Blueberries – All you Wanted to Know: Are they intelligent plants – why are there some good and some bad years – how to get grow and adapt etc. This article by Joe D. Shorthouse, Professor Emeritus in Department of Biology at Laurentian University that orgionally appeared in the Sudbury Star January 23rd 2016.

Blueberries have played a key role in the lives of Sudburians for generations, .

I have studied the lowbush blueberries shrub since arriving in Sudbury in 1975 and over the past year have gained a new appreciation for its amazing adaptations. I did this by sitting in the middle of patches for a couple hours each week from April to October of last year observing and photographing the flowers, saw how many shrivelled from frost in May and how the tiny green berries began to enlarge and then suddenly fell from the plants in July.

The purpose of this article is to share some of my findings and to offer an explanation as to what went wrong when the 2015 berry crop failed. I also explain why some botanists consider plants such as blueberry shrubs as intelligent.

Lowbush blueberry, with the scientific name Vaccinium angustifolium, is a member of the heath family and is found naturally in the forests of eastern Canada. It is a low spreading deciduous, perennial shrub averaging 35 cm in height. The leaves are glossy blue-green in the summer, then turn red to purple in the fall. Flowers are white, bell-shaped and about 5 mm long. Berries are dark blue and are covered with a white powdery material called bloom.

There are two species of blueberry shrubs in the Sudbury area. The second and less common is Vaccinium myrtiloides, and distinguished by fuzzy leaves and stems compared to the smooth surface of angustifolium.

A third species, the northern highbush blueberry Vaccinium corymbosum, is 1-3 m tall and has been transplanted to farms where it grows like apple trees. Berries from highbush are the ones we see in our grocery stores, but are not as divine on the tongue as our lowbush blueberries.

Lowbush blueberries have been a food staple for centuries, with indigenous peoples and settlers maintaining patches in coniferous forests by burning in 3-4 year cycles. Today, they are managed by growers and are the only ones marketed as "wild" blueberries.

Sudbury's lowbush blueberry is a fascinating shrub in many ways. They thrive in the poor quality soils on our hills where the pH is between 4.6 and 5.2 and levels of metals are high because of past smelting activities. They are one of the first plants following lichens and mosses to colonize smelter-damaged hillsides. Research at Laurentian University has shown that metals do not accumulate within the fruit even though leaves, stems and roots of Sudbury shrubs may have elevated levels.

Sudbury blueberry shrubs commonly grow in close association with stunted white birch trees and it appears they benefit each other. Thick mats of shrubs with their intertwined stems accumulate birch leaves in the fall which helps protect the ground from drying out and over heating.

A good way to illustrate the uniqueness of shrubs such as lowbush blueberry (and most other plants in the natural world) is to compare them to animals. A key difference is that shrubs evolved as sessile organisms whereas animals evolved as mobile organisms.

Being literally rooted to the ground, shrubs must be able to withstand and adapt to constantly changing weather, encroaching neighbours and develop a passive resistance to being fed upon by animals. They must do this without being able to move to a more suitable environment. Animals, in contrast can move each day to find food, shelter, mates or escape predators by walking, flying or swimming away.

As a consequence, the bodies of shrubs are designed differently from animals. Shrubs are composed of hundreds of distinct interconnected modules with each module capable of surviving on its own. Whereas animals have evolved to concentrate most of their vital functions in a few organs, shrubs have avoided restricting key functions to one area. If they did, their removal by herbivores would jeopardize survival of the entire organism.

Not having a central nervous system and a brain is another key difference between shrubs and animals. However, even without brains, all parts of a shrub are connected and information on light, moisture and manufactured food products is constantly exchanged between leaves and roots, flowers and stems.

Shrubs have an extensive understanding of their immediate environment and react to light, temperature, water, nutrients, touch, soil structure, toxins, microbes, gravity, insect attack and chemical signs from other plants by altering their growth.

In addition, shrubs can circulate fluids without a heart, breath without lungs, detect light and sound without eyes and ears, digest food without a stomach and smell without having a nose. They can also taste, feel, communicate and grow outwards to reach water, food, light and oxygen without having sensory organs like those of animals.

The most sophisticated part of plants may be the roots. Roots do not flounder randomly as they grow downwards, but search for the best position to take in water, avoid competition and garner chemicals.

Charles Darwin concluded his last book, The Power of Movement in Plants, by noting, "It is hardly an exaggeration to say that the tip of the radicle (root) ... acts like the brain of one of the lower animals ... receiving impression from the sense organs and directing the several movements."

Since Darwin's era, researchers have found that the tips of roots serve as brain-like information-processing systems. In addition to sensing gravity, moisture, light, pressure, and hardness, roots can also sense volume, nitrogen, phosphorus, salt, various toxins, microbes, and chemical signals from neighbouring plants. Roots can alter course before they hit an obstacle, showing that plants are capable of "seeing" an obstacle in the dark through their many senses. No animal can do this.

In addition, a blueberry seed germinating underground with no light knows that the shoots need to grow up and the roots grow down. Shrubs sense gravity at the tips of their roots and tell the rest of the plant which direction is optimal for its growth. How they do this remains a mystery.

So, instead of a single powerful brain, blueberries have a million tiny computing structures that work together in a complex network, something like the Internet. The strength of this evolutionary direction is that it allows shrubs to survive even after losing 90 per cent or more of their biomass. No animal can do this. Not having a single brain, or a single heart or a pair of lungs makes plants much harder to kill.

Blueberries don't see light signals but they respond to light by absorbing it in their shoot tips, and then somehow translate this into instructions that tell the plant tissues to bend towards the light. However, light for a shrub is much more than a signal. They use it to turn water and carbon dioxide into sugars that in turn provide food for all animals.

Blueberry shrubs also have the sense of smell. Many plants emit odours that animals and humans are attracted to, but plants also sense their own odours and those of neighbouring plants. Plants attacked by insects and herbivores emit "distress" chemicals warning adjacent leaves and neighboring plants to build up chemicals such as phenolic and tannins that make them unpalatable to insects.

Most blueberry shrubs are resistant to attack by leaf-eating insects, but there are instances their resistance is breached. For example, the outbreaks of forest tent caterpillars in 1989 and gypsy moths in 1994 were so severe, blueberry shrubs throughout the Sudbury region were completely defoliated after the caterpillars had eaten all the birch and oak leaves.

In both cases, the blueberry shrubs survived unscathed. They likely moved water and sugars from the leaves to the underground parts as the onslaught was occurring and had enough reserves the following spring that leaves, flowers and fruit returned to normal.

Another major difference between shrubs and animals is that shrubs are long-lived perennials. Given the right conditions, they theoretically can live forever, whereas animals live for a set period of time, reproduce and then die. This means that the blueberry shrubs we visit in mid-summer may have been alive at that site from the time the first white pine trees were cut down 140 years ago.

The late botanist Tim Plowman wasn't interested in comparing plants to animals. He was happy to just appreciate them as plants, but when pushed to make a comparison is alleged to have stated "They can eat light, isn't that enough?"

Blueberry shrubs reproduce sexually using flowers to produce seeds or vegetatively by making copies of themselves. They do this by sending out underground shoots and forming new plantlets along the length of these shoots. Animals in contrast, can only reproduce sexually.

Remember that blueberries are stationary critters and cannot move when it comes to the need for their pollen (sperm) being carried from the anthers (male part) to the pistil (female parts) of another flower. To solve this dilemma, they trick insects such as bees and flies into carrying pollen from flower to flower to fertilize their seeds.

Blueberry flowers attract insects by providing them with a meal of sweet, energy-rich nectar located at the base of the flowers. Insects have difficulty hanging onto the upside down bell-shaped flowers and as they struggle to feed on the nectar, they continue to beat their wings. Pollen is shaken out of the flowers and falls onto the backs of the insects. Called buzz pollination, the pollen is inadvertently carried to the next plant where it sticks to the stamens.

The formation of fruit surrounding the developing seeds is another way in which blueberry shrubs cleverly trick animals into aiding their dispersal to new sites. Seeds develop at the base of fertilized flowers inside berries that slowly swell in early summer. Of interest, the immature berries turn upwards as they enlarge.

Immature fruit starts off light green and odourless such that they are not obvious to herbivores. They only develop an odour once mature and then they attract animals such as deer, bears, foxes, skunks, squirrels, mice, and many species of birds.

Seeds pass through the digestive system unharmed and are excreted in the animals' droppings far from the place they were eaten. Seeds deposited in this way find themselves surrounded by a supply of fertilizer and if the conditions are right, they will start a new lowbush blueberry shrub.

New shrubs growing from seeds become a bushy plant over the next three of four years. Once it becomes established, this mother plant sends out underground shoots called rhizomes. New, white, leaf-less shoots called adventitious shoots arise vertically along the length of the rhizomes.

Once the white shoots break out of the soil or leaf litter, they darken and leaves appear along their length. These unbranched plantlets are flower-less in the first year, but in subsequent years, they become branched or multi-stemmed and produce flowers. Each new plantlet found along the length of a rhizome is called a ramet.

All the ramets we see in Sudbury look like individual plants, but in fact they are all connected to the mother plant and are genetically identical. Over the years, all the rhizomes and ramets extending from a mother-plant form a large patch that botanists call a clone. Patches (clones) up to 10 metres or more in diameter are actually a single plant.

The rate of spread by rhizomes averages 5 to 8 cm per year while in the managed fields of the Maritimes, they can grow 40 cm in one season. New ramets at the edge of a clone are always the youngest.

Growing as clones with extensive mats of rhizomes contributes to the success of blueberry shrubs and illustrates how clever they have become. Somehow, the mother plant can direct the number and direction of new rhizomes and ramets and send them towards sources of moisture or nutrients.

Since all parts of the clone are interconnected, ramets that find moisture or nutrients such as nitrogen or phosphorus, send them to parts of the clone that are deficient. Similarly, new rows of ramets sent to sunny spots send sugars made by photosynthesize to ramets in shady spots seeking water. Thus, growing as a clone not only allows blueberry shrubs to spread horizontally, they actually forage for resources in a patchy environment and share the resources found.

How mother plants detect increasing gradients of moisture and nutrients is unknown. These are amazing feats that no animal can copy. Furthermore, rhizomes somehow avoid collision with sister ramets and large structures such as rocks. Rhizomes even start growing around rocks before contacting them!

Although all the ramets act collectively for the good of the entire clone, each ramet can also act independently. If a ramet becomes separated from a mother plant by, for example, frost heaving, it becomes a mother plant and sends out rhizomes of its own.

As if these attributes aren't amazing enough, there is evidence that leaves of ramets chewed upon by insects produce a signal that spreads over the whole network and switches on a defence mechanism in undamaged ramets.

Leaf and flower buds develop on the shoot tips of mature plants in the fall such that they are ready to open in the early spring. There are more flower buds than leaf buds on younger shoots compared to older plants and this is why growers in the Maritimes prune or burn their shrubs. Fields comprised of new shoots on mature plants have a high density of fruit.

We don't prune or burn patches of blueberries in Sudbury and this is why patches are less productive as they age.

Tricking animals into helping them reproduce and spread their seeds are only two traits among many that illustrate how clever plants such as blueberry shrubs have become in their life history strategies.

However, some botanists go further and argue that plants such as blueberries can be considered 'intelligent' and claim that plants are much more like animals than most people think.

Most definitions of intelligence fall into one of two categories. The first is worded so that intelligence requires a brain and refers to intrinsic mental qualities such as reason, judgment, and abstract thought.

The second category is less brain-bound and defines intelligence as the intrinsic ability to process information from both abiotic and biotic stimuli that allows optimal decisions about future activities in a given environment. Lowbush blueberries do not have brains but they certainly ascribe to this second definition.

Using the concept of intelligence when describing plants is contentious with many researchers. It is difficult to say whether behaviours observed in plants which look like learning, decision-making, and intelligence deserve to be called by these terms. Many argue that the words should be reserved exclusively for creatures with brains and that plants be considered as beings that evolve adaptations.

However, using terms such as intelligence in plant biology has sparked new attempts to understand how they function and survive. For example, as Daniel Chamovitz states in his book What a Plant Knows, we are learning that some plants remember attacks by insects such as tent caterpillars or gypsy moths or conditions they endured in the past, such as drought, and modify their current physiology based on those memories.

According to American botanist Michael Pollan, author of several popular books on plants including The Botany of Desire, plants "have ways of taking all the sensory data they gather in their everyday lives ... integrate it and then behave in an appropriate way in response. And they do this without brains, which, in a way, is what's incredible about it, because we automatically assume you need a brain to process information."

In a similar vein, we assume that ears are necessary to hear and yet researchers have played recordings of caterpillars munching on leaves and the plants reacted by secreting defensive chemicals -- even though the plant wasn't actually threatened. According to Pollan "It is somehow hearing what is, to it, a terrifying sound of a caterpillar munching on its leaves."

The lost blueberry crop

In many ways, 2015 a strange year for lowbush blueberries in the Sudbury area. Early spring was normal and a good crop of flowers appeared, but then we had several days in May with frost and many of the flowers were damaged.

However, flowers that survived the frost in more protected sites, and those that appeared a few days later, were not damaged. These flowers were successfully pollinated by insects and turned into small green berries.

Immature berries were developing normally and then there was a period of below average precipitation from June to August. The thin layer of soil on Sudbury hills dehydrated and as the shrubs experienced drought, they went into their bag of adaptive tricks and reacted by simultaneously dropping their fruit.

This not only occurred in areas of dry soil fully exposed to the sun, it also occurred in shaded areas with adequate moisture. It was as if a message was sent out by the most stressed plants to warn others of a pending drought and they all reacted collectively.

One possible chemical messenger is ethylene which could have been released by plants suffering the most severe effects of the drought. Ethylene is a known regulator of responses to environmental stresses and is produced naturally throughout the life cycle of all plants. It initiates leaf senescence, the aging process that produces autumn foliage, and is produced in copious amounts in ripening fruit.

Perhaps ethylene was the signal used by blueberry shrubs in the Sudbury area instructing ramets to drop their fruit. I observed this drop in mid-July last summer both in Sudbury and on Manitoulin Island.

A week later the leaves shrivelled and dried. They became so brittle they crunched beneath your shoes. It was as if a signal emitted and received over the entire region raised the alarm that damaging drought was eminent and water and food resources must be pulled into the rhizomes and roots for use later when conditions improved.

The shrubs remained this way until late September when rain occurred. Once moisture levels returned, the shrubs moved water back into the stems and sprouted new leaves which produced food and contributed to the overall resources of the clone.

These observations show how intimately blueberry shrubs are attuned to weather conditions. Late frosts frequently occur, but some of the flowers do survive. If all flowers are damaged, or if it is too cold for pollinators to do their work, the shrubs simply put off their attempts to reproduce by seeds until the following year and instead put their resources into expanding the clone.

So, it appears we lost the 2015 crop by a combination of two key factors. First the frosts in mid-May reduced the number of flowers, but more importantly, the drought in July and August caused the plants to drop their berries.

Fortunately for long-lived shrubs such as lowbush blueberry, the loss of berries in one year is non-consequential. However, if the trend continued, it could become a serious problem for the shrubs, never mind a major disappointment for Sudburians.

There is also the worrisome possibility that the 2015 drought was a local indicator of global climatic change. Another local indication of global climatic change was the high temperatures and lack of precipitation (snow) experienced in the fall of 2015.

If there was agreement that some plants exhibit a form of intelligence, I would place our lowbush blueberry shrub at the top of the list

I hope readers will join me in having a new found appreciation for our lowbush blueberry shrubs Their ability to thrive on once industrially damaged hillsides and overcome frequent periods of adversity attests to how superbly adapted they are to the Sudbury area. It is not too much of a stretch to consider them Sudbury's most intelligent plant.

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