Quercus garryana
Pacific University Oregon White Oak Rehabilitation Case Study

Jared Kawatani, '17
Center for a Sustainable Society, Pacific University

Introduction

Quercus garryana can be found in British Columbia, Washington, Oregon, and California. Some of its common names are: Gary Oak, Oregon White Oak, and Oregon Oak. They are large slow growing hardwood trees that grow in woodlands, savannahs, and prairies. They are very versatile trees as they can grown in cool climates, humid coastal climates to hot, dry inland environments. But they prefer moist, fertile sites over the very dry conditions that they can grow in as well.

Unfortunately, there are multiple problems that Oregon white oaks face over all as a species on the west coast. One of those issues is that they are threatened by the encroachment of other trees because they are sun loving and have a low tolerance for shade and thus get outcompeted. Historical records show this encroachment originally started to occur due to a loss of forest fire management done by the Native Americans in the area. These fires played a part in preventing the woodlands, savannahs, and prairies from being encroached on by the surrounding forests, and prevent bugs from eating the acorns that the Native Americans preferring to eat. The oaks have adapted to the environment that the Native Americans had created. Not only are they being out competed by the Douglas firs, their habitats are being lost to development.

Oregon white oaks are also threatened by sudden oak death by the plant pathogen *Phytophthora ramorum* that was found in the south range of the trees (California and southern Oregon). Although the Oregon white oak species is not significantly affected by this pathogen, as other oak species, the pathogen could become more of a problem if it moved up to the PNW as it is primarily spread by water. The gold spotted oak borer is another issue as it has be introduced to southern California which they believe was transported through firewood and are taking preventative measure. Due to the overall challenges that the Oregon white oaks experience in the Pacific NW, it is extremely important for us to do as much as possible to preserve and protect the oak woodlands that we currently have in the region.

One historical site where there is a problem of declining health of the Oregon white oaks is on the Pacific University's Forest Grove campus. The trees on the Forest Grove campus have long been considered a point of pride among Pacific Students, Alumni, and Faculty. They are also considered a community resource by the local residents, as they have are considered to be a part of the collection of majestic trees in the within the city of Forest Grove.

With the decline in health of the trees on Pacific's campus, there is a high possibility that the trees could be lost to disease and environmental factors in the near future. This is significant because they are extremely valuable visually, monetarily, and they are a core part of the image and history of the University. A related area of concern is that there are also are problems with introducing new trees on campus to replace the ones that are lost, because they are expensive to replace and take many years to grow to a similar height of the current trees. Many of the trees planted in the last few years have been being lost due to them not having the proper conditions in which they can grow a vigorous, healthy root system, the cornerstone of all plant health.

<u>Investigation</u>

In the fall of '15, Center for a Sustainable Society began to work with the facilities department and Pacific Landscape on an investigation of how to manage the health of the Oregon white oaks in a way that can preserve their health for years to come. In order to do this, a test plot was selected that includes the oak trees in the median of the Mac-Walter parking lot and the area by Walter and Bates house. This area includes 10 trees of different ages, three are younger and seven are older. Ron at Pacific Landscape Management said that these were probably the trees in the worst condition on campus. This paper will present the results and analysis of the soils, and leaf tissue sample that we took and our proposed treatment to the test plot area (picture of area to the right).

In order to assess the environmental health of a particular species in a given environment, it is first important to look at the necessary elements of an ideal growing environment, and compare them to the current growing environment. In the case of Oregon white oaks, they require the following to survive:

1. Soil

   They generally grow on these soil orders (defined by the US soil taxonomy): Alfisols, Inceptisols, Mollisols, and Ultisols. These soil orders are a wide range of different types of soils and thus the trees are able to survive in a wide range of soil types. These areas can be rocky, thin soils, deep loams, and heavy clays of valley bottoms. The soil type that they prefer is deep loam, which is generally 40% sand, 40% silt, and 20% clay. This allows for good drainage and aeration.
2. Water

   Oregon white oaks are drought tolerant trees and prefer areas that are dry during the summer and wet during the winter. Thus they are well suited to live in areas near rivers where it is wet during the winter and dry during the summer. They also prefer soils that are slightly acidic and prefer a pH between 4.8-5.9.
3. Sunlight

   Oregon white oaks prefer full sun and are very intolerant to any changes in sunlight. It is able to grow in the shade of its own species, but the growth of Douglas firs and other large tree species will kill them once they overtop the Oregon white oaks because they get shaded out.
4. Nutrients

   All plants need a balanced ratio of primary, secondary, and micronutrients. The primary nutrients are phosphorus (P), sulfur (S), chlorine (Cl), Calcium (Ca), Magnesium (Mg), potassium (K), and sodium (Na). These play a major part in the major process and the makeup of the plants but cannot function without the secondary nutrients, which are boron (B), iron (Fe), manganese (Mn), copper (Cu), and Zinc (Zn). These nutrients are helpful in the function of the major processes. There are also many micronutrients that do not need to be added as much, but they are still very important. Some of the micronutrients are chromium, cobalt, iodine, molybdenum, selenium, tin, vanadium, nickel, and fluorine.

5. Complementary plants in Native Habitat

   Native species to woodlands, savannah, meadows, and grasslands are what generally grow in compliment to Oregon white oaks. Here are just a few species of plants that grow in their native habitat:

   - Western buttercup
   - Camas
   - White Yarrow
   - Blue Wild Rye
   - Tufted Hair Grass
   - California Hazel
   - Western Sword Fern
   - Sweet Cherry
   - Snowberry
   - Serviceberry
   - Oregon Ash

After investigating the ideal growing conditions of Oregon white oaks, we began to investigate the how this compares to the current growing conditions on the Pacific University Forest Grove campus.

<u>Water, Soil & Tissue Analysis</u>

Water Analysis

Prior to selecting the test plot, there was a need to test the pH of the water to ensure that an acidic water source was not a contributing factor. When pH is low, water available to be up taken by the plants roots is not possible, potentially necessitating an increased amount of summer irrigation,

In water pH testing done previously by students of Deke Gunderson PhD., they found that the water on campus has a lower pH, which they believe could be a possible reason why we need to water the lawns to achieve turf health.

With information that the water on campus has a lower pH and could be a possible reason why Pacific University needs to over water the lawns, water pH was tested around campus.

Table 1. pH levels across the Forest Grove Campus

Location	**Dispensing**	**pH**	**Standards:**
Vanders 111	sink	6.89	4
Old College Hall	facet	7.48	6.86
Gilbert 104	sink	6.72	10.01
Cascade Bathroom	sink	7.22	
Burlingham Bathroom	sink	7.34	
Warner Hall	facet	7.16	
Price Bathroom	sink	7.9	
Library Bathroom	sink	7.68	
UC Outside	facet	7.3	
Strain Bathroom	sink	7.46	
Stoller Bathroom	sink	7.5	
Knight Hall	facet	7.51	
Drake House	facet	7.47	
CDC	facet	7.52	
World Languages	facet	7.42	
		Average: 7.37	

After collecting water samples around campus and testing the pH levels we found that there was no area on campus that had a lower pH. The average of all the samples take was 7.37, which is slightly basic.

**All figures referenced below can be found at the end of this section*

** Reference figure 7 for the different types of nutrients*

Soil Analysis

To look at the physical characteristics of soil composition in our test plot area, we performed a soil jar test. The different layers of the soil have different densities, which allows us to see the different layers. Soil is made up of sand, silt, clay, fine clay, and organic matter (listed in decreasing density.) After a week to let the layers settle, we observed that there is a large amount of clay in the soil, and no silt or sand was observed. There were also clay particles floating in the water and a small amount of organic matter floating at the top. It is not possible to change the basic texture of the soil and so we will have to work on adjusting the structure of the soil, which we will do through adjusting the cation exchange capacity, which will be discussed later.

The bottom right corner of figure 4 shows that the pH of the soil is 4.7, which is very strongly acidic according the State University of New York College of Environmental Science and Forestry (SUNY-ESF) scale. It is generally recommended to raise the pH to be slightly acidic soil (6.4) because it allows minerals to be more soluble/available. Figure 2 is a helpful tool that shows the availability of each nutrient in the soil at different levels of pH. In figure 2 you can see that that all nutrients are available in the greatest quantity, can be found in soil at a slightly acidic pH. Currently since the soil is at a pH of 4.7, generally the macronutrients are less available compared to the micronutrients. Oregon white oaks specifically prefer higher concentrations of Mn and so they prefer to have soils a little more than slightly acidic when Mn is more available. You can see in figure 2, pH decreases as the availability of Mn increases until it is at its maximum capacity. But if Mn exceeds the levels of Fe in the soil it becomes toxic to the plant.

The low pH is also causing there to be a lack of availability to the macronutrients in the soil and a higher availability of the micronutrients (does not mean that there is lots of micronutrients available). In addition to the low pH, an explanation for the low levels of the macro and secondary nutrients may be due to nutrients being leached to the soil, or exhausted from the soil reserves. In typical instances where significant amounts of nitrogen fertilizer are used, plants uptake significant amounts of micronutrients from the soil to maintain their internal mineral balance. This leads, long term, to the soil reserves being depleted faster than the plant can replenish them. Figure 2 also shows that these interactions occur when there is a higher availability of micronutrients. These nutrients play a major role in the Oregon white oak trees.

The bottom left corner of figure 4 shows the soil electrical conductivity of the soil (labeled as ECe), which is very low at 0.2. "Soil electrical conductivity is a measurement that correlates with soil properties that affect crop productivity, including soil texture, cation exchange capacity (CEC), drainage conditions, organic matter level, salinity, and subsoil characteristics" (Grisso 2009). To make the soil healthier the bar on the graph should be more toward the upper end of the average area.

Next to the soil electrical conductivity is the cation exchange capacity (CEC), which is a measure of the soil's ability to hold and release various positively charged nutrients. (The Ideal Soil) We will be specifically looking at the saturation levels of K, Mg, Ca, and Na. These nutrients are positively charged and bind to the negatively charged clay and soil organic matter (SOM). Adjusting the saturation levels is important because a higher CEC means that more nutrients are adsorbing, (binding to the soil) allowing it to be more accessible to plants rather than the nutrients being washed away.

The percent cation saturation in figure 4 can be found in the top right corner. Dr. William Albrecht, a scientist who focused his work on experimenting with the different saturation ratios listed previously, found that the ideal saturation ratio, although varying from soil to soil contained a minimum of : 65% Ca, 15% Mg, 4% K, and 1-5% Na. In less dense, sandy soils, a higher % of cations in Mg (up to 20%) is optimal, but the minimum base saturation for Ca should always stay above 65%. In our test plot, the soil has a higher amount of clay content so we set the ratios to: 68% Ca, 12% Mg, 4% K, and 1.5% Na. Ca tends to tighten the soil and Mg tends to loosen it. Comparing these percentages to the percentages in figure one we can see that there is a 31.3% difference in Ca, a 3.8% difference in Mg, 0.4% difference in K, and 0.5% difference in Na. All of these nutrients need to increase by those amounts of percent differences.

Tissue Analysis

The levels of the different nutrients in the Oregon oak trees depend on what point in time the trees are in their life cycle, what time of year it is, and other environmental factors. This is just something to note when looking over the results of our data. As you can see, Figures 5 and 6

show that there is a significant amount of calcium found in the leaves and we believe this is due to the fact that they plant is attempting to fix Ca into the soil for next year. By up taking Ca into the leaves before they fall off, it allows the leaves to break down during the winter and be incorporated back into the soil so that the nutrients is available in the root zone the next year. Nutrients in the soil get leached out with all the rain that occurs during the winter in the PNW along. One common theme within all plant in the plant kingdom is that they will pull primary cationic (Mg, Ca, K, Na) nutrients from their roots, stems and lower leaves to keep the upper portion of their canopy healthy. This often appears as an interveinal chlorosis, or discoloration on the lower leafs. In extreme instances, a plant will sacrifice roots, whole branches, leaves and nearly it's entire lower 60-80 % of its total mass to keep the upper portion of the canopy healthy. This leads, in time, to a plant or trees that becomes significantly unhealthy, because they don't have the root system to support the amount of nutrients the canopy needs to photosynthesize, or the root strength to support the whole weight of the canopy. Thus the canopy slowly declines until the root system can no longer support it.

Plants invest more in plant growth in the spring and reproduction in the fall. The secondary nutrients are extremely important to these processes. One of the important minerals in reproduction is Mg and is used a lot in the fall. This is why we see low levels of Mg in the soil analysis (figure 4) and high levels in the leaf tissue samples (figures 5 and 6). The tree is uptaking Mg to use it for it reproduction processes. Mg along with Cu is also important in the horizontal cell wall strength, so the strength in the branches and twigs of the tree. Zn and Fe are important to the vertical growth and strength of the plant. If you look at the Mulder's chart (figure 2), you can see that Mn has an interaction with Cu, Zn, and Mg in which the low levels of these nutrients is causing the Iron to be tied up in the soil. Cu and Zn are also being tied up by the in interactions that these nutrients have with Ca and Mn. Mn ties up Cu and increases the availability of Ca, which ties up Zn. This also is the cause for the high levels of Ca in the leaf tissue samples (figures 5 and 6). The high uptake of Mn is due to Oregon white oaks preferring to have higher levels of Mn and the current high acidic soil is allowing for the availability of the nutrient. It is also allowing for the high availability of Fe in the soil which is important in chlorophyll production, When Fe is higher than 2x of Mn in soil, the plant will often display an excessive vertical growth habitat, and a decreased canopy vigor and expansion.

With low levels of some of the micronutrients in the soil and in the leaf tissue sample, this may be the cause for a lot of the branch dropping on campus. We believe this may be the cause because as we stated before, Cu is important to the strength in branches and twigs and Zn is important to the vertical strength. Cu is also important to the metabolism of nitrogen and so the oak trees are having a hard time processing N due to the lack of micronutrients.

Note: Figures 4 and 5 generally have the same trend in them although they do have their differences.

Figures for Results and Analysis

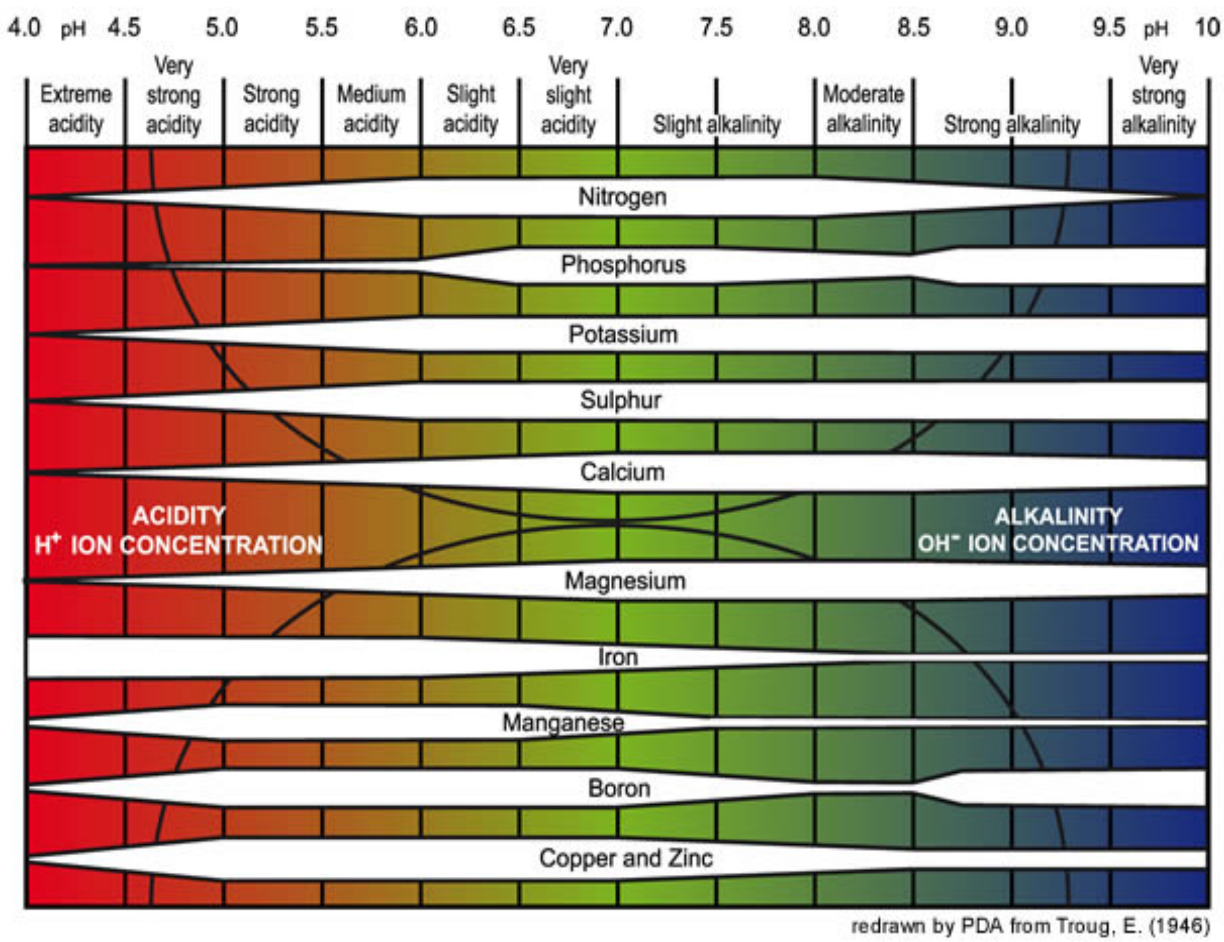


Figure 1. The chart shows the pH range along with the availability of important nutrients in the soil

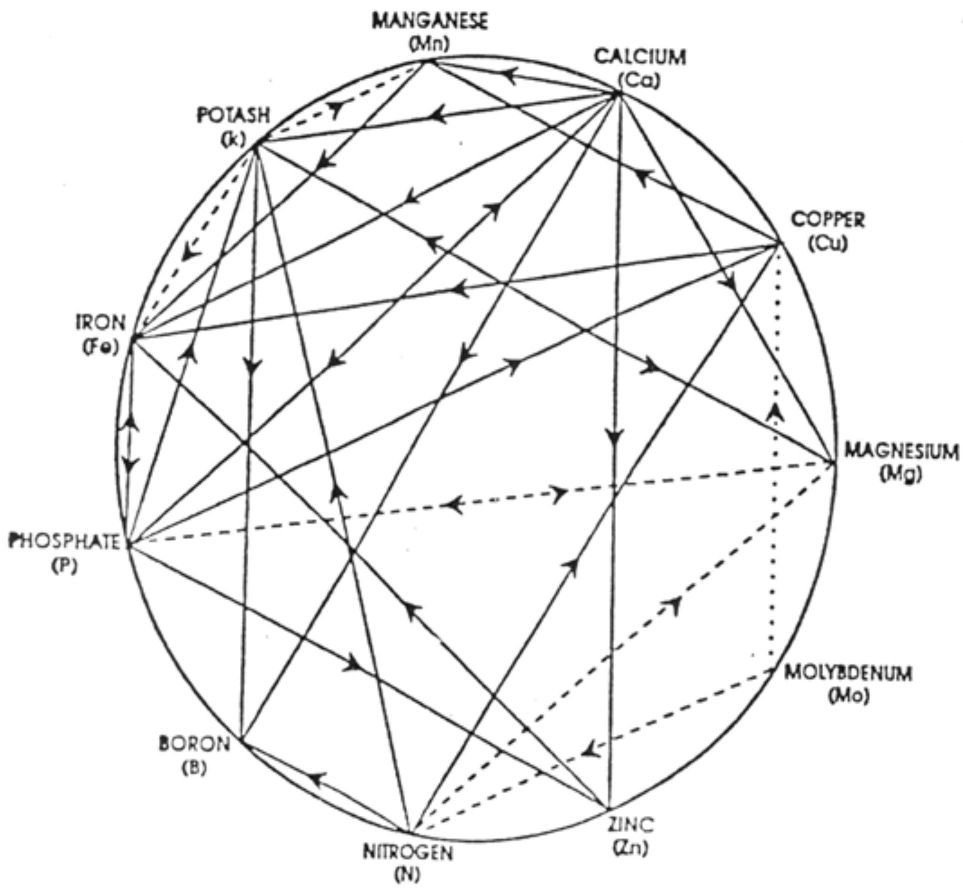
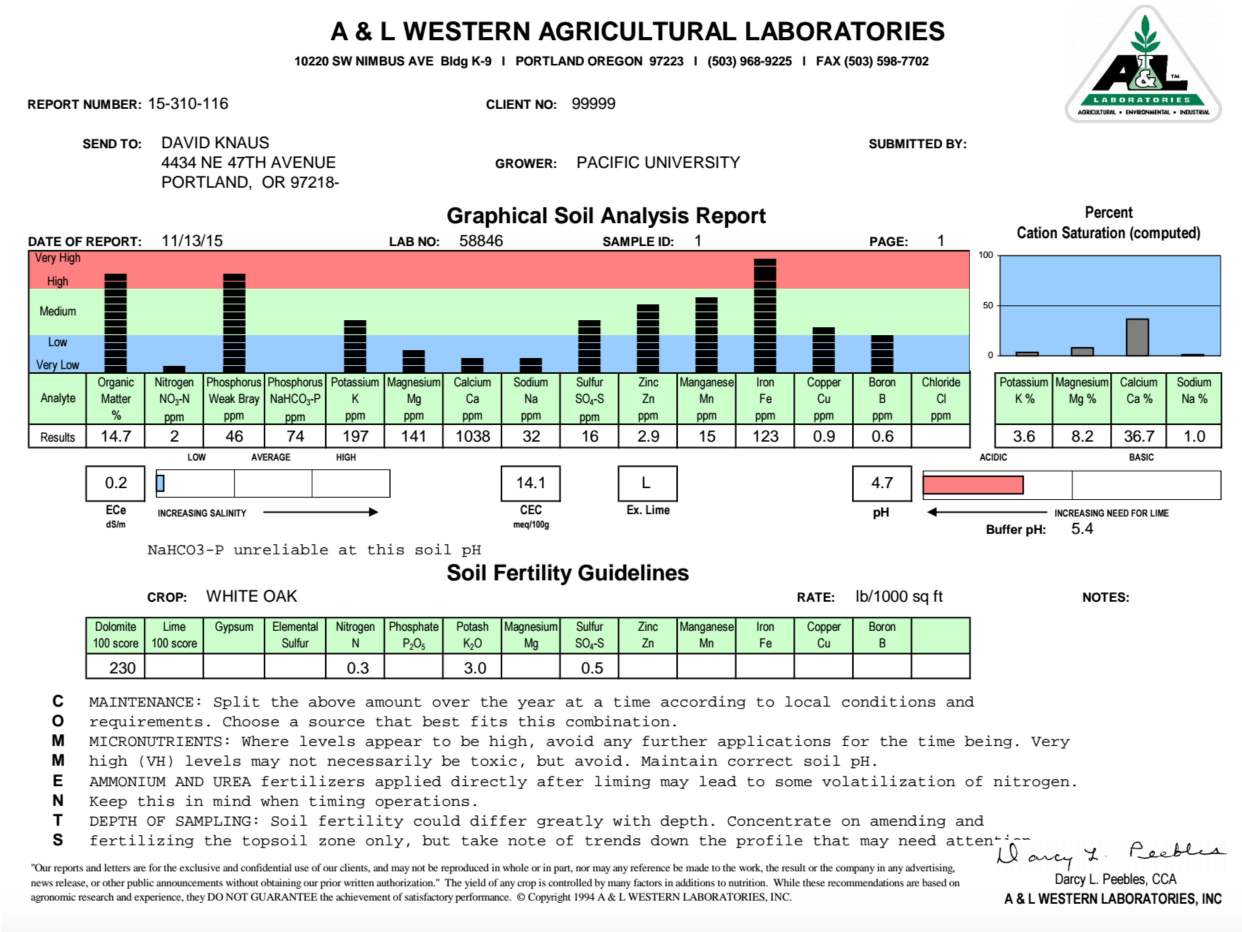


Figure 2. The Mulder's chart shows the interactions between the different nutrients. If a nutrient has an arrow pointing to another nutrient, it means a deficiency of that nutrient or excesses of the nutrient may cause interference with its metabolism from whence the arrow originates. Arrows aimed at each other denote mineral synergy while arrows aimed away from each other denote mutual mineral interferences or antagonism.

Figure 3. For the soil jar test, soil was collected by digging down about half a foot below the surface and collecting half a quart of soil at each location. The two locations were the area by bates house and Walter and the median of lot G. Jar was filled half way and shaken till mixed well, let settle for a day, shaken again, and let sit for a day.



A & L WESTERN AGRICULTURAL LABORATORIES

10220 SW NIMBUS AVE Bldg K-9 I PORTLAND OREGON 97223 I (503) 968-9225 I FAX (503) 598-7702

REPORT NUMBER: 15-310-116 **CLIENT NO:** 99999

SEND TO: DAVID KNAUS
4434 NE 47TH AVENUE
PORTLAND, OR 97218-

GROWER: PACIFIC UNIVERSITY

SUBMITTED BY:

Graphical Soil Analysis Report

DATE OF REPORT: 11/13/15 **LAB NO:** 58846 **SAMPLE ID:** 1 **PAGE:** 1

Analyte	Organic Matter %	Nitrogen NO_3-N ppm	Phosphorus Weak Bray ppm	Phosphorus $NaHCO_3$-P ppm	Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm	Sodium Na ppm	Sulfur SO_4-S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Chloride Cl ppm
Results	14.7	2	46	74	197	141	1038	32	16	2.9	15	123	0.9	0.6	

Potassium K %	Magnesium Mg %	Calcium Ca %	Sodium Na %
3.6	8.2	36.7	1.0

ECe dS/m	CEC meq/100g	Ex. Lime	pH	Buffer pH
0.2	14.1	L	4.7	5.4

NaHCO3-P unreliable at this soil pH

Soil Fertility Guidelines

CROP: WHITE OAK **RATE:** lb/1000 sq ft **NOTES:**

Dolomite 100 score	Lime 100 score	Gypsum	Elemental Sulfur	Nitrogen N	Phosphate P_2O_5	Potash K_2O	Magnesium Mg	Sulfur SO_4-S	Zinc Zn	Manganese Mn	Iron Fe	Copper Cu	Boron B	
230				0.3		3.0		0.5						

COMMENTS

MAINTENANCE: Split the above amount over the year at a time according to local conditions and requirements. Choose a source that best fits this combination.
MICRONUTRIENTS: Where levels appear to be high, avoid any further applications for the time being. Very high (VH) levels may not necessarily be toxic, but avoid. Maintain correct soil pH.
AMMONIUM AND UREA fertilizers applied directly after liming may lead to some volatilization of nitrogen. Keep this in mind when timing operations.
DEPTH OF SAMPLING: Soil fertility could differ greatly with depth. Concentrate on amending and fertilizing the topsoil zone only, but take note of trends down the profile that may need atten-

Darcy L. Peebles
Darcy L. Peebles, CCA
A & L WESTERN LABORATORIES, INC

Figure 4. Test plot soil analysis results from A & L Western Laboratories. Soil was collected by digging down about half a foot below the surface and collecting half a quart of soil at each location. The two locations were the area by Bates house and Walter and the median of lot G.

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10220 SW NIMBUS AVE Bldg K-9 I PORTLAND OREGON 97223 I (503) 968-9225 I FAX (503) 598-7702

REPORT NUMBER: 15-313-080 **CLIENT NO:** 99999

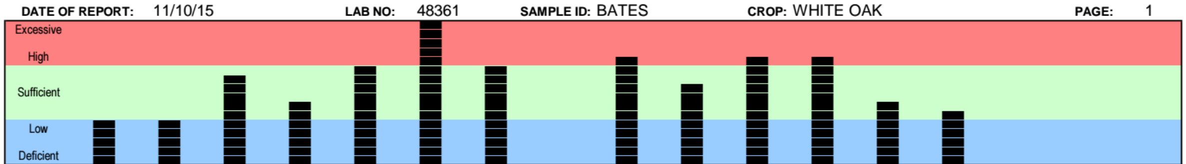
SEND TO: DAVID KNAUS
4434 NE 47TH AVENUE
PORTLAND, OR 97218-

GROWER: PACIFIC UNIVERSITY

SUBMITTED BY: DAVID

Graphical Plant Analysis Report

DATE OF REPORT: 11/10/15 **LAB NO:** 48361 **SAMPLE ID:** BATES **CROP:** WHITE OAK **PAGE:** 1



Analyte	Nitrogen N %	Sulfur S %	Phosphorus P %	Potassium K %	Magnesium Mg %	Calcium Ca %	Sodium Na %	Chloride Cl %	Iron Fe ppm	Aluminum Al ppm	Manganese Mn ppm	Boron B ppm	Copper Cu ppm	Zinc Zn ppm	Nitrate-N NO_3-N ppm	Phosphate PO_4-P ppm	
Test Results	1.27	0.09	0.30	0.86	0.17	2.33	0.04		206	123	945	44	9	31			
Normal Range	1.42 2.90	0.10 0.30	0.18 0.35	0.75 1.25	0.11 0.18	0.23 0.59	0.01 0.05		50 200	20 200	25 500	15 40	4 25	20 150			

Ratios	N/S	N/P	N/K	Ca/Mg	N/Ca	K/Mg	P/S	Fe/Mn	Fe/Al	K/Mn	Ca/B	Cu/Mo	P/Zn				
Actual	15.0	4.3	1.5	14.0	0.5	5.1	3.4	0.2	1.7	9	529		94				
Expected	13.0	8.0	2.0	2.0	6.7	6.7	1.7	0.4	1.0	40	100		50				

DATE SAMPLED: 11/05 **GROWTH STAGE / PLANT PART:** MRM/L

COMMENTS

CALCIUM: An excess may induce Mg or K deficiencies. Leaf tissue levels tend to rise toward maturity. High soil pH may induce Fe, Mn, B or Zn deficiencies. INVESTIGATE cause of imbalances before taking corrective measures. GROWTH STAGE and PLANT PART will have a large impact on results. View ratios with caution.

DEFINITION OF INTERPRETATION RATINGS

- Deficient: Plants should be showing visible symptoms of a nutritional deficiency. Plant growth would definitely be curtailed by an insufficient amount of this element.
- Low: Plants may be normal in appearance but probably will be responsive to fertilization with this element.
- Sufficient: Plants contain adequate amounts of this element for maximum yield and are normal in appearance.
- High: Optimum yields can be expected and plants are normal in appearance. However, concentrations of this element are higher than normally expected.
- Excessive: Plants probably show symptoms of a nutritional disorder or stunted growth. Yields may be reduced significantly by an excessive amount of this element.

Darcy L. Peebles

Darcy L. Peebles, CCA
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Figure 5. Leaf test plot analysis results from A & L Western Laboratories. 8-10 leaves were collected from each tree in the Bates house/Walter area.

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REPORT NUMBER: 15-313-080 **CLIENT NO:** 99999

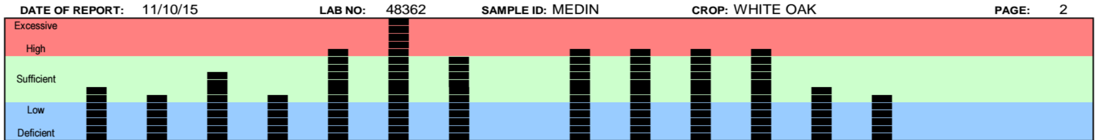
SEND TO: DAVID KNAUS
4434 NE 47TH AVENUE
PORTLAND, OR 97218-

GROWER: PACIFIC UNIVERSITY

SUBMITTED BY: DAVID

Graphical Plant Analysis Report

DATE OF REPORT: 11/10/15 **LAB NO:** 48362 **SAMPLE ID:** MEDIN **CROP:** WHITE OAK **PAGE:** 2



Analyte	Nitrogen N %	Sulfur S %	Phosphorus P %	Potassium K %	Magnesium Mg %	Calcium Ca %	Sodium Na %	Chloride Cl %	Iron Fe ppm	Aluminum Al ppm	Manganese Mn ppm	Boron B ppm	Copper Cu ppm	Zinc Zn ppm	Nitrate-N NO_3-N ppm	Phosphate PO_4-P ppm	
Test Results	1.75	0.11	0.27	0.74	0.24	2.42	0.04		376	212	867	42	9	36			
Normal Range	1.42	0.10	0.18	0.75	0.11	0.23	0.01		50	20	25	15	4	20			
	2.90	0.30	0.35	1.25	0.18	0.59	0.05		200	200	500	40	25	150			

Ratios	N/S	N/P	N/K	Ca/Mg	N/Ca	K/Mg	P/S	Fe/Mn	Fe/Al	K/Mn	Ca/B	Cu/Mo	P/Zn
Actual	15.0	6.4	2.4	10.0	0.7	3.1	2.4	0.4	1.8	9	582		75
Expected	13.0	8.0	2.0	2.0	6.7	6.7	1.7	0.4	1.0	40	100		50

DATE SAMPLED: 11/05 **GROWTH STAGE / PLANT PART:** MRM/L

COMMENTS

CALCIUM: An excess may induce Mg or K deficiencies. Leaf tissue levels tend to rise toward maturity. High soil pH may induce Fe, Mn, B or Zn deficiencies. INVESTIGATE cause of imbalances before taking corrective measures. GROWTH STAGE and PLANT PART will have a large impact on results. View ratios with caution.

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Figure 6. Leaf test plot analysis results from A & L Western Laboratories. 8-10 leaves were collected from each tree in the parking lot G median area.

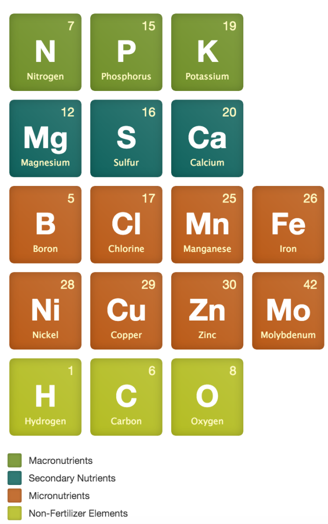

Figure 7. A list of the nutrients in their different categories of macronutrients, secondary nutrients, micronutrients, and non-fertilizer elements. Further information on what each of these nutrients does can be found here: http://www.cropnutrition.com/nutrient-knowledge.

<u>Results</u>

The soil type of the Pacific's campus is a significant contributing factor to the decline in health among both of the young and old trees, however, other contributing factors are competition from the coniferous species on campus for nutrients, allelopathy amongst the roots of conifers on campus and the current landscaping practices on the Forest Grove campus.

One goal of the current landscaping practices on campus is to keep lawns green, which is somewhat, juxtaposed to keeping the Oaks healthy. To keep lawns healthy in Oregon during the summer months, a significant amount of watering and a substantial amount of Nitrogen fertilizer is generally needed. While the grass on the campus benefits from these two inputs, the Oaks generally suffer. The amount of water that is applied to keep the lawn green, the amount of available Nitrogen, and competition from the campus's coniferous trees have led to the Oak trees to experience some rotting symptoms (trunk rot), excessive vertical growth, and lack of a full leaf canopy.

Based on a combination of soil and tissue analysis the results show the soils are lacking in some nutrients and higher in others. A significant amount of the primary cations (Calcium, Magnesium, Sodium & Potassium) are all low in both total concentration as well as plant availability. This indicates that to the Oak trees because they are not getting all the right nutrients that they need to be healthy, nor are there sufficient quantities present in the soil. Currently Pacific Landscape Management is using their own Organic Blend of NPK, which is designed for turf grass maintenance, but does not address all the nutrient needs of the Oak trees to keep them healthy. Pacific's fertilizer primarily focuses on Nitrogen--to keep the lawn green, however, there is no application of other minerals essential to plant growth such as Ca, Mg, Mn, Zn, B or others.

<u>Treatment Plan</u>

With the result from our tests we calculated the concentrations/amount of each mineral/element needed in PPM and lbs/acre, calculations were done using *The Ideal Soil: A Handbook for the New Agriculture,* this is a popular reference textbook used by accredited soil laboratories to develop agronomic soil recommendations. There are three categories of elements/molecules needed: primary, secondary, and micro. The elements that we looked a specifically are the ones in table 2.

Table 2. Primary and secondary elements

Primary Elements	Secondary Elements
Anions	
Sulfur	Boron
Phosphorus	Silica
Chlorine	Molybdenum
Cations	
Calcium	Iron
Magnesium	Manganese
Potassium	Copper
Sodium	Zinc
	Cobalt

In figure 4, under the bar graph there is a section labeled results, which tells us the current levels in ppm of the different elements in the soil. Using the current concentration we calculated the amount needed to be added to the soil. Calculation result can be found in table 3.

Table 3. Element and amount needed to increase soil health

Element	PPM	lbs/acre	lbs/1000ft^2
Ca	1287.6	2575.2	59.12
Mg	105.24	210.48	4.83
K	69.76	139.52	3.2
Na	26.995	53.99	1.24
P	23.76	47.52	1.09
S	18.88	37.76	0.87
B	0.69	1.38	0.03
Fe	-	-	-
Mn	-	-	-
Cu	0.55	1.1	0.03
Zn	4.076	8.152	0.19

Using the amounts need of each element, a prescription was put together taking into account the access to the fertilizers and the different characteristics of each one. After calculating out different combinations of prescriptions to get the concentrations to be as balanced as possible, we came to the prescription breakdown in table 4.

Table 4. Prescription breakdown

Product	lbs/acre	Pounds Needed
Dolomite Lime	1619	404.75
Fish Bone Meal	237.6	59.4
Liquid Calcium	1086.825 ppm	271.707 ppm
Sulfate of Potash	330	82.5
Sea Salt	135	33.75
Borax	0.1242	0.03105
Copper Sulfate	4.4	1.1
Zinc Sulfate (1H2O)	23.3	5.825

Our treatment plan consists of applying missing nutrients to the soil for the trees to rebuild their root systems, as well as performing nutrient spray applications to the trunk and leaves of the tree. To complement the soil mineral treatment plant described above, we will also be using the SOW 1 soil microbiology and bokashi tea, created from food waste at the UC & in Gilbert Hall. The SOW1 fermented microbes utilize actinomyces and lactobacillus to stimulate native soil biology. In field trials using these microbial inoculants, increased amounts of available nutrients have been observed, in addition to soil flocculation, aeration, and enhanced metabolic functions of damaged plants.   We will be putting the ground application of the prescription down once in the spring, along with SOW 1 fermented microbial extract.. We will also be doing monthly foliar sprays, applied by CSS/B Street workers through the summer. These consist of Blue Gold (an advanced form of biostimulant), supplemental Calcium liquid, and the SOW1 microbials. The trees will be compared through photo documentation before and after in the fall and also through leaf sample analysis.

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