Grade 11 Science

Evolution & Invasive Plants: Secrets to Success?

One of the key concepts of the theory of evolution is "natural selection"- the idea that a plant's adaptive traits will determine how successfully it can grow and reproduce in its environment. Despite decades of study, scientists are still trying to determine why Invasive Plants (IP) are so successful- they can use that knowledge to predict future plant invasions. Some general patterns have been identified for Invasive Plants in southern Canada and the USA. Let's discuss some adaptive traits that might help Invasive Plants spread in the Yukon landscape.

[Instructions for students: Split into groups of 5-6 students- *each group answers **1** question* – you have 10 minutes. Afterwards we will discuss the answers as a class, so have your answer ready to read allowed.]

1. Growth Rate and Generation Cycle

   Some plants are adapted to grow slowly and some adapted to grow rapidly. *Growing slowly* requires less energy (each day of the growing season) and the plants tend to live a long time. Slow-growing plants usually take a few years before they reproduce- they are called perennial plants. *Growing rapidly* requires a lot of energy each day and the plant often doesn't live as long. Rapidly growing plants might germinate from a seed in the spring and reproduce the same summer- they are called annual plants.

   Question: Which strategy do you think successful Invasive Plants use most? Why?
   Answer: Typically IP grow rapidly and produce many small seeds. Growing rapidly means they often outcompete other plants for light and water and nutrients. While many IP are annuals, they can be perennials [or biennials] too. In fact, some plants will act as annuals, biennials or perennials, depending on the conditions in their local environment! Yukon example: White Sweet clover.

2. Plant Sex

   Some plants can only reproduce through sexual reproduction. Pollen must be transferred from one flower on one plant to another flower on a separate plant- the sperm in a pollen grain fertilizes an egg in an ovary in the second flower. This gives maximum genetic exchange.
   Meanwhile, some plants don't need to have sex with a different plant every time they reproduce to make seeds. The pollen produced in a flower can be used to self-fertilize the eggs in the ovaries in the same flower. This is called self-fertilization. Furthermore, some plants can reproduce asexually- they can produce an entirely new plant from a stem or root part that detaches from the parent plant. These are called clones.

   Question: Which strategy do you think successful Invasive Plants use most? Why?
   Answer: a bit of a trick question- while most plants will undergo sexual reproduction at some point in their lifespan, northern climatic conditions are often so poor that attempts at sex are unsuccessful and the plant aborts their flowers. In these instances they can use self-fertilization to ensure that at least some seeds are dispersed each season. Furthermore, asexual reproduction also helps perpetuate the species via clones in certain conditions. So the answer is- a very successful IP will be able to use all three strategies to ensure reproduction takes place! Yukon examples: Oxeye Daisy, Common Tansy, and Creeping Thistle.

3. Seed Production

Some plants produce only a few seeds per fruit. They provide each seed with lots of stored energy (starch) so that when it germinates it has energy right away, regardless of what is happening in the local environment. The seeds tend to be bigger.
Other plants can produce 20,000 seeds or more per plant per year. The seeds are smaller and have less stored energy with them to help them germinate.

Question: Which strategy do you think successful Invasive Plants use most? Why?
Answer: Most IP produce many small seeds. Yukon example: Creeping Thistle, Spotted Knapweed. Producing small seeds allows them to disperse seeds long distances and in many directions, increasing the chances that some of the seeds will germinate in favourable conditions. Quantity over Quality is their strategy- because in new or frontier habitats, the investment in a few seeds may not be worthwhile (more risk if genetically unfit to survive).

4. Protection from Attack/ Predation

There are many living organisms that attack plants, for example: insects, mammals, bacteria, fungi, etc. Through evolution plants have developed traits or strategies to protect themselves from these threats.

Question: Can you think of ways plants protect themselves? And
Why do you think invasive plants manage to survive, even though there are predators/ threats in the new area they are invading?
Answer: IP produce thorns, spines and hairs (e.g. Creeping Thistle). They produce poisons or just chemical compounds that make them unpalatable (e.g. Leafy Spurge, Common Tansy). Furthermore, many IP release chemicals into the soil that kill neighbouring plants…this helps them remove their competition from their surroundings (e.g. Spotted Knapweed).
It is important to note that, once they spread to new territories, many IP have no natural predators to reduce their population size. This means IP can become abundant (or dominant) and spread rapidly.

5. Tolerance to changes in climate / environmental conditions

Some plants are adapted to grow in a wide variety of environmental conditions- a wide range of temperature, moisture and soil conditions.
Other plants are adapted to grow in very unique or specific conditions- narrow temperature, moisture and/ or soil conditions.

Question: Which strategy do you think successful Invasive Plants use? Why?
Answer: IP can typically grow in a wide variety of environmental conditions—indeed, this is precisely what allows them to invade new areas. Most of the "top invaders" that have arrived in the Yukon over the past 20-30 years are found all over North America. Climate change is believed to be a significant contributing factor to the sudden invasions of IP in the Yukon.

6. Competition for Resources

Most plants need to use their leaves and shoots to get light energy for photosynthesis. Most plants need to use their roots to get water and nutrients (like nitrogen and phosphorus) from the soil. There are usually other plants trying to capture the same sunlight and nutrients.

Question: Do you think Invasive Plants are successful competitors for these resources? Explain why.
Answer: IP tend to be highly competitive by nature. Whether it's through rapid growth, chemical warfare, or more adaptability to a changing climate, IP can dominate needed resources and destroy habitat for native species.

Answers:

The answers provided here are generalizations. Most of these questions have multiple "right" answers because Invasive Plant species have incredibly diverse life strategies! So this exercise will give students the opportunity to think about evolutionary adaptive traits and they will likely be able to say something "true" for at least one Invasive Plant out there!

The take-home message is that *predicting the successful spread of Invasive Plants is a really big challenge* for all scientists and resource managers! Each species needs to be studied intensively to find a means for controlling its spread.

Budgeting 30 minutes for this exercise.

Jen will use concluding statements as a segue to the next section on Taxonomy and Dichotomous Keys-

"The Aster family (Asteraceae) is one of the most diverse plant families on the planet (an estimated 32,000 species- in Yukon ~145 species) and is considered one of the most advanced in terms of evolutionary adaptations. It should come as no surprise, then, to learn that 8 of the 10 IP of greatest concern in the Yukon are from this family!"

Jen will give short description of the aster family and describe how to use dichotomous keys.