

DEFINING DROUGHT:

HOW RTI TEABAG FERTILIZER CAN HELP SEEDLINGS TO OVERCOME IT



Recently, more and more silviculture foresters find themselves facing mortality in their plantations on dry sites due to drought conditions. The recent audit done by the Forest Practices Board of regeneration in the Douglas-fir zone confirms this. However, given the results that many of the sites audited are not performing up to regeneration expectations, are there ways that we can successfully regenerate these sites up to expectation consistently? What is the real source of the problem that needs to be addressed?

Given that identifying the problem is the key to the solution, the purpose of this paper is to define the issue in these drier ecosystems from the perspective of the seedlings that you are trying to regenerate. We are given many best management practices (BMP's) to follow, but have you ever asked yourself what specifically the site limiting factors the BMP's are trying to address and how they are addressing it? Understanding the reason why you wish to apply different management practices is key to their successful implementation. It is my hope that after reviewing the following information, you will better understand the main issue that needs to be addressed on drier sites and how to overcome it. In addition, there will be discussion in how RTI teabag fertilizer can also assist as a part of your successful silviculture regime. Success on dry sites is not a result of any one BMP, but successfully putting them all together to address the site limiting factors at hand. Proper nutrition is a big part of the equation.



Part 1: Drought is a Fact of Life In Drier Ecosystems

It would not be a surprise to anyone that drought, or a lack of moisture, is considered the main limiting factor when regenerating drier forest ecosystems. When having a conversation with foresters regarding a dry summer in which they suffered a lot of mortality in their plantations, they will often say that they had a bad drought. But what exactly does that mean in terms of how it impacted the tree seedlings that they are responsible for?

Defining Drought: What Is It?

There are important three critical components to drought:

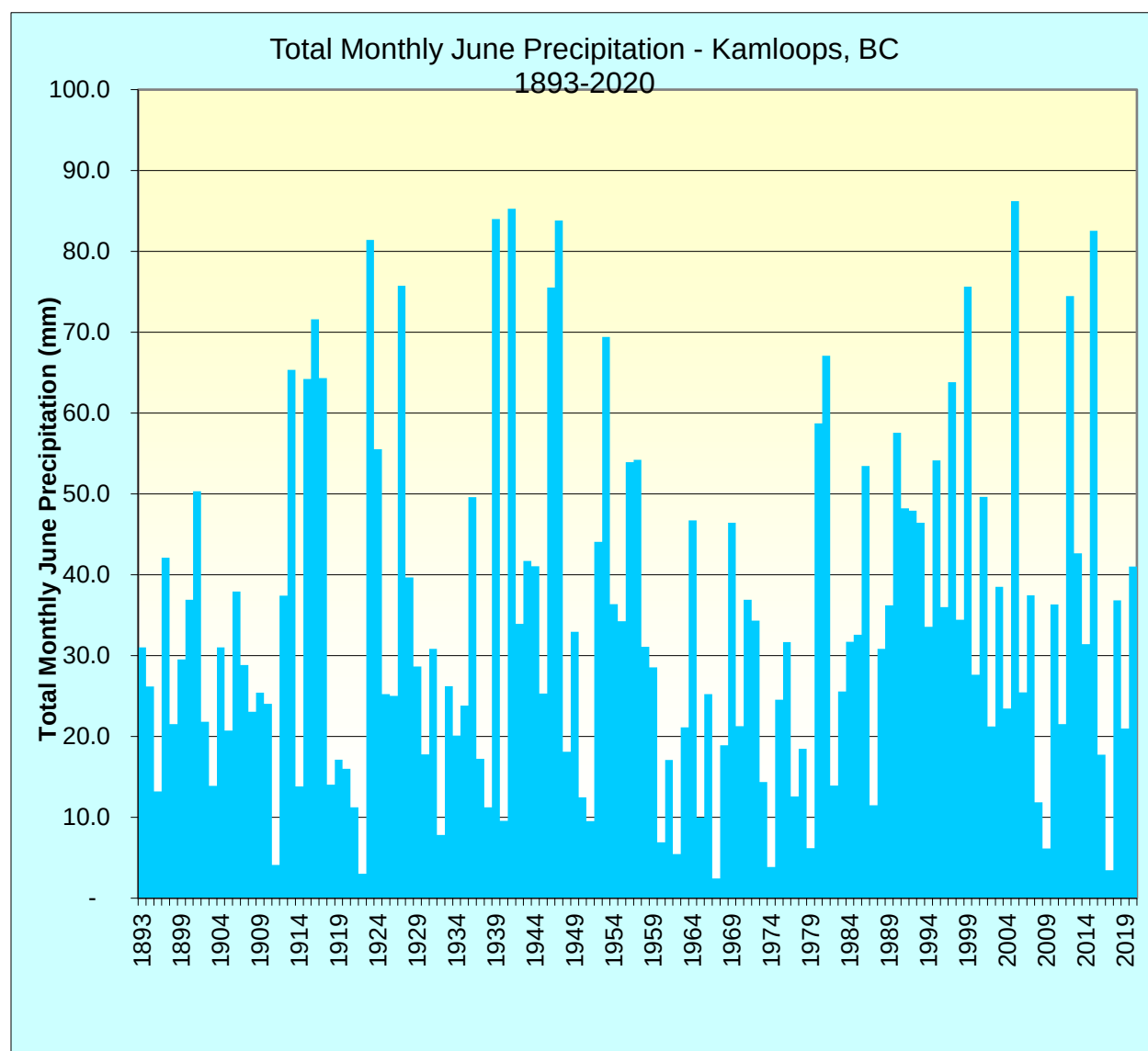
1. Weather - the lack of precipitation and the resulting soil moisture deficit. More importantly high air temperatures/ low humidity resulting in an atmospheric moisture deficit that desiccates the seedlings.
2. The timing of the drought occurrence during the growing season.
3. Intensity – The length of time between precipitation and when precipitation finally fell, was it enough to re-charge the soil

In order to help break it down, and to put drought into perspective, provided in the following pages are a number of charts showing the weather for Kamloops during the June of 2017, one of the hottest, driest summers on record in the BC Interior and one that won't quickly be forgotten.

The First Aspect of Drought: Weather

It has been suggested that Climate Change is increasing the likelihood that we will be experiencing hotter and drier summers, and that periods of drought will increase as a result. The hot dry summers of 2017 and 2018 were said to be evidence of this and it is implied that something new is occurring. However, when looking back at the data from the Kamloops weather station over the past 127 years it is quite evident that periodic hot, dry summers are simply a function of climate in the interior of British Columbia. In other words, hot, dry summers like those in 2017 and 2018 are not new and are to be expected from time to time. Therefore, if foresters are going to successfully regenerate forests in drier ecosystems, like those in the BC Interior, they are going to need to anticipate that hot, dry summers can and will happen and manage for them accordingly. Many of the past plantation failures can be directly attributed to failure to anticipate this simple fact, and thus, key site limiting factors that prevented seedlings from obtaining moisture during periods of drought were not addressed prior to planting.

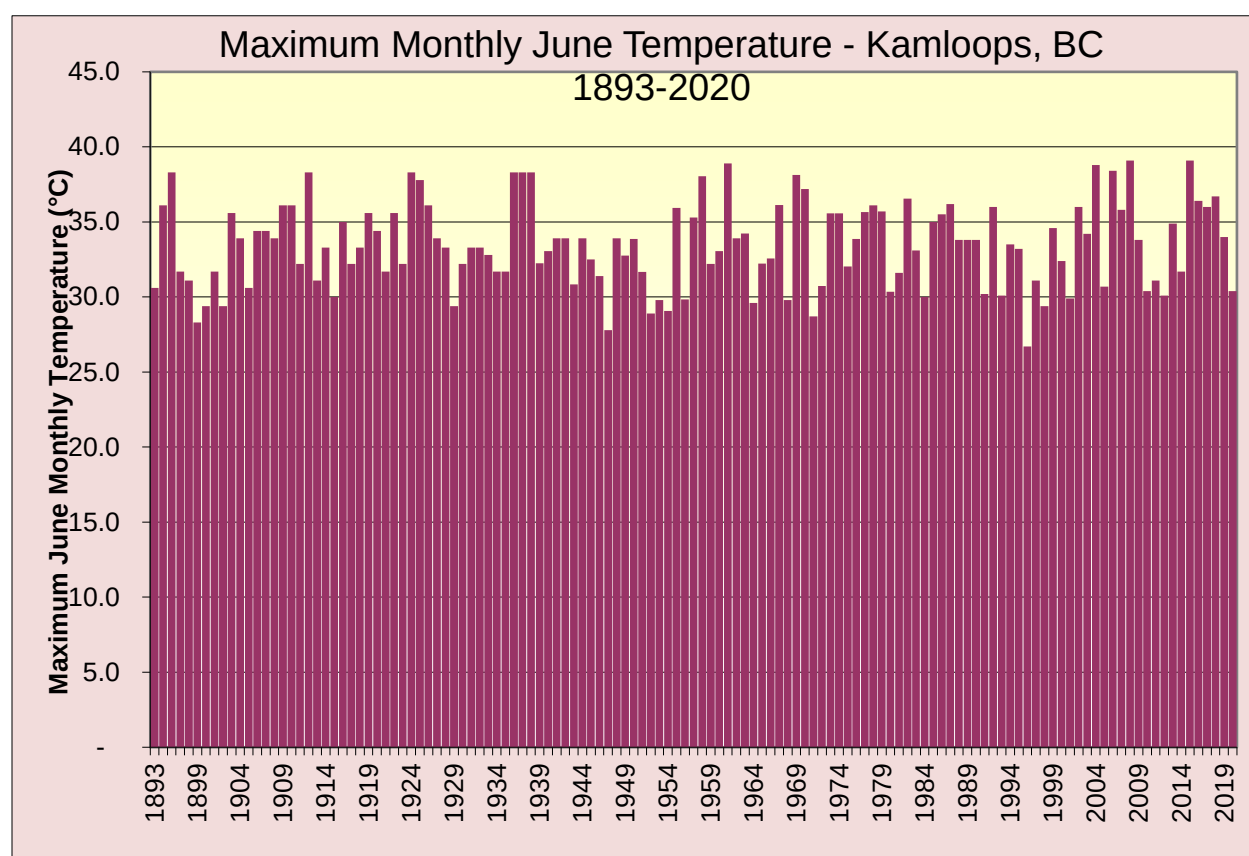
Below is a chart for Kamloops that shows the total precipitation for the month of June over the past 127 years. For Kamloops, the moisture deficit that helped to set up for the massive fires of fires experienced of 2017 was experienced in June of that year. Most of us had not experienced a dry June like 2017 in our careers so it felt brand new. In fact, one needs to look back into the early 70's (1974) to find a similar period of low precipitation. In addition, the chart also shows that low June precipitation like that of June 2017, occurred also in 1967, 1922, and 1911. And these are only the extremes! Looking at the data, there have been many, regular periods of spring drought over the past century. Thus, periods of extreme drought, or any kind of drought period for that matter, are not unprecedented in these ecosystems and the chance that they could occur needs to be anticipated and managed for. From looking at the chart, **predicting when drought will happen from year to year is not possible.**



Total Monthly Precipitation received during June for Kamloops, BC from 1893 to 2020

Air Temperature

When putting drought into perspective, it is not only the amount of precipitation received that matters. I think that we would all agree that what also plays a very critical role is air temperature. High air temperatures combined with low humidity can create a vapour pressure deficit (VPD) around the seedling. The higher the temperature, the lower the humidity which results in a greater the vapour pressure deficit. If the VPD is too great, the seedling will stop photosynthesizing, growing, and potentially even desiccate to the point of death. Although this is often not considered, a VPD in the atmosphere surrounding the seedling can have even a greater negative impact than dry soils, especially when the seedling is flushing. Here is a chart for Kamloops showing the maximum daily temperature for the same time periods.



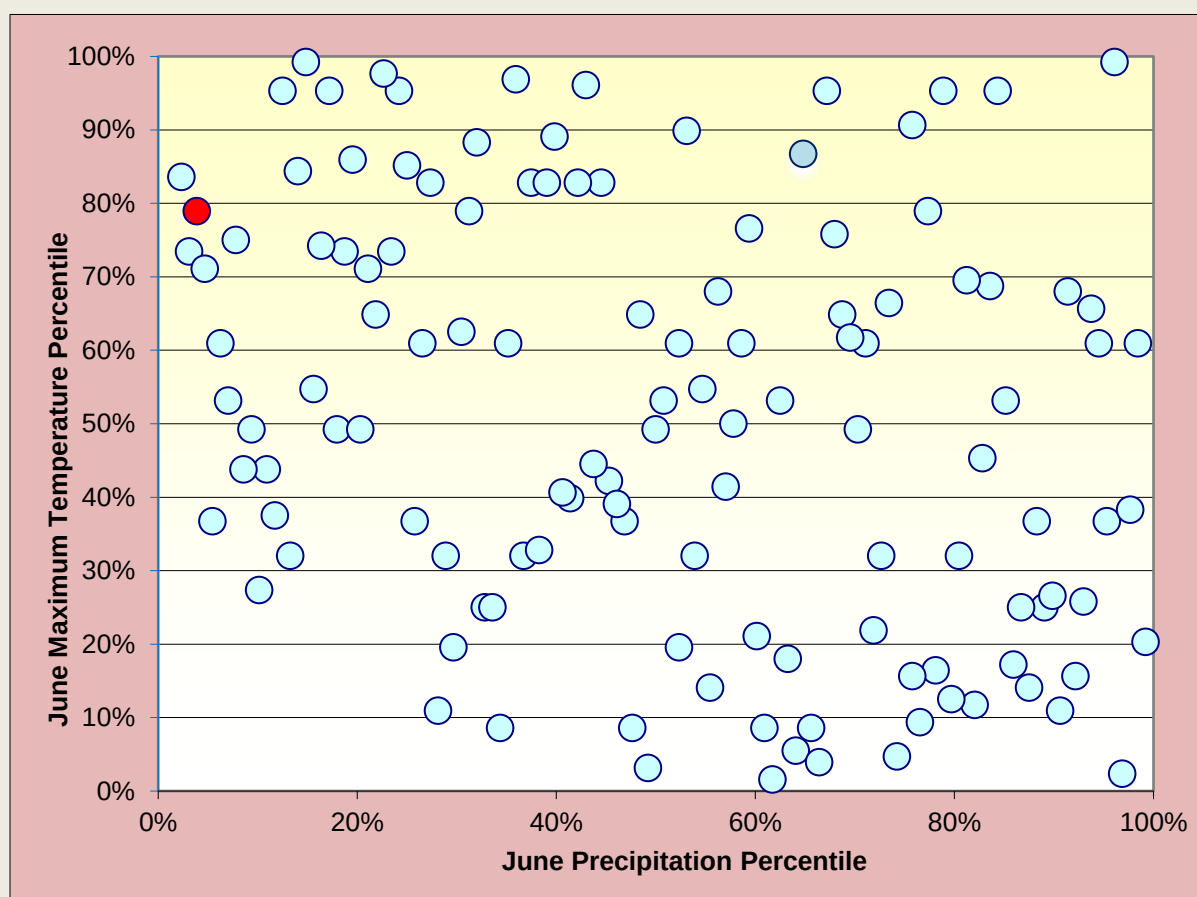
Maximum Monthly Temperature during June for Kamloops, BC from 1892 to 2018

Although the maximum daily temperature recorded in June of 2017 was not the highest daily maximum temperature ever recorded during June, it was certainly among the highest. Maximum May temperatures were also approximately 36°C during the other extreme May droughts previously mentioned: 1974, 1967, 1922 and 32°C for 1911. However, this chart also clearly shows that very high temperatures occur during the spring on a regular basis in the BC Interior.

Putting the 2017 drought in perspective – How bad was it?

The drought of 2017 in the BC southern interior is not one that anyone will forget any time soon given its impact. Seedling mortality occurred on a massive scale during that summer. As per the data from the Kamloops weather station in 2017 a time period of extremely low precipitation, combined with relatively high maximum daytime temperatures was experienced. But out of curiosity, how bad was it for these areas compared with the same time periods over the last 127 years? The following chart should help to define the relative severity of the drought experienced during the June of 2017. Each “bubble” represents the temp. vs. precipitation of one of the past 127 years. The further left the bubble the drier the June, while the higher up the bubble, the hotter the June.

This area experienced a maximum daily temperature in the highest 79th percentile while at the same time experiencing monthly June precipitation in the lowest 96th percentile. However, it still wasn't the worst!



Weather For Kamloops, BC – June, 2017 Relative To Other Years Since 1893

The information presented above is quite fascinating stuff and certainly helps to put things in perspective, given the vast majority of us haven't ever experienced a spring like that in our forestry careers.

The Second Aspect of Drought: Timing During the Growing Season

We have now covered drought in terms of weather, but they say in life that “Timing is everything!” and drought in terms of seedling performance and mortality is not just a function of what happened with regards to the weather but when.

When thinking in terms of drought, most foresters think of it terms of the lack of precipitation that fell and how long the dry spell lasted. And although that is certainly an important consideration, have you ever thought about it in terms of timing? In fact, partly what made the drought so severe for seedlings during the spring of 2017 in the BC southern interior was when it started.

Seedling Physiology and Growth Patterns

There is no more vulnerable time for a seedling than when it is starting to flush in the spring. Seedlings start their bud burst based on the accumulation of growing degree hours. When conditions are suitable the seedlings burst bud and start extending their leaders. Initially as it grows and extends its needles, leader, and branches the foliage is very lush, as per the seedling shown in the adjacent photo, and as a result the seedling transpires a lot of water. Hence, it is not an accident that seedlings grow during the wet spring months when there is lots of soil moisture and cool temperatures and higher humidity. The waxy cuticle layers that help a seedling control its moisture loss during the later summer months have not yet formed and the seedling is extremely vulnerable to any kind of moisture deficit. The brand-new foliage during this period is not really that much different than lettuce in its ability to control moisture loss.



During the spring of 2017 in the BC Interior, despite the fact that it was early enough in the growing season that there was initially probably sufficient soil moisture from the spring snow melt and spring rains, the greater issue was the high air temperatures/low humidity, creating a vapour pressure deficit around the seedling during a time when they were most vulnerable to desiccation. Soils would certainly have dried out mid-late June.

Even if the seedlings were to survive, their growth would have been impacted as the low humidity levels shut down their ability to photosynthesize and grow. The combination of potentially inadequate soil moisture combined with a high vapour deficit caused by high air temperatures at that time of year, before the seedlings are capable of handling it, was a sure recipe for mortality on a large scale.

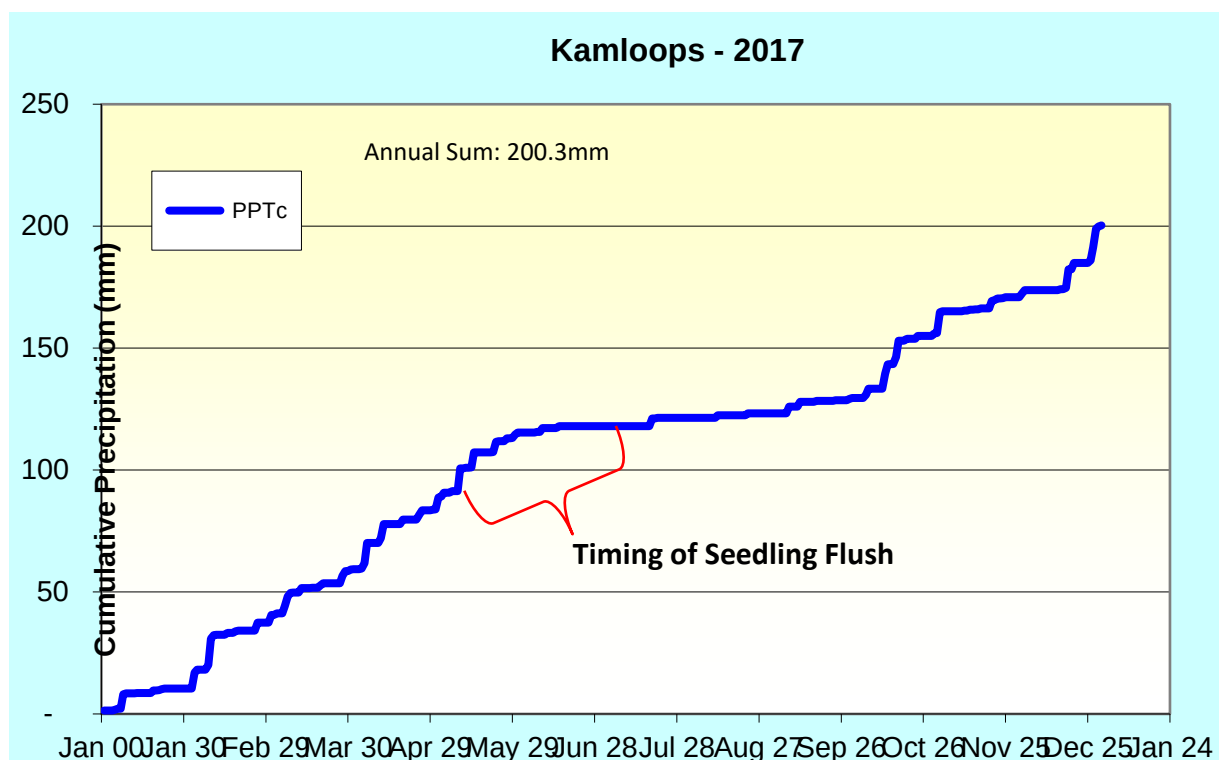
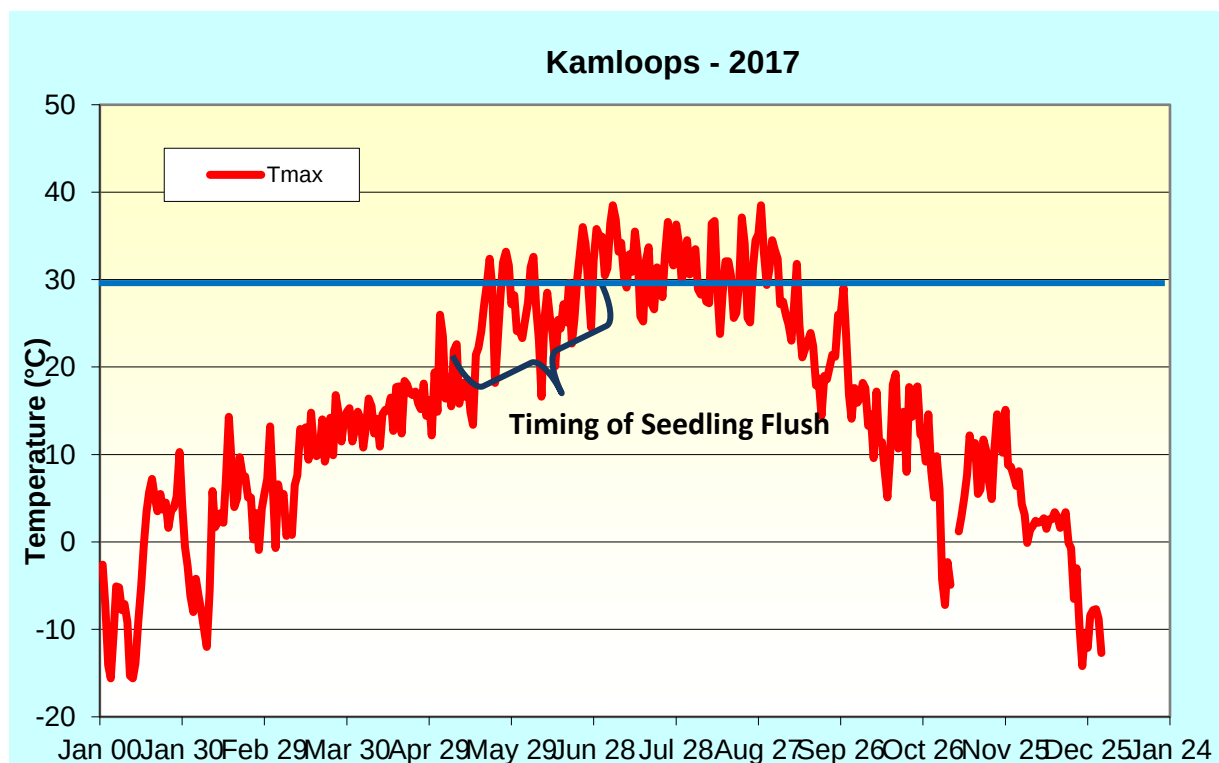


Example of a desiccated seedling that couldn't survive a high VPD during the spring of 2017

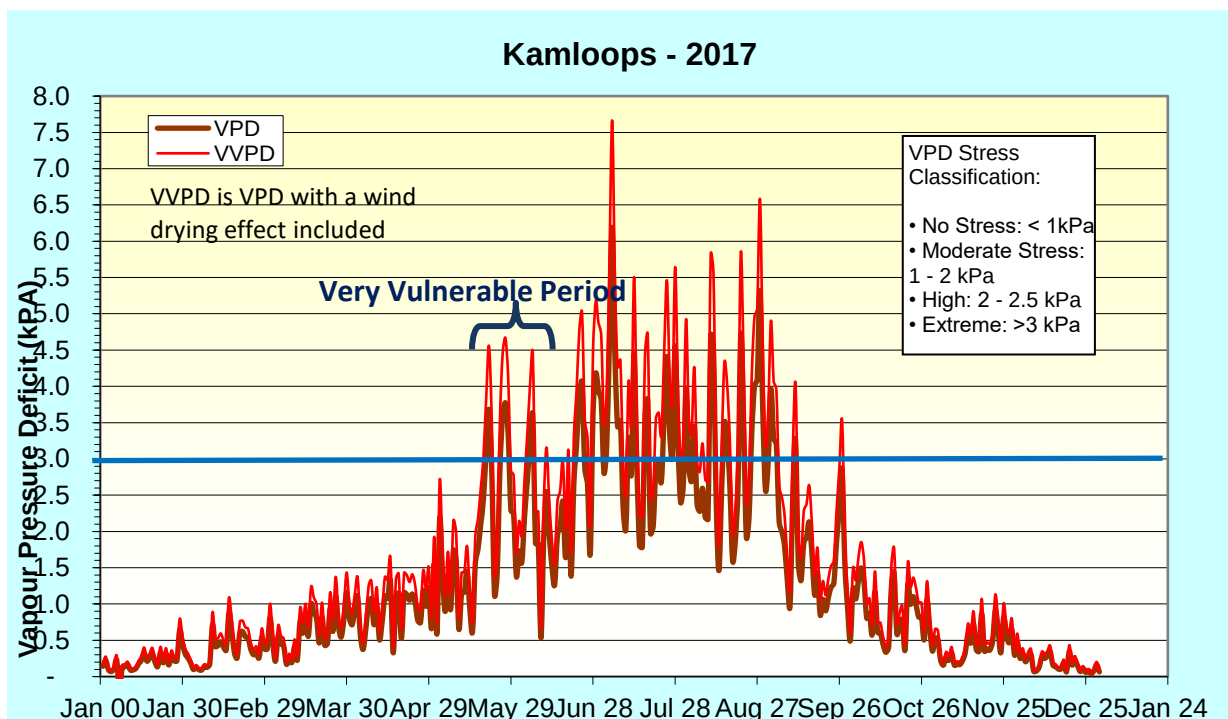
Another example of a seedling that died shortly after planting due to atmospheric moisture stress caused by a very high vapour deficit (VPD). It has barely flushed and the new foliage for the leader has the characteristic "Shepard's' crook" appearance.



To help you visualize this, below are some charts of the Kamloops weather during the spring of 2017. Pay particular attention to the weather during the time the seedlings were flushing. This generally happens in the drier ecosystems of the BC southern interior from May 10 until the end of June.



From the preceding charts we see that although there was lots of rain and cooler temperatures in early May, by the third week in May things changed substantially. Daytime highs were already in the low 30's! The high air temperatures combined with the dry air created unseasonably high vapour pressure deficits (VPD) as shown in the chart below. Pay particular attention to the vapour pressure deficit from mid-May until mid-June. Note that when the VPD gets over 3, trees are no longer photosynthesizing and mortality starts to occur. Yes, there may be adequate soil moisture but the seedling still needs to be able to transpire quickly enough to keep its foliage adequately supplied with moisture. This is very difficult to do when the seedling is flushing and its foliage is soft and lush like lettuce, not yet having the hardened off thick waxy cuticles ready for mid- summer conditions this early in the growing season. This is when most of the damage would have been done and even if the seedlings didn't die at this time, these stressed seedlings were not in any position for the long, hot summer drought that continued. Look at how extreme the VPD's were during that summer!



What Is Vapour Pressure Deficit (VPD)?

We consider the water content of a living leaf to be 100% RH, meaning completely saturated. The air on the other hand is normally unsaturated. This differential enables water to flow from the plant to the air and the seedling pulls water and nutrients up from the soil as this occurs. However, when the VPD is at high levels caused by hotter, drier air, the evaporation rate from the seedlings' stomata may be too fast, causing the seedling to dry out. During a period of very high VPD seedlings go on the defense and try to control moisture loss by closing their stomata. However, despite this effort, it may not be enough to completely control the loss of moisture during their very vulnerable growth period. Not only that, closing the stomata in an effort to retain water, stops the intake of the CO₂ used for photosynthesis (which means no food for the seedling), which further stresses the seedling and impedes growth and development.

The Third Aspect of Drought: Intensity

Exacerbating the spring drought of 2017 was its intensity. There were long periods of dry weather with very little precipitation. What little fell was certainly not enough to even begin to re-charge the soil, which becomes more and more hydrophobic the longer the dry period lasts. South to west aspects and steep slopes can further exacerbate things. Looking at the precipitation chart on page 8, only 15mm of rain was received from June 1 until Oct. 5. Combined with the extreme temperatures, it was the nail in the coffin for many seedlings after such an extremely challenging spring.



Example of a desiccated seedling that couldn't survive the long drought of 2017. You can tell that it went further into the growing season as its leader is fully extended and, although it can't be seen in the photo, the bud was forming

Key Take Home Message

To be consistently successful on drought-prone BC Interior sites, the standard operating procedure can not be to build a programme around the hopes of good soil moisture and weather conditions. Expect a drought and manage to that reality. Be surprised when you get good conditions!

PART 2: What Can You Do To Assist Your Seedlings Through A Drought?

Despite how bad the drought of 2017 was, there are many seedlings that still survived as there are many things that foresters can do to help their seedlings overcome drought conditions in dry ecosystems. This is reviewed in much greater detail in the brochure **“DRY SITES AND RTI TEABAG FERTILIZER - Putting the 2017 Drought Into Perspective”**

And once again, given the unpredictability of specific weather patterns from one year to the next, knowing that extreme events like have happened in 2017, do occur and can occur again, to have consistent regeneration success in dry ecosystems we must prepare our seedlings for potential periods of adverse drought conditions, particularly in the spring when they are most vulnerable. But how do we give our seedlings the best opportunity to overcome the adversity? Understanding how to make soil moisture available to the seedling while at the same time reducing vapour pressure deficits around it during periods of drought is key, especially taken in the context of seedling growth patterns and physiology.

Microsite Selection/Preparation

The first and most critical factor in regard to assisting seedlings in overcoming periods of inadequate soil moisture or high vapour pressure deficits, is a suitable microsite that helps a seedling overcome site limiting factors. This is reviewed in much greater detail in the brochure **“DRY SITES AND RTI TEABAG FERTILIZER”**, however I will review the concepts that must be addressed briefly here with the following photos.

This site, a dry, exposed ridge in the IDF dk2, in the McLure Fire was planted “as – is” within 2 years of the fire occurring. 16 years later there was essentially no stocking as site limiting factors were not addressed prior to planting.





The vegetation, the matt of grass in particular, outcompeted the seedlings for moisture which was already very limiting on this southerly exposed, sloped site. Note that the root mass of the grass is 3x the vegetation that you see on top. Soils were dense and rocky. The end result is hardly surprising.



Therefore, to get the site re-stocked, 16 years after the fire, the site was prepared with aggressive site prep. (mounding) that addressed the site limiting factors that inhibited the seedlings from obtaining adequate moisture, including atmospheric moisture (ie. lowering the VPD).



Seedling now thriving on a dry site where regeneration had previously failed when it was planted “as-is” without RTI Teabag fertilizer.

Below are some things to note with regards to the microsite the seedling on the previous page is planted in that allowed it to thrive. ***Note: These are things to consider for each site, however, how overcoming them is ultimately accomplished (ie. type of site prep., block orientation, microsite selection, etc.) will be dependent on individual site objectives and characteristics.***

1. **Competing vegetation** (including the roots) **was removed** from around the immediate vicinity of the seedling.
2. The exposed mineral soil allowed the **snow melt and rain that was received to penetrate down to the seedling roots.** If the site prep. creates a depression, it will also help to collect water around the roots, for years.
3. The seedling was **planted as low as possible** to maximize the availability of soil moisture as long as possible into the growing season.
4. The soil was mounded during site prep. to **provide shading to the seedling** during the hottest part of the day to lower the VPD around the seedling foliage. If site prep is not possible, shading could also be obtained from logs or stumps and even the stand adjacent to the opening. ***Note: Not all site prep. is created equal and if it is not aggressive enough on certain sites to provide shading, seedling mortality will still not occur, although certainly not as much as planting “as-is”***

Because moisture stress on dry interior sites can be so severe, failing to address any single one of these elements could lead to seedling mortality. Once again, how you do it is up to you, but **failure to address even a single site limiting factor will always lead to a poor result in the dry ecosystems of the BC Interior.**

Planting Timing

The second critical factor to assisting seedling to overcome periods of inadequate soil moisture or high vapour pressure deficits is microsite is the timing of planting. Planting as close as possible to the site becoming snow free is critical so that the seedling is able to flush, extend its leader, and develop its root system in the spring when soils are moist and air temperatures are cool. If access to the site first thing in the spring is not possible due to access constraints, a fall plant is something to consider if conditions will allow.

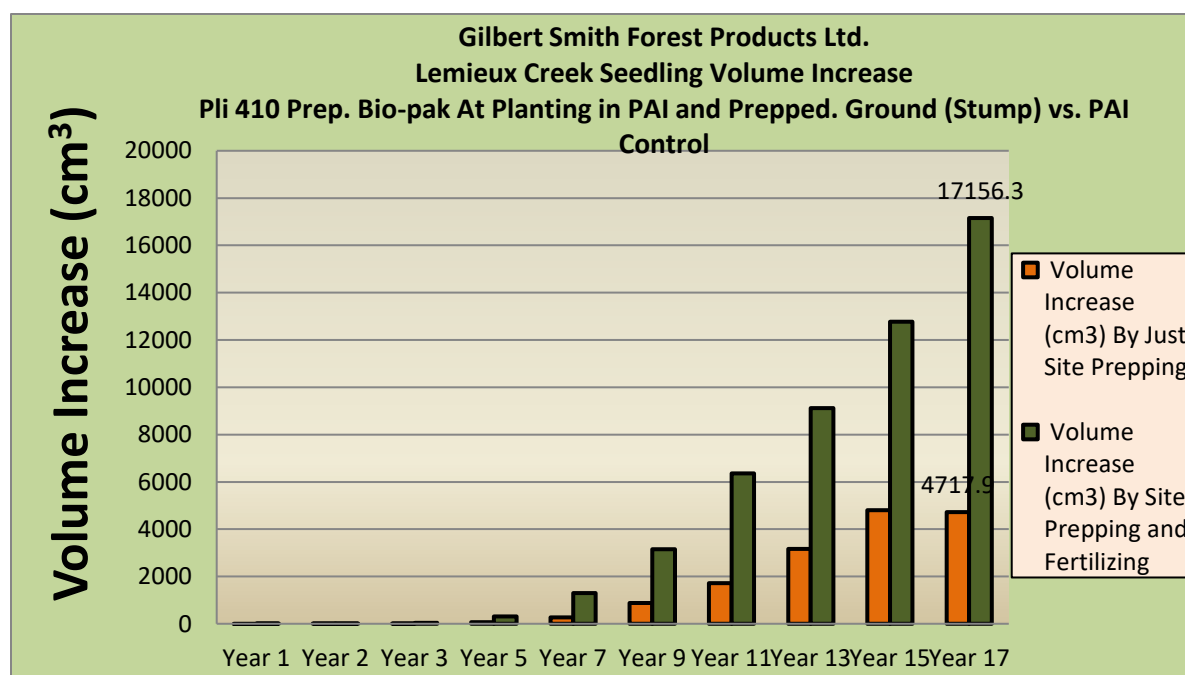
Nutrition: What Role Does RTI Teabag Fertilizer Have In Assisting Seedlings to Overcome Drought?

Although the microsite and timing of planting may be the foundation, seedling nutrition also plays a critical role in helping a seedling to overcome periods of drought. **To be successful on dry sites, foresters need to think long term, beyond just the first growing season, and develop seedlings that won't just survive but be strong to take on the stresses of the site.** Performance does matter. When considering the vegetative competition and browse pressures that these sites can have.

Part 3: RTI Teabag Fertilizer Benefits

First, if site prep. is utilized to establish the seedling, and the seedling is planted in the lower soil profiles to maximize soil moisture availability, the additional nutrients provided by RTI teabag fertilizer are very beneficial. The lower soil profile is devoid of organic matter, and thus, generally lacks adequate nutrition. This not only impacts the seedling but also the soil biology associated with it. Poor associations with soil biology will severely limit the tree over the long term from obtaining nutrients and moisture from the soil. RTI Teabag fertilizer for dry sites helps to overcome this hurdle.

Note: 17 year results from the Lemieux Creek fertilizer trial (IDF mw2) clearly demonstrate fertilizing with RTI teabag fertilizer can take the benefit of any site preparation conducted and multiply it.



Lw after the second growing season. Planted in a well prepared spot and fertilized with RTI Chilcotin PHP 17-5-7 at the time of planting. And this is a tree that was planted in the spring of 2019 during a time of very high VPD!

Leader Tip

Note the shading that would have been provided by the mound during the first growing season



Second, the development of the root system demands optimum nutrition in a couple of different ways. Not only is the development of the fine root system that uptakes moisture and nutrients very nutrient demanding, so is the development of the foliage that feeds the roots with energy. Maximizing root production is critical in assisting trees to overcome periods of drought.



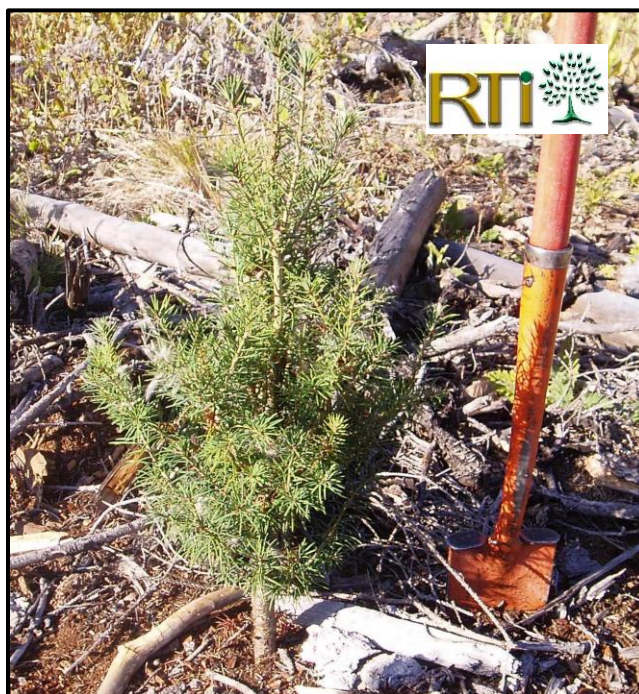
The seedling on the left was not fertilized at the time of planting vs. the one on the right, grown on the same site, that was fertilized with the Gilbert Smith PHP 18-10-10. The fertilizer assisted the seedling to develop a stronger root system to tolerate the late summer drought.

Thirdly, optimum nutrition provided by RTI Teabag fertilizer makes the seedling more vigorous and provides the tools it needs to harden itself up and take on the stress that results from drought. **Defense compounds and the waxes that protect the needles from environmental stresses are very nutrient demanding.**

Fourthly, RTI teabag fertilizer strengthens the stem by building caliper. If you have browse pressures from deer or voles, or even trampling from cattle, developing a thick caliper is critical to resisting these pressures.

Here is the target we are trying to achieve. This foliar, root, and stem biomass can only be achieved with adequate, balanced nutrition. RTI teabag fertilizer provides what forest soils can not!

Fdi fertilized with Continuem - third growing season.





Last, and not least, and this is very important to consider, **just because a seedling gets through the first growing season alive does not mean that it will ever make it to being a crop tree!** RTI Teabag fertilizer strengthens the vigour of the seedling to help it perform to its maximum!

What are the chances that this **unfertilized** seedling (on prepped ground) will ever make it to FG when the competing vegetation can quickly blow up as per the photo below, even in areas that have been site prepared. Good luck! Can you afford not to fertilize at the time of planting?



**The first growing season is
not the end!**



**Seedlings
fertilized
with RTI
teabag
fertilizer
are set up
for the
long term!**

**Get the value out of
your site prep. and
reduce the liability of
having to go back and
re-plant by fertilizing at
the time of planting
with RTI Teabg fertilizer
so that your seedling
doesn't just barely
survive, but thrives!
These are Fdi fertilized
with RTI Chilcotin-paks
PHP 17-5-7. Above Year
2, Below Year 5.**



RTI Has You Covered With Different Teabag Fertilizer For Different Types of Dry Sites

In addition, at RTI, we realize that not all drought situations are the same, so we have developed a number of different products over the years to assist you. Here is a summary of the various products that we have to assist you overcome periods of drought. One of the greatest limiting factors of dry sites is that they can lack soil organic matter, so with the exception of the Hydration-pak, all of our products contain organic matter in one form or another to hold nutrients, to provide a home for beneficial soil microbes, to hold soil moisture around the seedling, and to provide beneficial organic compounds that stimulate root production.

Anything that you can do for the seedling to assist its establishment by making moisture available, allow for easy root extension, and starting its growth pattern earlier in the season to get through its growth cycle so that it can harden up before the summer drought period hits will be of benefit.

What Is the Best RTI Teabag Fertilizer Blend To Use For Dry Sites?

Depending on your situation, RTI has 5 different fertilizer blends that will assist you with regenerating dry sites.

Chilcotin –paks 10g 17-5-7: Designed for general dry site applications and the most commonly used blend. It contains 9g of fertilizer and 1g of humates to stimulate the growth of the root system and can also be used on sites that have been impacted by fire. It can be placed in the same hole as the seedling as per other RTI PHP blends

Chilcotin – Worm paks 20g 15-4-5: This blend was designed for interior sites that have, higher pH and been severely impacted by fire or other sites where all of the organic matter has been removed from the site such as deeply cut old roads and landings. This teabag contains 10g of fertilizer as well as 10g of worm castings included to replace the organic matter missing from the soil. The worm castings will also help to stimulate root growth and the associated soil biology that releases soil nutrients to the seedling over the long term. Not only that, the elevated available calcium provided by the worm castings appears to be giving the seedlings an extra edge to overcome prolonged periods of drought.

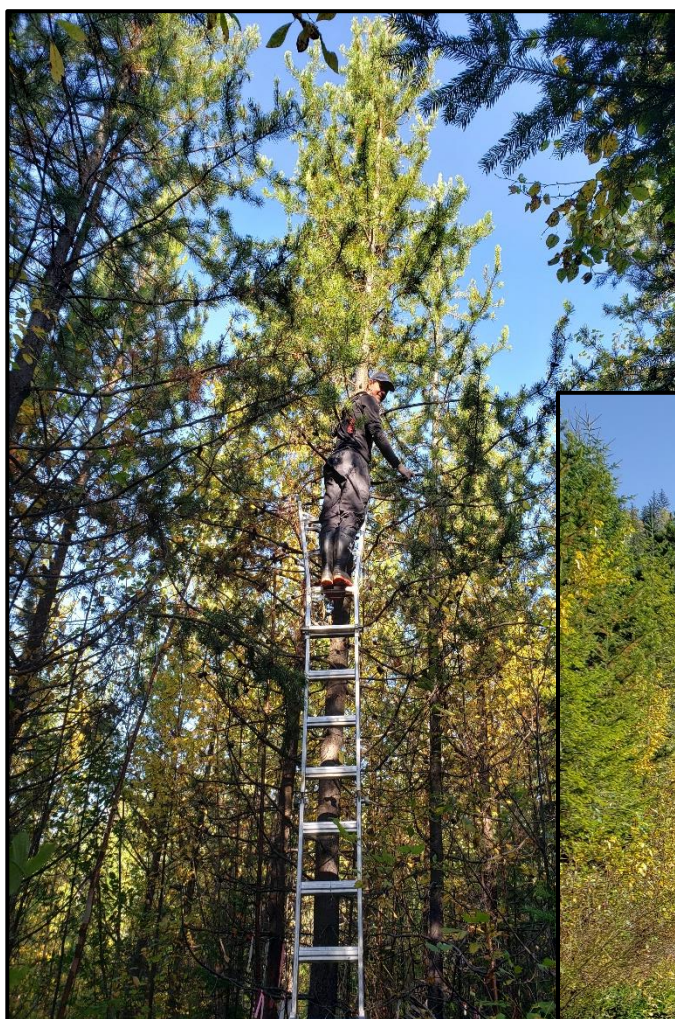
Hydration-paks 10g 16-8-5: The original dry site fertilizer! This blend contains 8g of fertilizer and 2g of moisture retaining polymer that will retain up to 250ml of water around the seedling when fully swollen. At the end of the day we would rather provide nutrition to the seedling for the development of the root system, as per the Chilcotin-pak. However, there are fast draining sites where the water does not stick around long enough or you can't plant early enough for the seedling to utilize the fertilizer to set up its root system before the summer drought hits. This is where the Hydration-pak should be deployed so that it can hold moisture around the seedling while the root system is being developed.

Chilcotin 20g 15 - 5 -6 with Bio-char – This is the new kid on the block and is in the trial stage at this time. It has the same fertilizer blend as the 10g Chilcotin, but has 10g of Bio-char to hold nutrients around the seedling and to stimulate beneficial soil organisms that will live within the Bio-char. If you would like to try a sample next year let me know. It can go in the same hole as the seedling which is really important on dry sites so that the seedling gets the nutrients as soon as possible prior to the soil drying out. It also is for those sites that have been heavily impacted by fire and have had all of their organic matter burned off.

Further Information

If you have questions or require more information on how to establish seedlings on dry sites with RTI Teabag Fertilizer, please do not hesitate to **contact Darius Bucher, R.P.F., Integral Forest Management Ltd. at integralfm@telus.net or (250) 318-8861.**

Also, please check out RTI's brochure *Leading Edge Planting Hole Placement(PHP) Technology* which describes how the teabag fertilizer works.



Yes it's possible! Here I am checking out a 14+m tall 18 yr old tree fertilized at the time of planting in the IDF mw2 at Lemieux Creek, near Little Fort BC. This site prepped and RTI teabag fertilized block was declared FG Yr 5 and now looks like this!

