Environmental Systems and Societies

*Measuring the Secondary Productivity Elodea canadensis*

**Learning Goal:** I want you to gain an understanding of primary productivity. I want you to learn techniques for measuring factors that affect or indicate primary productivity.

**Success Criteria:** You will set up an investigation, record results and calculate primary productivity correctly.

**Background information:**

**From Wikipedia, the free encyclopedia**

Elodea:

The American water weed lives entirely underwater with the exception of small white [flowers](http://en.wikipedia.org/wiki/Flower) which bloom at the surface and are attached to the plant by delicate stalks. It produces winter buds from the stem tips that overwinter on the lake bottom. It also often overwinters as an [evergreen](http://en.wikipedia.org/wiki/Evergreen) plant in mild climates. In the fall, leafy stalks will detach from the parent plant, float away, root, and start new plants. This is the American water weed's most important method of spreading, while seed production plays a relatively minor role.

Silty [sediments](http://en.wikipedia.org/wiki/Sediment) and water rich in nutrients favor the growth of American water weed in nutrient-rich lakes. However, the plants will grow in a wide range of conditions, from very shallow to deep water, and in many sediment types. It can even continue to grow unrooted, as floating fragments. It is found throughout temperate North America, where it is one of the most common aquatic plants.

**How do we use them to measure primary productivity?**

There are really two ways. The first involves measuring Oxygen production. If we put an elodea plant in a bottle of water in the light and measure the Oxygen produced we can use that as a measure of Gross Primary Productivity since Oxygen is a bi-product of photosynthesis.

We will compare that to the Oxygen content of water without a plant and to that of an elodea plant put in a jar of water but in the dark. From these readings we can determine respiration and if we have gross primary productivity and respiration determining net primary productivity is easy.

So how does this work? We put the jar in the dark so no photosynthesis can occur because there is no energy to power the process. Since no photosynthesis is occurring, no oxygen is produced. We know through our class discussions that photosynthesis only happens when it is light, but respiration happens continuously 24/7. We also know that respiration requires oxygen. If we know the amount of oxygen that was dissolved in the water before the jar was placed in the dark and we know the amount of oxygen dissolved in the water after the jar is removed from the dark we can calculate how much oxygen was used to do respiration by using this equation:

Start (D.O. level) – End (D.O. level) = Amount of oxygen used for respiration

We use that number to represent how much respiration happened because we could plug it into the equation:

C6H12O6 + 6 O2 yields 6 CO2 + 6 H2O + 38 ATP

We know how much Oxygen was used so we could convert the mg/L to moles and we could determine exactly how much respiration occurred (don’t worry, I am not asking you to do this).

The second jar is used to estimate the amount of photosynthesis that occurs. Photosynthesis is complementary to respiration in the sense that it makes glucose and oxygen which are required for respiration. So if we measure the amount of oxygen that is dissolved in the water before we set our ecosystem jar into the light and then measure the amount of oxygen dissolved in the water after a set amount of time (a week, for instance) we can calculate how much oxygen was produced as a bi-product of photosynthesis by using this equation:

End (D.O. level) – Start (D.O. level) + respiration = Gross Primary Productivity (in other words how much photosynthesis occurred)

The reason you have to add respiration to the equation is the plant produced enough oxygen and glucose via photosynthesis to do that much respiration, so we have to account for it. For this reason I suggest calculating respiration first.

The reason GPP can be calculated using oxygen is because you could plug in the amount of oxygen produced into this equation:

6 CO2 + 6 H2O yields C6H12O6 + 6 O2

Just like with respiration we know how much Oxygen was used so we could convert the mg/L to moles and we could determine exactly how much photosynthesis occurred (don’t worry, I am not asking you to do this either).

The other way to measure primary productivity is through biomass gained or lost. So how does this work? We put the jar in the dark so no photosynthesis can occur because there is no energy to power the process. Since no photosynthesis is occurring, no glucose is produced. We know through our class discussions that photosynthesis only happens when it is light, but respiration happens continuously 24/7. We also know that respiration requires glucose. Additionally we know that organisms can convert glucose into biomass (proteins, carbohydrates and lipids) if they have more glucose than they need for energy purposes. If we know the amount of biomass that was in the plant before the jar was placed in the dark and we know the amount of biomass in the plant after the jar is removed from the dark we can calculate how much glucose was used to do respiration because biomass can be turned back into glucose when the organism needs glucose for energy. We can calculate how much biomass is converted to glucose and then used for respiration by using this equation:

Start (D.O. level) – End (D.O. level) = Amount of glucose used for respiration.

We would expect the plant to loose biomass in the dark because it is not producing glucose via photosynthesis so it has to convert some of itself into energy to survive.

We know how much glucose was used so we could convert the grams to moles and we could determine exactly how much respiration occurred (don’t worry, I am not asking you to do this).

Since we know that organisms can convert glucose into biomass (proteins, carbohydrates and lipids) if they have more glucose than they need for energy purposes we can use the second jar is used to estimate the amount of photosynthesis that occurs. Photosynthesis is complementary to respiration in the sense that it makes glucose and oxygen which are required for respiration. So if we measure the amount of biomass that is in the plant before we set our ecosystem jar into the light and then measure the amount of biomass in the plant after a set amount of time (a week, for instance) we can calculate how much glucose was produced as a bi-product of photosynthesis by using this equation:

End (D.O. level) – Start (D.O. level) + respiration = Gross Primary Productivity (in other words how much photosynthesis occurred)

The reason you have to add respiration to the equation is the plant produced enough oxygen and glucose via photosynthesis to do that much respiration, so we have to account for it. For this reason I suggest calculating respiration first.

The reason GPP can be calculated using biomass (glucose) is because you could plug in the amount of glucose produced into this equation:

6 CO2 + 6 H2O yields C6H12O6 + 6 O2

Just like with respiration we know how much glucose was used so we could convert the grams to moles and we could determine exactly how much photosynthesis occurred (don’t worry, I am not asking you to do this either).

Remember these are two separate methods that can be used to estimate productivity. They are independent of each other (as evidenced by the different units of measure). I would predict that if you did calculate GPP by converting the dissolved oxygen and the biomass to moles the moles of glucose would be the same (or nearly the same) for either method. That is why you can use either method to calculate primary productivity and you can do both to double check the level of productivity. If one is negative and one is positive, that should tell you an error occurred either in the execution of the experiment or the calculation of data.

**What to measure**:

Before:

* The mass of each piece of elodea (make sure you have removed as much excess water from the leaves as possible—otherwise they will have a greater mass than they actually have.)
* The dissolved Oxygen in the water sample

After:

* The mass of each piece of elodea ( Again make sure you have removed as much excess water from the leaves as possible—otherwise they will have a greater mass than they actually have.)
* The dissolved Oxygen in the water samples

**Equations to use:**

Dissolved Oxygen:

* Respiration = the starting dissolved O2 concentration – the dark bottle dissolved O2 concentration
* Net Primary Productivity = Ending dissolved O2­ concentration - Starting dissolved O2 concentration
* Gross Primary Productivity = Net Primary Productivity + Respiration

Biomass:

* Respiration = Mass of elodea before going into the dark – Mass of dark bottle elodea after coming from the dark
* Net Primary Productivity = Mass of elodea before going into the light – Mass of light bottle elodea after being in the light
* Gross Primary Productivity = Primary Productivity + Respiration

**You will need to:**

* Create a data table(s) to store information. I will be looking for:
  + A proper title
  + Units of measure
  + Variables labeled and in the correct location
  + Data is correct and recorded with the correct level of precision
* Measure the above factors today and in one week and record in the data table.
* Calculate gross and net primary productivity, and respiration using the two different methods. Then record them in a separate data table using the above criteria.
* Draw conclusions about the productivity of elodea.
  + Part one of the conclusion should be an explanation of how the equations work. In other words how do these equations allow us to say how much respiration and photosynthesis occurred?
  + Part two of the conclusion should be an explanation of how photosynthesis and respiration are related to gross primary productivity and net primary productivity.
  + Part three of the conclusion should be an discussion of your results including:
    - A summary of your results.
    - A discussion of whether or not the results match your expectations. This should also include a discussion on the errors that may have occurred during the investigation this should include:
      * A list of the possible errors
      * Why you think they occurred
      * How they might have affected your results
      * How you would control the investigation differently to prevent this error from reoccurring.
    - A discussion of how your results translate into GPP and NPP and Respiration