TERRA NOVA

About the effect of fertilizers on the ecosystem of a fen lake.

DynaLearn level 2 | Version 1.0

Summary
This lesson is based on the situation where a Dutch fen lake collapsed due to excess of fertilizer but was able to restore after removing one type of fish species from the lake. The ecosystem collapsed after a chain of events set off by fertilizer coming in from nearby farmland. Removing bream from the murky ecosystem set off another chain of events that reversed the process.

Given name	
Surname	
Class	
Date	

Comments by teacher

1. Introduction

Nature in fen lakes as they existed until the fifties and sixties of the last century is a benchmark for environment managers in our delta country. The shallow waters, a few meters of water on remaining fen lakes, offered space for particularly rich flora and fauna. With the start of intensive agriculture around 1960 many fertilizers were used. This caused the concentration of nutrients in the environment to increase slowly but steadily. In our fen lake, the clear water with the ecosystem of predatory fish (such as pike), water fleas (algae eaters) and aquatic plants (see Figure 1a) could turn within a few months into a species-poor cloudy water where bream churns the bottom of the lake and many blue-green algae (producers) appear (see Figure 1c).

Terra Nova, in the Netherlands and **the Shannon basin** in Central Ireland are waters with such a history. In this lesson, you will create a **model** in order to learn about these sudden changes.

(a)

(b)

(c)
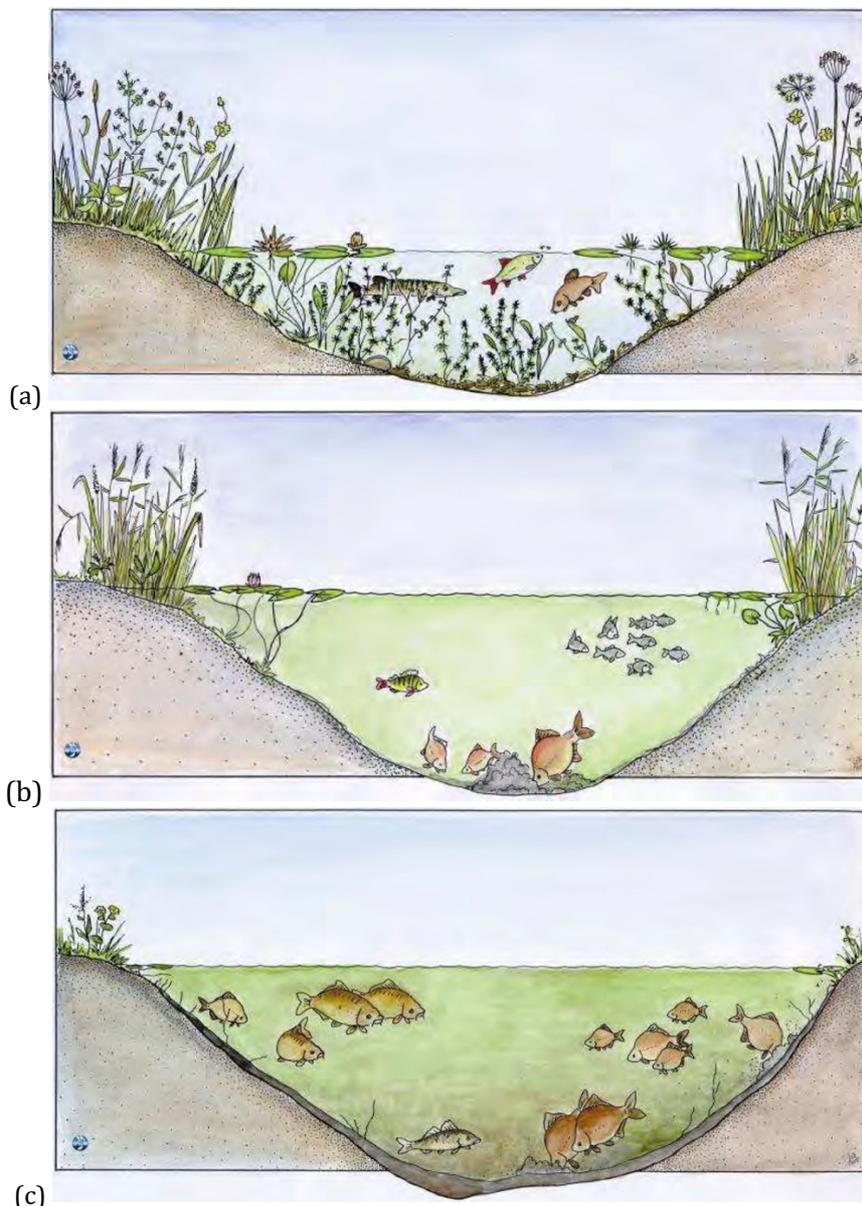
Figure 1. Change from a clear fen lake (a) to a cloudy water (c).

2. Starting DynaLearn

There are several ways to log in. Use one of the two options below. Then check whether the login was successful (see 'Let's check').

Via a code:
1. Go to DynaLearn (https://create.dynalearn.nl/).

2. Click on 'log in with code', at the bottom left.

3. Enter the project code and your (school) email address.

4. Copy the code from the confirmation email received from *dynalearn.nl* (see spam folder if needed) and fill in the other details.

5. Log in to DynaLearn.

By invitation:
1. Copy the login details from the invitation email received from *dynalearn.nl*.

2. Go to DynaLearn (https://create.dynalearn.nl/).

3. Log in to DynaLearn.

> **Let's check!**
> After logging in, you will automatically enter the workspace of the assignment. You can
>
> recognize it by the question mark on the right side of the screen ❓. Is the question mark missing? Then first:
>
> o   In DynaLearn, click 🗎. Click on 'Select template'.
> o   Choose 'Terra nova' and press 'Load'.

Save model file and start:

1. Click on 🏷 top left. Change the name to 'Terra nova' and click 'Save'.

2. How do you proceed? Just follow the steps in this workbook. Note! You can't skip steps. Ask for help if you can't figure it out at a certain step. The video function 🎥 in DynaLearn shows how a model ingredient can be made. The boxes contain a brief explanation about the model ingredient. Put a check mark √ next to the step you performed. This way you keep track of where you left off.

3. Blue-green algae

1. Read Box 1.

> **Box 1.** Entity and quantity
>
> An entity ⊕ is usually a physical thing in a system (e.g., car, human).
>
> A quantity ⊘ is a measurable property of an entity (e.g., temperature, length).

2. Create your own entity called *Blue-green algae* (see 🎥 → ⊕). The entity *Fen Lake* has already been created.

3. Create the quantity *Number* of the *Blue-green algae* entity (see 🎥 → ⊘).

4. Create a configuration *Live in* between the entity *Fen Lake* and *Blue-green algae* (see 🎥 → ⊕⊕).

5. Read Box 2.

> **Box 2.** Help function
>
> If the question mark ⑦ or an ingredient in your model ⊕ is red, then something is wrong. Click the question mark ⑦ for a hint. Then click on a number, for example ① to see where the error is in your model. Only use the question mark if you can't figure it out yourself!

6. Try out the help function by making a mistake on purpose. Click ⑦ to see which notification you get. Fix the error.

4. Water fleas, breams and pikes

You now know how to place entities and quantities in your model. Next, you are going to make a food chain with organisms that live in the fen lake of Terra Nova.

> ... The fen lake is now clear again. Because the bream no longer churns the soil, the silt settles, and the clarity increases. In addition, the bream can no longer eat water fleas. The water fleas therefore get the chance to consume the blue-green algae (producers). This also makes the water clearer and perennials can grow. Its roots and stems strengthen the silt layer and stop the stirring of the bream. For pike, this environment is ideal. Because pike hunt from aquatic plants for (among others) bream ....

1. Read the text above. Complete the food chain below with the organisms that appear blue in the text (the arrow means: *eaten by*).

Blue-green algae	→	...	→	...	→	...

2. Create an **entity** for **each** organism in your model.

3. You can keep the model organized and clear by using a few buttons at the bottom right of the screen. Click regularly on ⚡ to align everything neatly. Click ↗ to make your model fit on the screen.

4. Link the entities together with a "configuration". Assign to the "configuration" box what the food relationship is. Pay attention to the correct direction of the arrow. (tip: who eats who?).

Aquatic plants are not part of the food chain in this model but are an important entity.

5. Create an entity *Aquatic plants* and place it near the *Pikes.*

6. Link with configurations the entity *Aquatic plants* to the entity *Pikes* and to the entity *Fen lake*. In the "configuration" box, always indicate what the relationship is. Think about the right direction of the arrows.

7. For **each** entity, create a quantity *Number.*

In a food chain, the number (= quantity) of predators (= entity) directly influences the number of the preys.

8. Read Box 3.

> **Box 3.** A cause-effect relationship
>
> In Dynlearn, there are two types of relationships:
> - Positive relationship ⊕: the quantities change in the same direction (if quantity 1 increases, then quantity 2 also increases)
> - Negative relationship ⊖: the quantities change opposite (if quantity 1 increases, then quantity 2 decreases. Or vice versa: if quantity 1 decreases, then quantity 2 increases)

9. How does the predator affect prey? (cross out or remove what doesn't apply)

> If the number of predators increases, the number of preys *decreases/remains the same/increases.*

10. What type of relationship fits the relationship between predator and prey?

> A *positive/negative* relationship.

11. Make the cause-effect relationships between the quantities (see ◼️ → 📈). Start with the relationship between aquatic plants and pikes. There is always only one relationship between two quantities.

12. Is your screen content a bit messy? For a better organization, click ⚡. Click ⤢ to fit your model on your screen.

5. Effect of aquatic plants

The next step is to start the simulation of your model.

1.   Read Box 4.

Box 4. Change of a quantity.

A quantity can change. This is indicated by . The delta symbol (δ) is the mathematical sign for change (also called the derivative). The down arrow (▼) is a decrease, the zero (Ø) is constant and the up arrow (▲) is an increase.
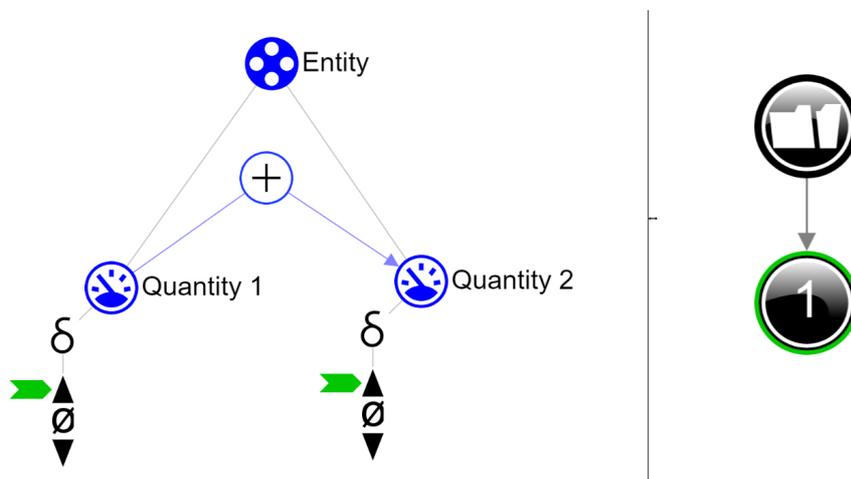
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2.   Set as initial change (see ■ → ➤):

   a.   *Number* of the entity *Aquatic plants* is increasing.

3.   Read Box 5.

Box 5. Read the outcome of a simulation.

After starting a simulation (with), a window appears on the right in which the possible states of the system are indicated. There is one possible state in this example .

You can click on the state to view the outcome. The condition then acquires a green edge. In the model, the change for this state is indicated by a green arrow ➤ . The model shows that in state Quantity 1 increases and that therefore Quantity 2 also increases.

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4.   Read Box 6.

Box 6. Help function

If the explanation mark appears , something is wrong during the simulation. Click on the explanation mark for a hint. Then click on a number, for example ❶, to see where the error is in your simulation.

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5. Start the simulation ⊙.

6. What happens to the other quantities in the outcome of this simulation?

Number (pikes): decreasing /increasing

Number (breams): decreasing /increasing

Number (water fleas): decreasing/increasing

Number (blue-green algae): decreasing/increasing

6. Abiotic factors

There are also two important **abiotic factors** in the fen lake that play a role in this model: (1) the **amount of nutrients** and (2) **the clarity**.

1. Create the *Clarity* quantity of the entity *Fen lake*.

2. Create a *Nutrients* entity.

3. Create the quantity *Amount* of the *Nutrients* entity.

4. Create two "configurations" with this new entity, one with the *Fen Lake* entity and one with the *Blue-green algae* entity. Pay attention to the correct names and direction of the arrows.

5. The two new quantities each have a positive relationship (⊕) with **one** of the quantities in the food chain. Which entities do these quantities belong to?

Quantity	Has a positive relationship with the **quantity** of **entity**
Clarity	The more clarity the more [name of quantity]
Nutrients	The more nutrients the more [name of quantity]

6. Two of the quantities of the food chain have a negative relationship (⊖) with "Clarity" Which two are they?

Quantity	Has a negative relationship with...
[name of quantity]	The more [name of quantity] the less clarity
[name of quantity]	The more [name of quantity] the less clarity

7. Add the four relationships mentioned above to your model. Also read Box 6 .

7. The effect of Agriculture

1. Create a new entity named *Agriculture* and an entity *Fertilizers* and the quantity *Amount*.

2. Make sure that the quantity *Amount* of the entity *Fertilizers* influences another quantity, make the correct **relationship** in your model.

3. Read Box 6. Is your model completely finished?

> **Box 6.** Progress bar
>
> At the bottom of the screen is the *progress bar* (see example below).
>
> Entity says: 4/4/0, this means: 4 created, 4 needed, 0 error. For quantity it says: 5/17/1: this means: 5 made, 17 needed, 1 error. If all the numbers are green, that type is settled.
>
> 4/4/0   3/3/0   5/17/1   0/26/0   # 12/24

4. You probably noticed that there are still some configurations to be made. Create the missing configurations see ▇ → ☻☻).

After the start of intensive agriculture, the increase in the amount of nutrients in surface water is identified as the main cause of water clouding. To test whether our model agrees with this we will start a simulation.

The next step is to start to simulate your complete model.

5. Remove the blue arrow at quantity *Number* of the *Aquatic plants* entity by clicking on it and clicking on the trash can.

6. Set as initial change (see ▇ → ➤):

    a. *Amount* of the entity *Fertilizers* increases ▼.

7. Start the simulation ⊙ .

8. What happens to the other quantities in this outcome of the simulation? In the list, cross out what doesn't apply.

Amount of nutrients: increases/decreases

Clarity: increases/decreases

Number of aquatic plants: increasing/decreasing

Number of pikes: increasing/decreasing

Number of breams: increasing/decreasing

Number of water fleas: increasing/decreasing
Number of blue-green algae: increasing/decreasing

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9. You will see that an exclamation point will now appear ⓘ. Click the exclamation point.

   There are two positive feedback loops in the model: ① ②

   How many positive and negative **relationships** are there in the loops? Can you deduce when there is a positive feedback loop? Enter your answer below

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①

Number of positive links: [#]
Number of negative links: [#]

②

Number of positive links: [#]
Number of negative links: [#]

A positive feedback loop occurs when [supplement....]

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8. Solutions

1. Many other waters still suffer from clouding. What solutions can you think of to reverse the clouding?

Solution 1: [supplement....]

Solution 2: [supplement....]