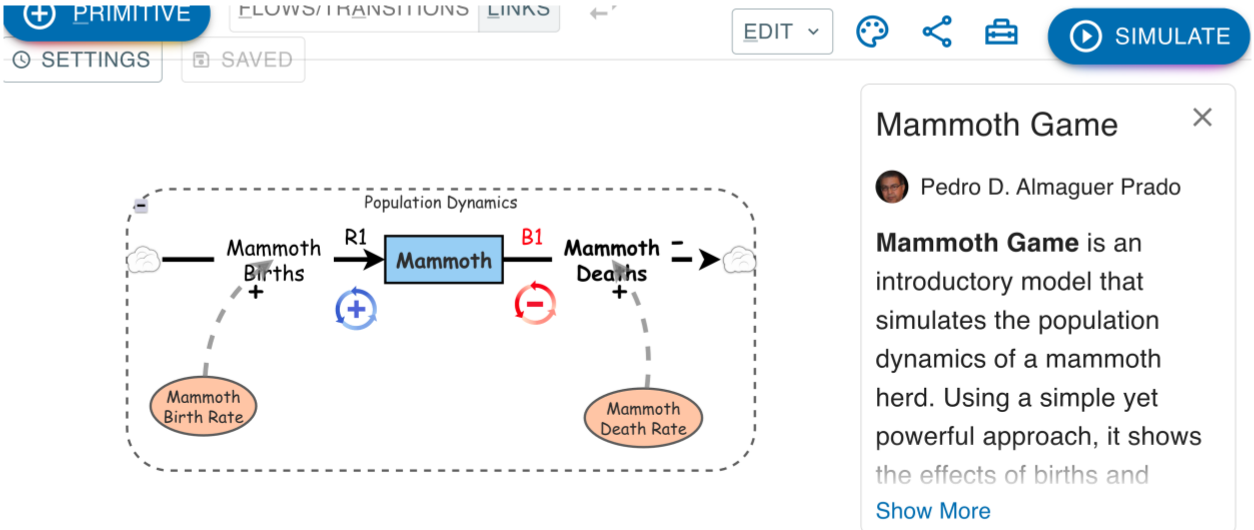


Figure 19: Elements grouped with Make Folder to represent model sectors.

How to develop Storytelling in your model

Before creating a visual narrative with the **Storytelling** feature, it is essential to properly prepare your model to simplify selection and improve clarity:

1. **Label all links**: Assign a name or number to each causal link to easily identify and control what appears in each step of your storytelling.
2. **Differentiate causal signs**: If you've used multiple "+" or "–" signs, add unique identifiers ("+A", "+B", "–C") to each one in the associated text box. This avoids confusion during storytelling stage creation.
3. **Visually organize your model**: Align and group elements by sector (using **Make Folder** if needed), so the narrative flow is easy to follow.

Once ready, click the **Storytelling** icon in the top canvas menu. From there, you can create a step-by-step explanation, revealing elements as needed. This feature is ideal for:

- **Teaching or explaining your model clearly**
- **Professional or academic presentations**
- **Ensuring system understanding** by showing relationships progressively

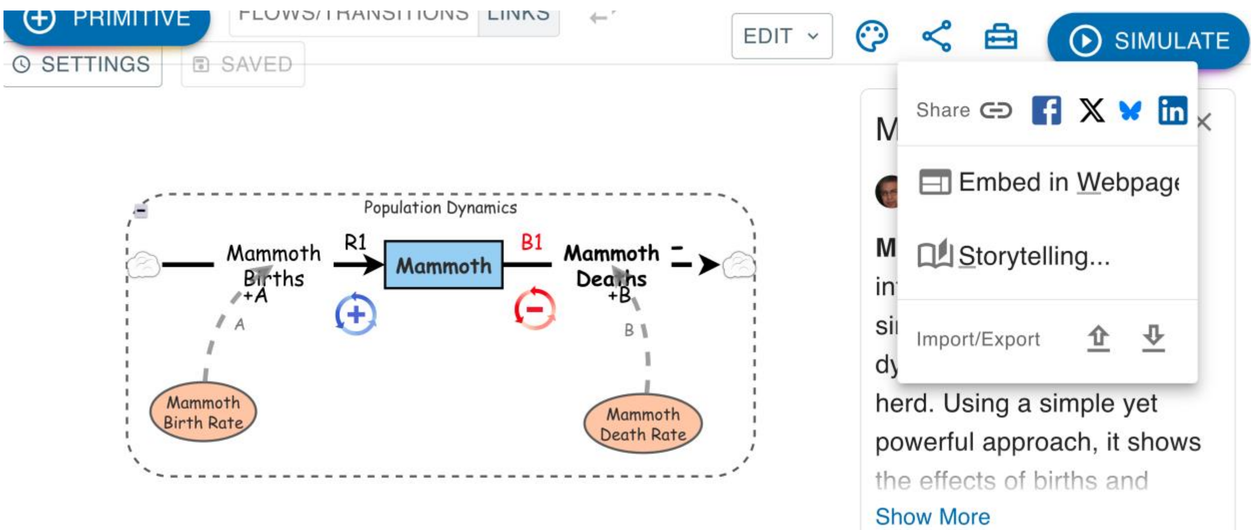


Figure 20: Model ready for Storytelling: all links and signs labeled.

Accessing the Storytelling Designer

To begin building a step-by-step visual narrative of your model, you need to open the **Storytelling Designer**. This environment allows you to define **stages**, where you can control which elements of the model are shown, hidden, or highlighted, helping to clearly explain its structure and behavior.

☑ Step 1: Access the Storytelling Designer

1. Go to the **top menu** of the modeling environment.
2. Click on the icon or dropdown menu labeled **Storytelling**.

3. A side panel or floating window titled **Story Designer** will appear.

This workspace allows you to manage each stage of your visual story, add descriptive text, control the visibility of elements, and design a clear, progressive presentation of your model.

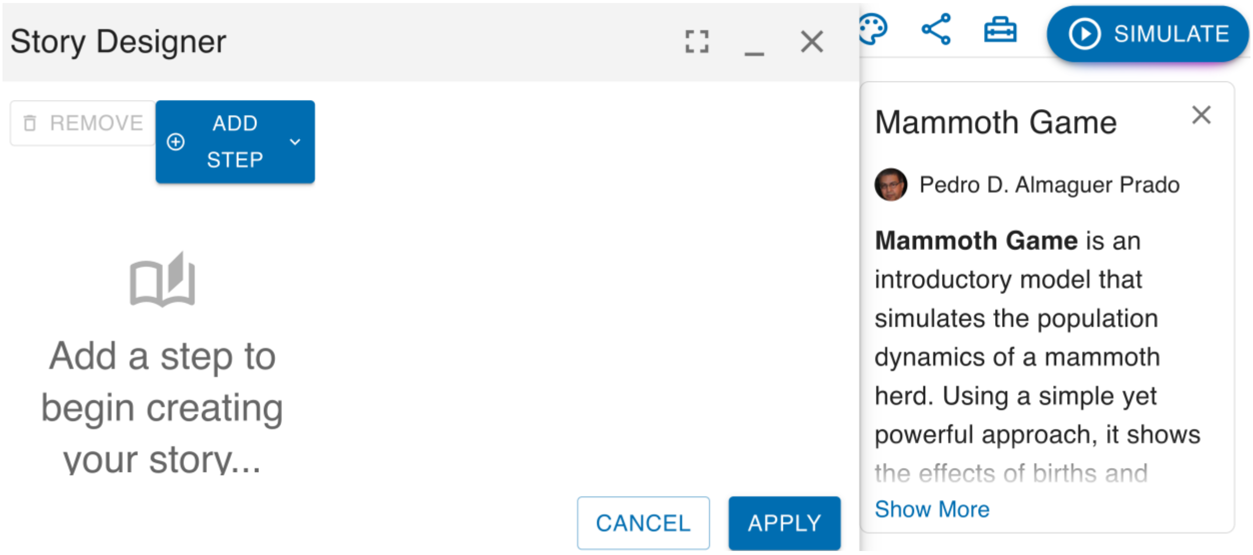


Figure 21: From the top menu, select "Storytelling" to open the Story Designer.

▯ Step 2: Create the first step of your story

With the **Story Designer** open, you're ready to build your narrative step by step.

1. Click the **Add Step** button to create the first stage.
2. Then select **Change Visibility** to define which elements will be shown, hidden, or highlighted in that step.
3. You can also:
   - Add **explanatory text** to each step to guide understanding.
   - **Open or close folders** to show or hide entire sections of the model.
   - **Turn on or off specific elements** like flows, variables, stocks, or pictures.
   - Temporarily **change colors or shapes** to emphasize certain items.
4. Repeat the process to add more steps and build a clear, progressive presentation of the model.

This makes it easier to communicate or teach system models in a structured and compelling way.

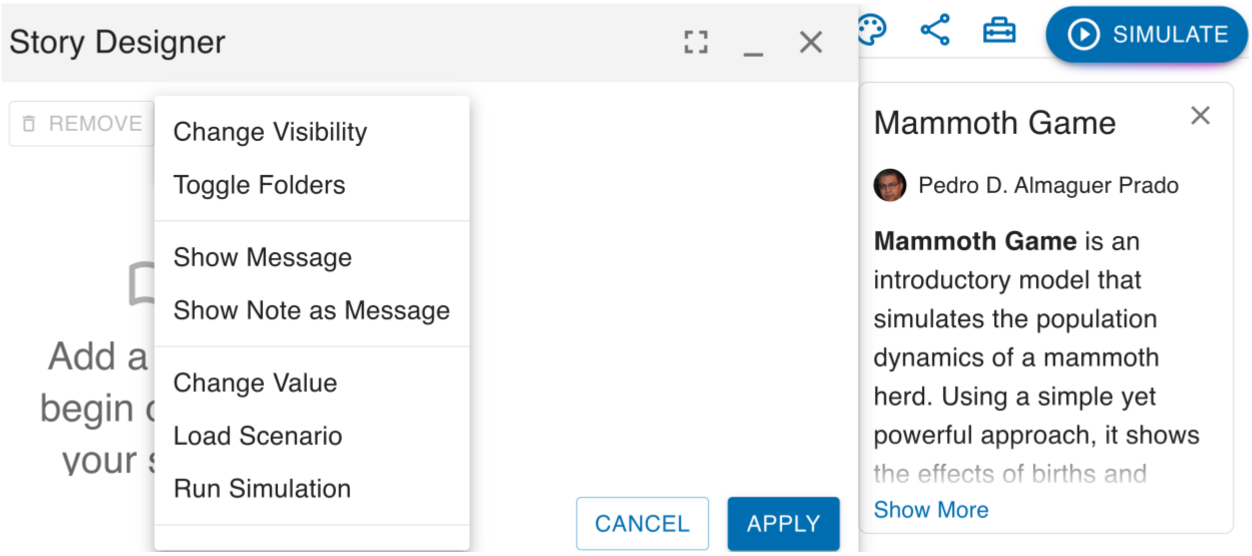


Figure 22: Add a step, control visibility, open folders, and add text to tell your story.

◯ Step 3: Start with a blank canvas

Your first storytelling step should remain **completely blank**, with no primitives visible. This allows you to **begin telling the story from zero**, revealing each component step by step in a clear, structured way.

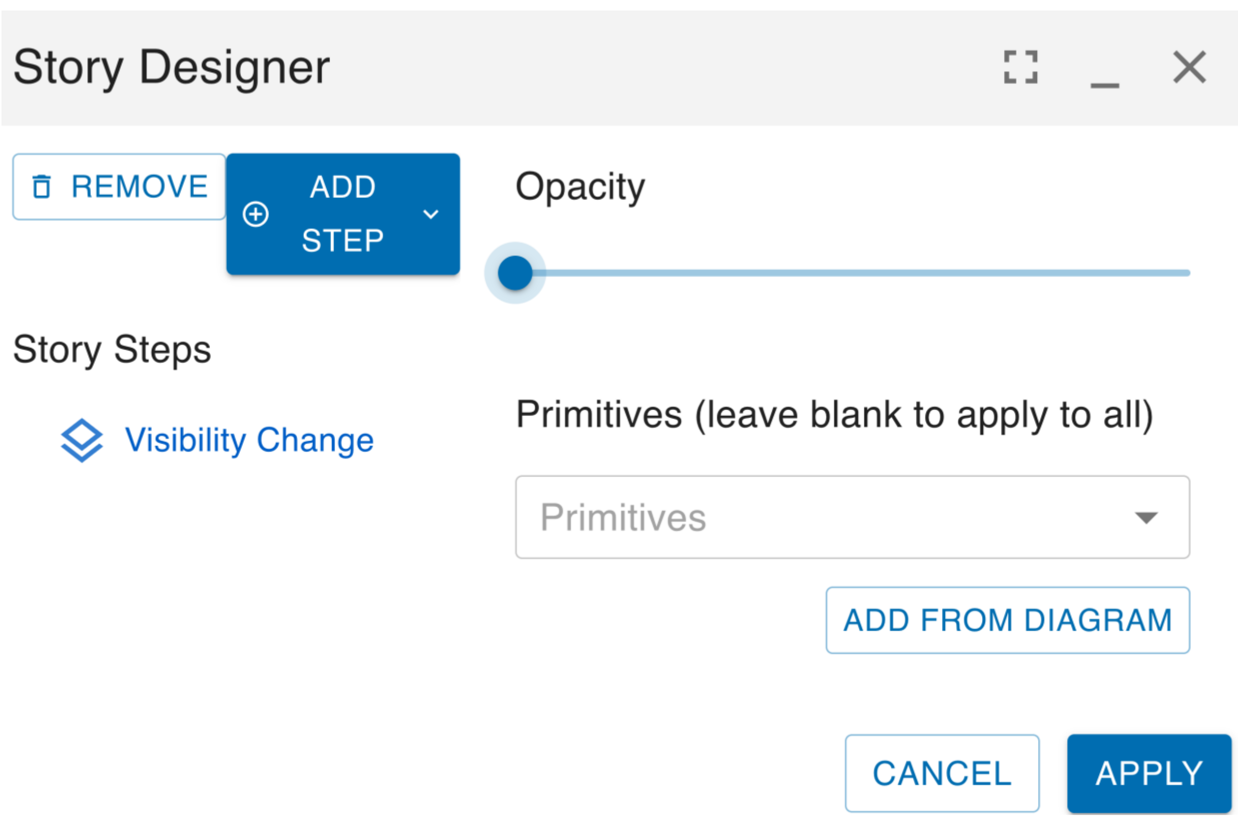


Figure 23: Initial blank canvas to begin the storytelling.

Step 4: Introduce the first section — Mammoth Stock and Folder

Now, let's begin telling the story. In this first step, **reveal the stock named "Mammoth Population"** along with the **folder labeled "Population Dynamics"** that groups related elements. This helps the audience understand the initial core structure of the model. Use the **"Change Visibility"** option to display these specific elements in this step.

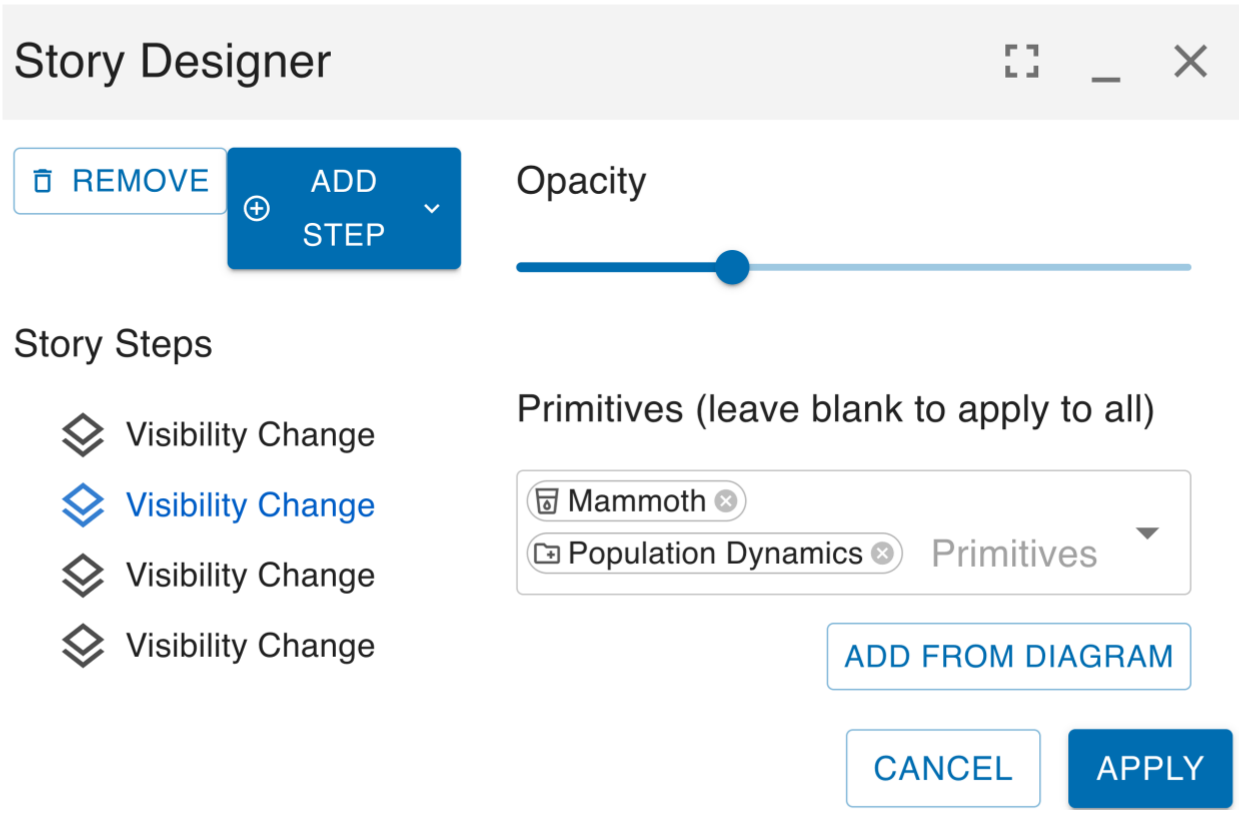


Figure 24: Reveal of Mammoth stock and its folder.

Step 5: Show the Birth Cycle — Causal Loop A (R1)

In this storytelling step, we reveal all elements labeled with "A", representing the **reinforcing loop R1**, where the mammoth population increases through **births**. This includes:

- The mammoth stock
- The birth flow
- Related auxiliary variables
- All causal links labeled "+A" or "A"

This step helps to visualize how the system reinforces itself through population growth.

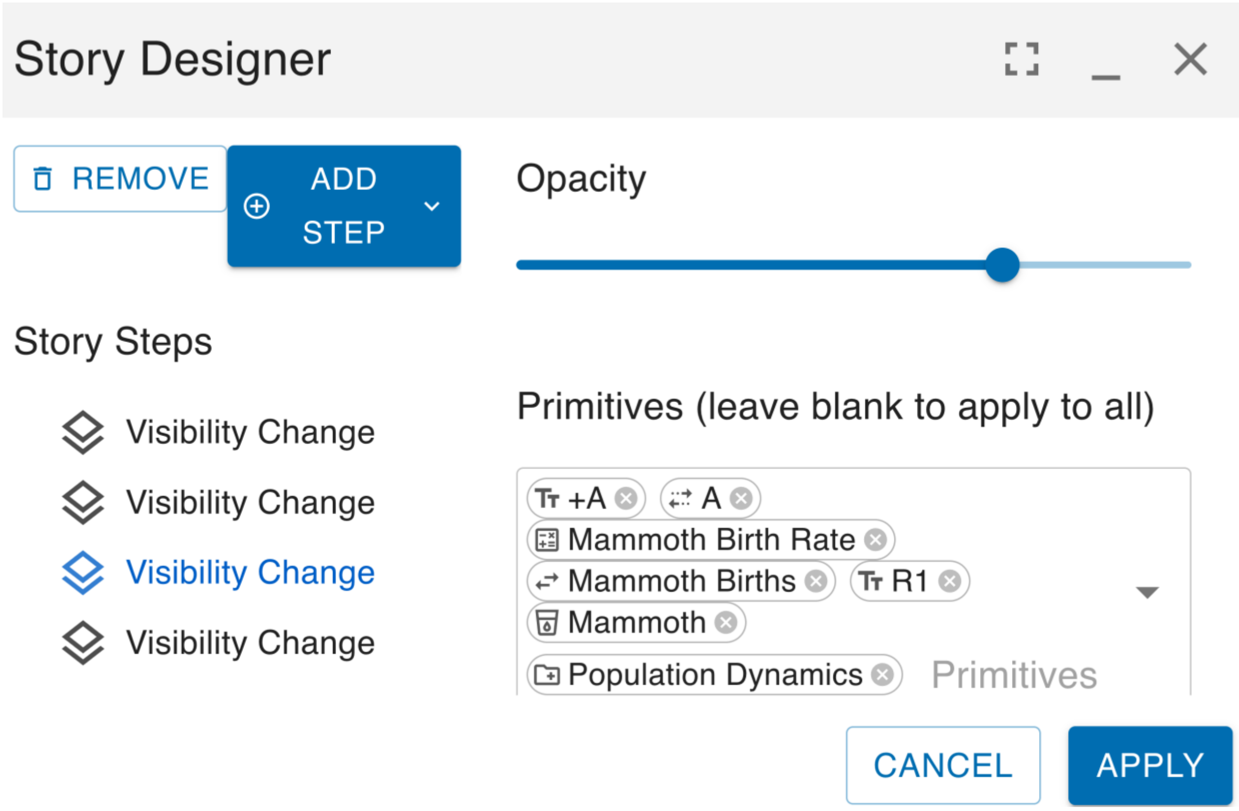


Figure 250: Birth loop (R1) revealed — labeled as A.

▨ Step 6: Show the Death Cycle — Causal Loop B (B1)

In this final step, we reveal all the elements involved in the **balancing loop B1**, which regulates the mammoth population growth through **deaths**. This step includes:

- The death flow
- Related auxiliary variables
- All links labeled as "+B" or "B"

This loop works as a **control mechanism** that slows down exponential growth and promotes long-term balance in the system.

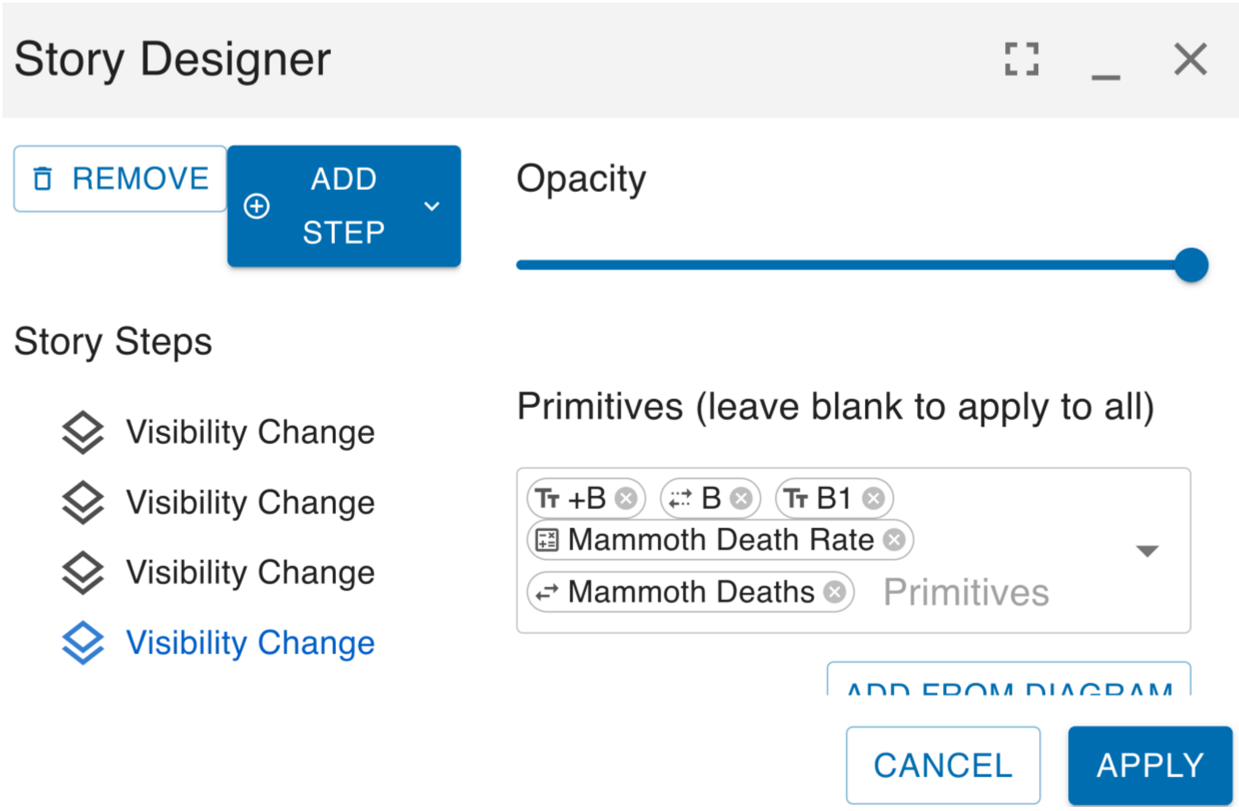


Figure 26: Death loop (B1) revealed — labeled as B

Complete Storytelling in 4 Steps

Step-by-step explanation of mammoth population dynamics

Step 1: Clean Slate (Story Start)

We start with a blank canvas to capture attention and set the stage. No elements of the model are displayed yet.
This step sets the context before the dynamics of the system emerge.

Step 2: Population Dynamics — Mammoth Stock

We display the main **stock** of the model: mammoth population, grouped inside the folder *Population Dynamics*.
Introduces the concept of accumulation as the model's foundation.

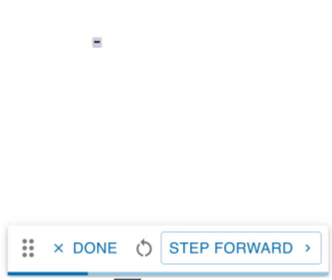
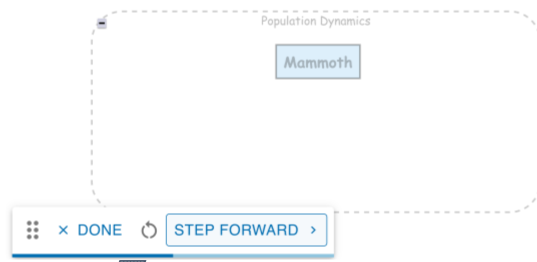
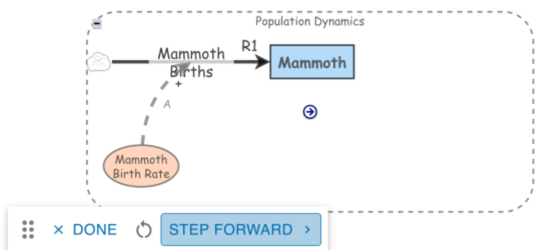
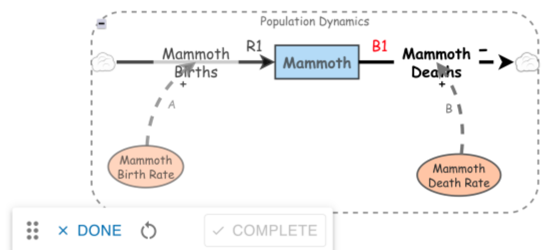
Step 3: Birth Cycle — Reinforcing Loop R1

We show the **birth flow**, related auxiliary variables, and all links labeled **"+A"** or part of loop **R1**.
This reinforcing loop drives exponential population growth.

Step 4: Death Cycle — Balancing Loop B1

Finally, we reveal the **death flow**, associated variables, and links labeled **“+B”** or part of loop **B1**.
👉 *This balancing loop slows growth and helps prevent collapse.*

Table 1: Complete storytelling in four steps — from mammoth stock to growth and control loops.

 *Figure 27: Step 1: Clean Slate (Story Start)*	 *Figure 28: Step 2: Population Dynamics — Mammoth Stock*
 *Figure 29: Step 3: Birth Cycle — Reinforcing Loop R1*	 *Figure 30: Step 4: Death Cycle — Balancing Loop B1*

✅ Final Step: Label cleaning and final presentation of the model

Finally, the letters "A" and "B" are removed from the signs of causal links (“+A” and “+B”), leaving them simply as **“+”**.
The **“A”** and **“B”** tags on the **arcs** are preserved to keep identifying the **R1 (reinforcing)** and **B1 (balancing)** loops.
👉 *The model is now clean and ready for presentation or simulation, with a clear narrative and structure.*

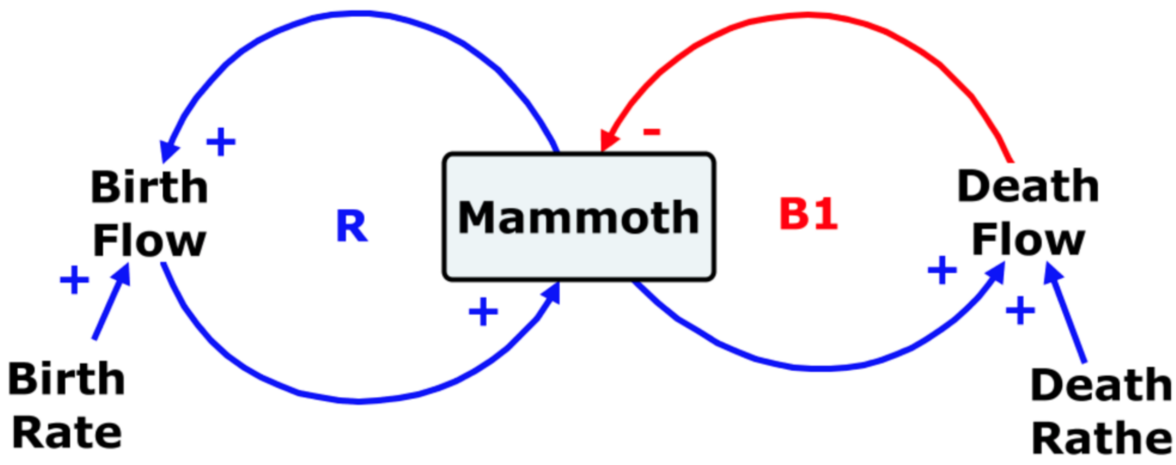


Figure 31: Causal Loop Diagram (CLD) of the MAMMOTH GAME: visualizes the causal relationships and feedback loops that drive the system's dynamics.

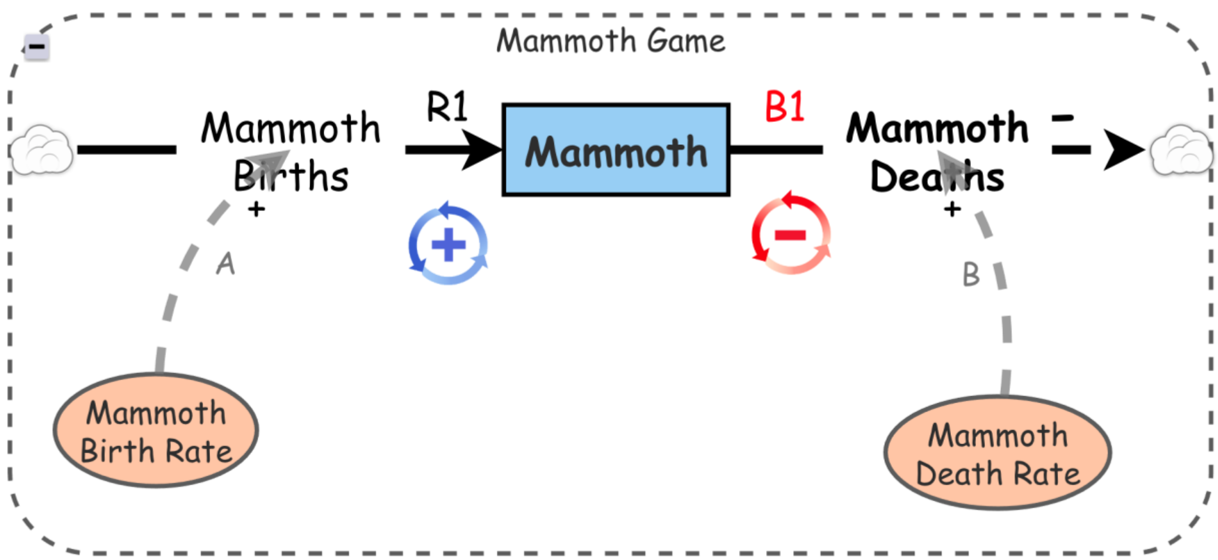


*Figure 32: **Stock and Flow Diagram (S&F) of the MAMMOTH GAME**: a structured representation that enables simulation of system behavior over time.*

Conclusion

In an increasingly interconnected and fast-changing world, understanding the dynamics of complex systems has become an essential skill. This article has demonstrated how one can build, document, and communicate a dynamic model using accessible visual tools—integrating everything from the creation of stocks and flows to simulation setup and narrative presentation through storytelling.

The ability to visualize behavior over time, modify key variables, and observe both intended and unintended consequences makes this approach a powerful tool for analysis, decision-making, and education.

Through each documented step—from adding text and images, grouping elements, customizing the model visually, to narrating its internal logic—the process shows how clear and structured representation can transform the understanding of complex issues and foster more conscious and sustainable decisions.

These kinds of models not only help explore hypothetical scenarios but also invite us to think in terms of **deep-rooted causes, feedback loops, delayed effects, and hidden structures** that often determine the outcomes of our actions.

In short, modeling, simulating, and storytelling is not just a technical task—it is a deeply educational and strategic act. It is the way to make the invisible visible, and to learn how to think systemically.

References

The Mammoth Game:
The Shape of Change
The text of
Lesson 3: The Mammoth Game
From the books
The Shape of Change
and
The Shape of Change: Stocks and Flows
By Rob Quaden and Alan Ticotsky
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