Environmental Performance of Treated Wood Research Cooperative

11th Annual Report

Gerald Presley
Jed Cappellazzi
Matthew Konkler
Department of Wood Science & Engineering
Oregon State University
Corvallis, Oregon

May 2022

This document contains preliminary information and was expressly prepared for use by members of the Coop Advisory Committee. Reproduction and distribution of this draft is expressly forbidden.

Advisory Committee Members

Arxada Wood Protection Inc. (Teri Muchow)

Creosote Council (David Webb)

Koppers Performance Chemicals (Heath Huschak/Jim Healey)

Nisus (Ken Laughlin/Jeff Lloyd)

Treated Wood Council (Jeff Miller)

Viance, LLC (Bob Baeppler/Kevin Archer)

Western Wood Preservers Institute (Dallin Brooks/Butch Bernhardt)

Wood Preservation Canada (Natalie Tarini)

Associate Members

Allweather Wood LLC	Conrad Forest Products	Renewable Resources Group Inc
Amerities Holding LLC	Culpeper Wood Preservers	Royal Pacific Industries
BB&S Treated Lumber of New England	Dominion Wood Preservers	S.I. Storey Lumber Co.
Bell Lumber and Pole	Exterior Wood, Inc.	Spartanburg Forest Products
Bestway Lumber	Genics Inc.	Stella-Jones
Biewer Lumber Company	Long Life Treated Wood Inc.	Sunbelt Forest Products Corp
Bridgewell Resources, LLC	Northeast Treaters	Tank Fab
Brooks Manufacturing Co.	Osmose Utilities Services Inc	Thunderbolt Wood Treating Company
Brown Wood Preserving Co., Inc.	Pacific States Inc.	Universal Forest Products Inc.
Chicago Flameproof and Wood Specialties Corporation	Permapost Products Co.	Wheeler Lumber Co.
		William C. Meredith Company, Inc

Personnel

Gerald Presley, Director

Matthew J. Konkler, Senior Faculty Research Assistant I

Table of Contents

Executive Summary 5
Introduction 9
Objectives 10
Objective 1: Develop Fundamental Data on Preservative Migration from Wood 10
  1.1.0 Migration of metals from treated grapevine trellis into vineyard soils and grapevine biomass 11
    1.1.1 Introduction 11
    1.1.2 Methods 12
    1.1.3 Results 15
  1.2.0 Metal migration from treated posts into soils, leave and apples in a certified organic apple orchard 22
    1.2.1 Introduction 22
    1.2.2 Methods 23
    1.2.3 Results 26
  1.3.0 Copper migration from treated wood garden boxes into soil and vegetable biomass 31
    1.3.1 Introduction 31
    1.3.2 Methods 32
    1.3.3 Results 35
  1.4.0 Monitoring the migration of polyaromatic hydrocarbons in soil from creosote-treated Douglas-fir and southern pine posts 38
    1.4.1 Introduction 38
    1.4.2 Methods 39
    1.4.3 Results 41
  1.5.0 Monitoring metal migration from a pressure-treated and sealed deck 44
    1.5.1 Introduction 44
    1.5.2 Methods 45
    1.5.3 Results 46
Objective 2: Develop Standardized Accelerated Methodologies for Assessing Treated Wood Risks 48
  2.1.0 Using a commodity scale leaching apparatus for environmental assessment tool validation 48
    2.1.1 Introduction 48

2.1.2 Methods 49
2.1.3 Results 50
Objective 3: Work Cooperatively to Develop and Improve Models to Predict the Risk of Using Treated Wood in Various Applications 52
Objective 4: Identify Improved Methods for Reducing the Potential for Migration 53
Objective 5: Evaluate the Environmental Impacts and Identify Methods for Reuse, Recycling, and/or Disposal of Preserved Wood that is Removed from Service 53
5.1.0 Measuring carbon emissions from landfilled treated wood 53
5.1.1 Introduction 53
Objective 6: Deliver Educational Outreach Programs on the Proper Use of Treated Wood in Relation to the Best Management Practices (BMPs) 55
6.1.0 Review of the existing literature describing the environmental impacts of oilborne preservative systems 55
6.2.0 Publication of EPTW research 55
References 55

Abbreviations

AWPA- American Wood Protection Association
ACQ- Ammoniacal Copper Quaternary
ACZA- Ammoniacal Copper Zinc Arsenate
BMPs- Best Management Practices
CA- Copper azole
CCA- Chromated copper arsenate
CuNap- Copper Naphthenate
DCOI- 4,5-dichloro-2-N-octyl-4-isothiazolin-3-one
EPA- United States Environmental Protection Agency
EPTW- Environmental Performance of Treated Wood Research Cooperative
PAH- Polycyclic Aromatic Hydrocarbon
TCLP- Toxicity Characteristic Leaching Protocol
UC- Use category
WWPI- Western Wood Preservers Institute

Executive Summary

Objective 1: Develop fundamental data on preservative migration from wood

1.1.0 Migration of metals from treated grapevine trellis into vineyard soils and grapevine biomass

We are continuing to monitor the migration of metals from horticultural posts into vineyard soils and plant biomass. This study includes four different preservative treatments along with untreated Douglas-fir and metal t-posts. Five of each treated posts were installed with Postsaver wraps and 5 without to measure the impact of these wraps on metal migration. Soil samples were taken at 0 and 6-months post installation at the base of each post in the trellis. Samples were analyzed for metal content and there was no detectable difference in Cu, Cr, of Zinc content in soils 6 months after installation as compared to background samples at each site. Arsenic levels in soil were below detection limit in most cases but were elevated around a few replicate ACZA-treated posts and in unwrapped ACZA posts there was a significant difference between background metal levels and 6-month metal levels. Further soil samples were taken 12 and 18 months after installation and are slated for analysis. Grapevine biomass was harvested from prunings taken 1 year after trellis installation and it was analyzed for metal content. No difference in metal content in any treatment or control vine biomass was detected. We plan to add more CA-C-treated posts to this study in the summer of 2022 because our existing CA-C treatment is not treated to AWPA standard retentions.

1.2.0 Metal migration from treated posts into soils, leave and apples in a certified organic apple orchard

We expanded a sampling effort on an Oregon Tilth certified organic apple orchard which contains ACZA and CCA-treated posts that were present before certification. A further 10 posts in the trellis were added to the sampling effort and the initial 5 posts were resampled according to a new sampling regime for a total of 15 posts and 5 control locations taken from around trees greater than 15 feet from any treated post. Soil samples were taken 4 and 8 inches from the base of each post for metal analysis. In addition, apples and leaves were sampled from trees next to each post or each control tree. Soil samples from the second sampling are yet to be analyzed. Metal levels in leaves and apples taken from trees near posts showed not difference in Cu, Cr, As, or Zn levels compared to apples and leaves taken from control trees.

1.3.0 Copper migration from treated wood garden boxes into soil and vegetable biomass

A study of the migration of copper from treated garden boxes was initiated in 2021 and data from the first season was collected. Raised beds, 4 x 10 ft, were made CA-C treated 2 x 12-inch Douglas-fir lumber or untreated Douglas-fir lumber. Two beds of each type were constructed. A mix of common garden vegetables were grown in each box type and were harvested throughout the season. The edible and inedible portions of vegetable biomass as well as soil samples taken upon installation were analyzed for copper content using ICP-OES. Plant materials taken from the untreated or treated garden boxes showed no difference in copper levels from produce grown in the first year of the study. In addition, fungal decay was detected on the untreated boxes 1 year after construction, whereas treated boxes showed no signs of fungal decay.

1.4.0 Monitoring the migration of polyaromatic hydrocarbons in soil from creosote-treated Douglas-fir and southern pine posts

A field-scale study of PAH migration from five southern pine and five Douglas-fir (6-7″ x 8′) creosote-treated posts as well as two untreated controls was sampled 3, 6 and 12 months after installation. Migration of sixteen EPA priority pollutants were monitored by this test. Three and 6-month samples were taken 6 inches from the base of each post and 12-month samples were taken at 6 and 12 inches from each post. The 12-months samples are currently being processed. Soil samples were 18-inches deep and they were divided into three 6-inch subsections at different soil horizons. Results show that after three and six months most of the heaviest PAHs were not detectable above the detection limits of our instruments and most other PAHs that were detected were not distinguishable from controls. However, some PAH accumulation was detected particularly in the upper 6 inches of the soil samples which suggests that the main PAH input is originating from water washing PAHs down the post and depositing on the upper soil layer. PAHs that appeared to be elevated in the upper soil layer for at least one post species were fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, and benzo[b]fluoranthene/benzo[k]fluoranthene together. We are continuing to monitor migration at sampling locations farther from the post to delineate the lateral migration boundary.

1.5.0 Monitoring metal migration from a pressure-treated and sealed deck

A deck was constructed using pressure treated lumber at Peavy Lodge at Oregon State University through a donation of materials from one of our cooperative members. We took this opportunity to monitor copper migration from the deck immediately after installation and continuously for 6 months. Our first set of analyses was done over the first 6 months of monitoring exhibited a similar pattern that was observed in previous best management practice research in the cooperative. Copper concentrations were highest in the first samplings and started to taper off with subsequent collections. We are continuing to collect water runoff samples from beneath the deck at present and sampling will continue until at least the rains stop in the summer months.

Objective 2: Develop standardized accelerated methodologies for assessing treated wood risks

2.1.0 Using a commodity scale leaching apparatus for environmental assessment tool validation

A commodity scale leaching apparatus was constructed and tested on pressure treated posts. The testing apparatus was made from a 15-gallon plastic cone-bottom tank and simulates low flow environments such as a lake or a pond. Water was passed over ACQ or CA-C treated posts at the lowest rate possible with the setup (100-200 ml/min) and 1 liter water fractions were collected over a period of several hours. Copper levels were measured in the leachate to measure how well the apparatus could detect metal impulses from treated wood. Our initial tests only registered very low concentrations of copper leaching into the water and most of the samples collected were below the detection limit of our analytical lab. This study will be continued once we gain the ability to perform our own atomic spectroscopy analysis because the detection limits we can currently reach are not sufficient for our current prototype leaching apparatus.

Objective 3: Work cooperatively to develop and improve models to predict the risk of using treated wood in various applications

Commodity scale leaching experiments described in Objective 2 will be used to test the accuracy of the Environmental Assessment Tool hosted on the OSU website. Our initial experiments with that apparatus are only to prove the method and have not yet developed date for incorporation into the model. Once these experiments are further developed, the model will be used to produce estimates of metal concentrations in water that will be compared to experimental observations. Those comparisons will be described in objective 3 once they are done.

Objective 4: Identify improved methods for reducing the potential for migration

As part of our study to monitor the migration of preservative chemicals into vineyard soils and plant tissue, half of all posts installed in this study have been installed with Postsaver wraps. No difference in metal migration between wrapped and unwrapped posts are measurable at this time. We will continue to monitor this study as it develops.

Objective 5: Evaluate the environmental impacts and identify methods for reuse, recycling and/or disposal of preserved wood that is removed from service

The EPTW recognizes that wood disposal plays an important role in determining overall lifecycle impacts, particularly from a carbon lifecycle assessment perspective. We are planning a federal grant submission in partnership with Mississippi State University to study the fate of carbon in disposed wood commodities. The proposed research will investigate methane emissions from wood stored in anaerobic conditions with the aim of improving wood life cycle assessments. Proposal submission is planned for 2022.

Existing literature on methane emissions from disposed wood is being researched and a summary will be included in subsequent reports for reference. Currently both the EPA and the IPCC estimate that significant quantities of the carbon in wood Methane emissions from disposed wood could be a deciding factor in determining whether wood products are considered as a lower carbon alternative to steel and concrete and we believe this issue is important to investigate.

Objective 6: Deliver educational outreach programs on the proper use of treated wood in relation to BMPs

A summary of OSU's work testing BMPs over several years was disseminated in the 2020 Proceedings of the Canadian Wood Preservation Association which was submitted to the group in early 2021 as a summary document.
The EPTW continues to plan to deliver a review of the impact of oilborne wood preservative systems on aquatic environments. This effort has stalled but is still planned.

Introduction

Treated wood is widely used in a variety of environments and has a well-known ability to markedly extend the service life of products, thereby reducing the need to harvest additional trees. The chemicals used to protect wood from degradation are toxic at some levels and all are known to migrate, to some extent, from the products treated with these chemicals into the surrounding environment. The concerns about this migration are highest in aquatic environments. Previous studies have shown that the levels of migration are generally low and decrease over time. In addition, the Environmental Assessment Modeling Tool has been developed to predict the rates of migration from various treated wood commodities under a range of conditions. The treating industry also uses voluntary modified production procedures, Best Management Practices (BMPs), for some site-specific applications to improve the quality of these products, to reduce the presence of surface deposits, limit over-treatment, and, as far as practical, produce products with a reduced environmental footprint. The EPTW was established to help develop data on the performance of treated wood in the environment, beginning with aquatic applications. Extensive efforts were undertaken to validate best management practices for the prevention of preservative migration from treated wood and these continue today. The program is an extension of studies begun by Dr. Kenneth Brooks of Aquatic Environmental Sciences (Port Townsend, WA; Brooks 2011a).

Objectives

The overall goal of the EPTW is to develop knowledge that improves the ability to use and dispose of treated wood in a safe and environmentally sensitive manner. This goal is being addressed through the following objectives:

1. Develop fundamental data on preservative migration from wood
2. Develop standardized accelerated methodologies for assessing treated wood risks
3. Work cooperatively to develop and improve models to predict the risk of using treated wood in various applications
4. Identify improved methods for reducing the potential for migration
5. Evaluate the environmental impacts and identify methods for reuse, recycling and/or disposal of preserved wood that is removed from service
6. Deliver educational outreach programs on the proper use of treated wood in relation to BMPs

Over the past year, we have continued several efforts under some of these objectives, with involvement of the advisory committee. The results will be summarized by Objective.

Objective 1: Develop Fundamental Data on Preservative Migration from Wood

1.1.0 Migration of metals from treated grapevine trellis into vineyard soils and grapevine biomass

1.1.1 Introduction

Wood finds many uses in agriculture and is an excellent bio-based and often regionally sourced option for fencing, crop trellising or animal housing. Preservative treatment dramatically extends the life of wood used thereby saving time and expense in structure replacement on farms (Morrell et al., 1999). One drawback of using treated wood products in agriculture is that they are known to lose some chemical to the environment when exposed to water (Coles et al., 2014; M. J. Konkler et al., 2018; Konkler et al., 2020; Konkler and Morrell, 2019; Lankone et al., 2019; Lebow, 1996; Lebow et al., 2004; Zagury et al., 2003). The propensity to lose some chemical while in service has raised concerns among some farmers and regulators due to a fear of their potential impact on crop, animal, ground water and soil quality (Greven et al., 2007; Robinson et al., 2006). These fears, along with competitive prices of alternative materials such as steel have led an increasing number of producers to abandon the use of treated wood in their agricultural operations.

One driver of the move away from treated wood is the growth in popularity of organic agriculture. The USDA organic regulations exclude the use of treated wood in new structures built on organic certified land (NOP 5036, 2018). Farmers making the switch to organic are limited to more expensive naturally durable woods, untreated non-durable woods which require frequent replacement, or the use of alternative materials such as steel. Interestingly, organic regulations allow for existing treated wood structures to be “grandfathered in” on properties seeking organic certification. This means that at least some organic produce is currently produced using treated wood trellising or other type of treated wood materials on site. This situation would naturally cause one to question whether in-service treated wood in organic agriculture is impacting the quality of organic produce given the prohibition on the use of treated wood in new structures.

Previous work has clearly shown that soils around chromated copper arsenate- treated grapevine trellising show elevated chromium, copper and arsenic levels at least 50 mm (~2 inches) laterally from the post surface and 100 mm (~4 inches) vertically from base of the posts (Robinson et al., 2006). Analysis of CCA-treated fence posts also indicates arsenic migration into the surrounding soil, which was exaggerated by slopes (Schwer III and McNear, 2011). Finally, testing of CCA-treated stakes in ground contact resulted in elevated preservative metal levels up to 15 cm laterally and 20 cm deep in the surrounding soil (Lebow et al., 2004).

While migration into soil is well-known, the impacts of treated wood on metal content of the final produce and other parts of plant biomass are less clear. A prior study measured metal levels in grape and vine biomass in a vineyard supported by CCA-treated trellising and found no accumulation relative to untreated controls in leaves, vines or grapes produced by the plants over three years (Levi et al., 1975). However, this study contained limited replication (n=2) and was limited to CCA trellising, whereas several other treatments are commercially available for grapevine trellising today. Lab-based physiological studies have been done to measure the ability of grapes to accumulate metals found in CCA. Feeding greenhouse-grown grapevines planted in lysimeters with Cr, Cu and As containing solutions resulted in no accumulation of metals in the plant biomass, indicating that accumulation via roots is either not likely occurring or is negligible (Ko et al., 2007).

Controlled physiological experiments can provide useful data to help predict the likelihood of metal accumulation in various fruit crops via uptake through their root systems, but these studies do not simulate the reality of in-service treated wood functioning in close contact with fruit crops. Perhaps the highest risk for exposure of produce when it is grown with treated wood supports is the risk of accumulating metals from direct contact with the wood. This risk can only be measured in field experiments that simulate common agricultural practices.

Here we describe our most recent research results monitoring metal migration from an experimental vineyard trellis containing posts with four different preservative treatments studies done to measure the impact of treated wood on the quality of soils and fruit crop biomass. Posts were installed wrapped or unwrapped with postsaver wraps to measure the impact of these wraps on metal migration. Soil and plant biomass have begun to be collected every 6 months or annually from each treatment, respectively. Here we present background and 6-month soil metal concentration as well metal concentrations from the first year of growth of vine biomass.

1.1.2 Methods

An experimental vineyard trellis was constructed in the summer of 2020 at the Lewis Brown Horticultural Farm at Oregon State University. Trellising was installed in June-July 2020 and pinot noir grapes were planted shortly after the installation of the posts (Figure 1.4.1). Posts treated with four different preservative treatments were installed in the test site, ACQ Douglas-fir, ACZA Douglas-fir, CA-C Douglas-fir peeler cores and CCA lodgepole pine (Table 1.4.1). The posts were all nominally 4-5″ x 8′, although the ACZA-treated Douglas-fir were noticeably smaller than the other treatments. Ten posts from each treatment were installed, five with and five without Postsaver sleeves affixed to the posts 2′ from the post end. Four untreated and four steel posts were included in the trellis system as controls. Posts were installed 7-feet apart from one another and occupied two separate rows. Soil samples were taken from each location of each post at the time of installation to serve as a background measure of metal levels at each post’s location.

Figure 1.1.1: Photos of posts in grapevine trellising with a Postsaver sleeve (left) and the two rows of the completed grapevine trellis with plants at the base of posts (right).

One pinot noir grape plant was planted 6 inches from each post and drip irrigation lines were installed in each row with a drip head at each plant. Each post at the vineyard was cored at two locations for a total of 20 cores per treatment. Chemical retentions were determined from a composite sample of cores take from each treatment using X-Ray fluorescence spectroscopy according to AWPA standard A9-18 and are listed in Table 1.4.1.

Table 1.1.1: Retention levels in posts installed in an experimental grapevine trellis at the Lewis Brown Farm

		Target Retention kg/m^3 (pcf)	Retentions (posts in ground)	
Preservative	Species	UC4A	kg/m^3	pcf
ACZA	Douglas-fir	6.4 (0.4)	3.70	0.23
CCA	Lodgepole pine	6.4 (0.4)	6.79	0.42
ACQ-B	Douglas-fir	6.4 (0.4)	1.93	0.12
CA-C	Douglas-fir peeler core	2.4 (0.15)	0.34	0.02

Soil samples were homogenized, oven dried, and microwave digested according to EPA method 3052. Briefly, 0.5 g of soil was placed into PTFE microwave extraction tubes and 10 mL of concentrated nitric acid was added. Samples were digested for approximately 9.5 minutes at 180 °C with a total microwave digestion time of about 15 minutes. The resulting digestate was rinsed from the tube with DI water and brought up to a volume of 35 mL with DI water and analyzed for appropriate metals by ICP-OES and expressed on a mg/kg basis. Ten mL of the extract was analyzed for metal concentration on an Agilent 5110 VDV ICP-OES at the Soil Health Laboratory at Oregon State University.

Soil samples were taken 6, 12 and 18 months after installation from the base of each post in the trellis (~2 inches from the post). Six-month samples were analyzed for metal content and are presented in this report and subsequent soil samples are being held for analysis on new equipment being installed in our laboratory. Soil samples will continue to be taken at 6-month intervals. In 2021, prunings from the grapevines were collected and analyzed for metal content. These were taken one year after planting. Plant biomass was analyzed for Cu, Cr, As and Zn as described above. The results from the first year's prunings are described in this report. Metal content of soil and plant samples will be compared to control samples to determine whether any accumulation occurs over the course of this study.

Quantification limits for each metal using our extraction method and the equipment at the Soil Health Laboratory at OSU are listed in Table 1.1.2. Quantification limits for the analytical equipment at the Soil are well above what would be considered normal for an ICP-OES. Our understanding of the quantification capabilities of this equipment arose from discussions with the analytical laboratory during 2021. Previously the laboratory did not report their quantification limits to us in their reports but upon inquiry we determined that limits for the soil health laboratory were about 100 times higher than a typical ICP-OES of the same model. This means soil and plant biomass digests that are analyzed by the Soil Health Lab can reliably detect copper and arsenic to about 100 PPB (Table 1.1.2). This shortfall limits the utility of the data we have collected so far for this study because these high quantification limits only allow us to report accurate metal concentrations above single digits PPM in soil. For arsenic, this means we cannot detect in many cases background soil levels of arsenic and therefore cannot establish a baseline from which to measure any arsenic increases due to migration from treated wood. Because of this we are no longer using the Soil Health Lab at OSU for metals analysis and will be brining this analytical capacity into our own laboratory by using an atomic absorption spectrometer.

Samples there were below quantification limit are shown as zero in Figure 1.1.3 with an asterisk above values that are below the quantification limit. However, when a mixed population of replicate samples values is present, for example one measurement above the quantification limit and four below, a value half of the quantification limit is used in the calculation of the average value to account for uncertainty of whether the true value is closer to zero or closer to the detection limit. Unfortunately, because of our high instrument detection limits, we had to do this for some of the arsenic measurements.

Table 1.1.2: Quantification limits for ICP-OES instrument in the OSU Soil Health Laboratory. These are limits for solutions directly measured by the machine as well as the method quantification limit for 0.5 g of soil digested and diluted to 35 ml of solution.

Metal	ICP-OES Detection limit (PPM solution)	Method detection limit (PPM soil)
Arsenic	0.1	7
Copper	0.1	7
Chromium	0.05	3.5
Zinc	0.05	3.5

1.1.3 Results

Chemical retentions in the posts used in this study ranged in their levels, some at or close to AWPA UC4A standard levels for posts and some with far less chemical present (Table 1.1.1). CCA-treated posts contained slightly more chemical than the standard while ACZA and ACQ-treated posts contained about 58% and 30% of the metal required by AWPA standards. CA-C treated Douglas-fir peeler cores had only a small fraction of the required copper concentration, about 1/16th of the standard level. This is to be expected for Douglas-fir peeler cores because the heartwood of that species is very difficult to impregnate with any chemical. However, this treatment was still included in this study because these were commonly available commodities representative of what might be used in practice. The low chemical levels in some treatments shown here should be noted in the interpretation of study results as treatments with low chemical levels are less likely to show chemical migration into soil or plant biomass. We will be installing CA-C-treated pine posts in the summer of 2022 that meet the AWPA standards for copper retention.

Copper is a component of all the preservative systems tested and is expected to be one of the major mobile elements in this study. Average copper chromium and zinc levels in vineyard soils were similar in the background samples taken before installation for all from all treatments (Tukey's HSD, $p>>0.05$)(Figure 1.1.2). Arsenic migration is only expected from two treatments ACZA and CCA, and for most of these samples, levels in soil were similar from 0 to 6 months (Figure 1.1.2, B). Only some replicate soil samples taken from around ACZA-treated posts had elevated arsenic levels which led to elevated average arsenic levels in soils around ACZA-treated posts with or without postsaver wraps. After 6 months soil from ACZA posts without postsaver wraps had estimated arsenic levels of 24.8 PPM whereas all background samples around these posts were below detection limit. Soils around ACZA posts with postsaver wraps had arsenic levels of 15.5 PPM whereas background levels were not above the quantification limit. Using 50% of the quantification limit as a stand-in value for BQL samples, statistical analysis shows that arsenic levels were significantly elevated around ACZA posts without postsaver wraps versus background ($p=0.04$, Tukey's HSD). On the other hand, arsenic levels were not significantly elevated around ACZA posts with postsaver wraps versus background ($p=0.87$, Tukey's HSD). There was no statistical difference in arsenic levels between soils taken at 6 months around the wrapped or unwrapped ACZA-treated posts (p=0.98, Tukey's HSD). This is an early indication that there may be some mitigating effect of using postsaver wraps on ACZA-treated posts, although it is too early to tell definitively.

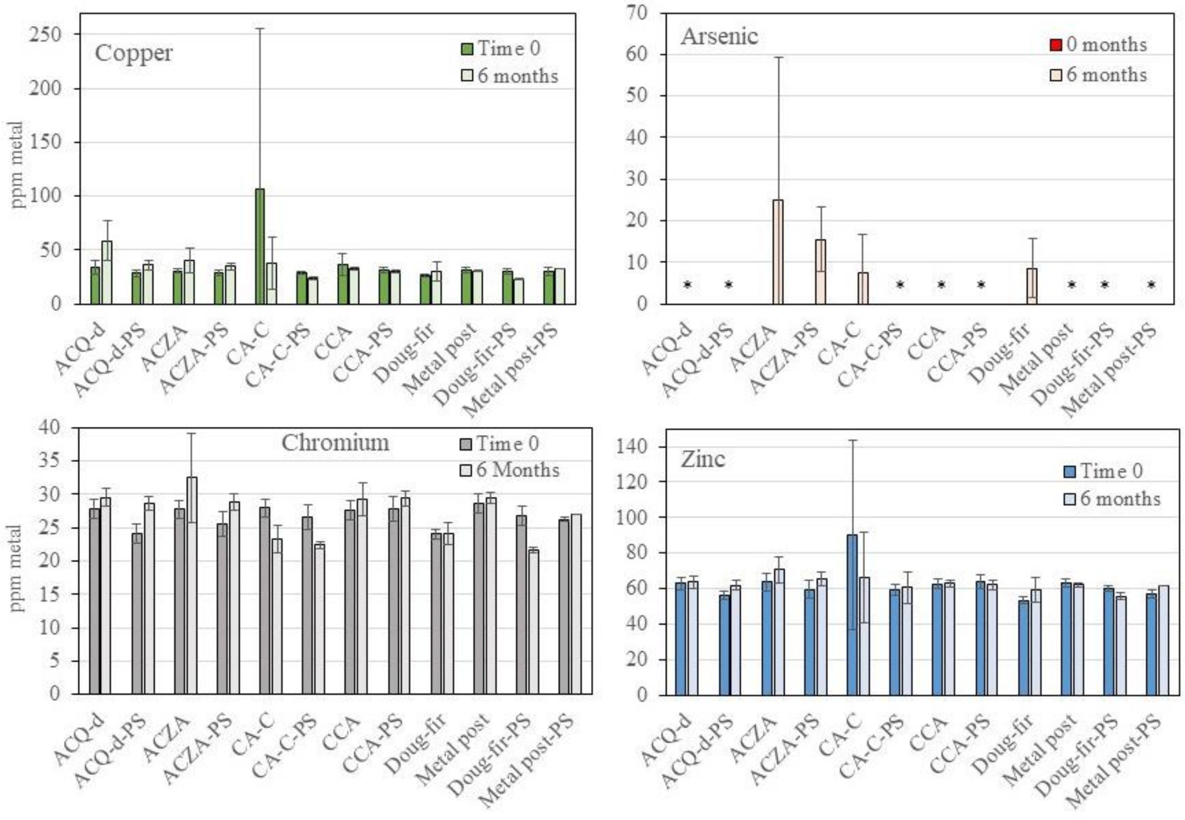

Figure 1.1.2: Copper, Arsenic, Chromium, and Zinc levels found in soils around vineyard trellising one year after planting. *Denotes samples where all replicates were below the quantification limit.

Previous study of metal migration from CCA-treated posts in a vineyard trellis showed that arsenic levels are elevated within 2 inches from the base of posts after several years of service (Robinson et al., 2006). The only metal migration observed so far in this study is arsenic from ACZA-treated posts. A longer study period will measure whether this trend continues. Robinson et al. 2006 used post excavation to sample lateral and vertical migration. While full excavation can provide a more comprehensive view of metal movement around posts, it only allows a single timepoint for analysis and introduces a greater risk of damaging post surfaces and introducing treated wood into soil samples. The study described here will continue to be monitored using soil cores taken at the base of treated posts.

In 2021, prunings were taken from the young pinot noir grapevines at the vineyard site and were analyzed for metal content as described above (Figure 1.1.3). Metal levels were generally low, and copper and zinc were only metals that were consistently detected above the quantification limit (Figure 1.1.4). There were no obvious differences among the different treatments at this first timepoint except for three individual replicate samples showing high levels of arsenic and chromium. These samples were taken from around an ACZA-treated pose, a copper azole-treated post and an untreated post. It is unclear why these levels were seen, but the fact that all metal levels in the sample were elevated together even where there was no source present in the trellis indicates there may have been an issue with the analysis. Regardless, there was no significant difference detected between samples at this time.

The vines were too small after one year to have any contact with the vineyard trellis. It is expected that the primary avenue of metal contamination to grapevine biomass would come from direct contact with the posts and as the vines grow, we will differentiate biomass that has contact with the trellis versus vine material without contact.

Figure 1.1.3: Picture of grapevines 1 year after planting just before pruning in summer 2021.

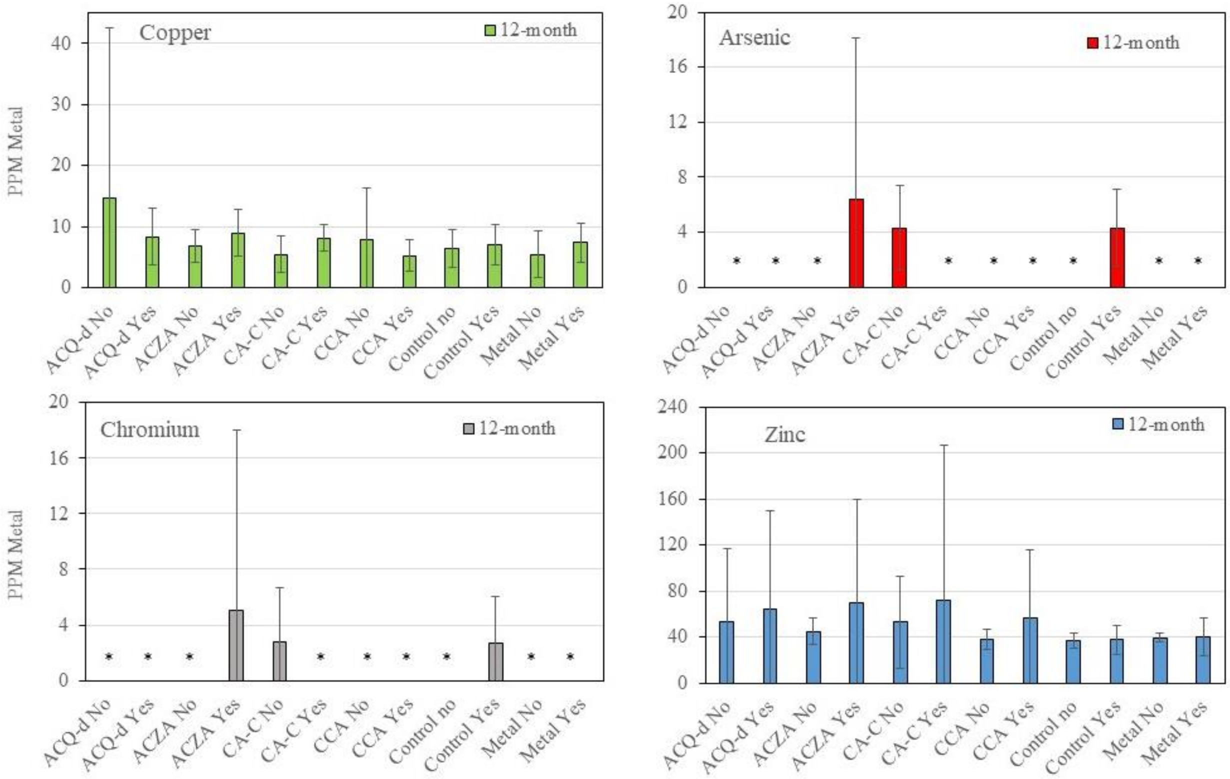

Figure 1.1.4: Copper (A), Arsenic (B), Chromium (C) and Zinc (D) levels found in grapevine biomass one year after planting. *Denotes samples where all replicates were below the quantification limit.

Table 1.1.3 Soil metal concentrations for background (0 month) and 6-month samples are shown in figure 1.1.2. Samples that are below quantification limit are highlighted in blue and are listed at 50% of the method quantification limit (3.5 PPM for As).

Post Tag	Treatment	Material	Postsaver	Background Time 0 Metal				6 months PPM Metal			
				As	Cr	Cu	Zn	As	Cr	Cu	Zn
1303	ACQ-d	Douglas-fir	No	3.5	26.8	28.2	59.0	3.5	27.9	82.9	58.9
1323	ACQ-d	Douglas-fir	No	3.5	25.5	29.4	58.9	3.5	28.3	73.0	61.1
1330	ACQ-d	Douglas-fir	No	3.5	28.3	45.5	63.6	3.5	29.4	61.1	64.1
1331	ACQ-d	Douglas-fir	No	3.5	28.7	33.2	67.3	3.5	30.1	37.1	66.6
1333	ACQ-d	Douglas-fir	No	3.5	29.5	34.0	66.0	3.5	31.7	37.6	68.1
1302	ACQ-d	Douglas-fir	Yes	3.5	22.7	26.2	55.4	3.5	29.4	33.6	61.0
1311	ACQ-d	Douglas-fir	Yes	3.5	24.0	34.5	57.1	3.5	28.2	44.3	63.6
1320	ACQ-d	Douglas-fir	Yes	3.5	24.8	28.8	58.5	3.5	27.6	30.9	63.0
1322	ACQ-d	Douglas-fir	Yes	3.5	26.3	28.8	57.6	3.5	30.4	38.1	64.8
1326	ACQ-d	Douglas-fir	Yes	3.5	22.7	25.7	52.3	3.5	27.5	32.7	57.5
1301	ACZA	Douglas-fir	No	3.5	27.6	29.6	60.7	14.8	30.6	41.1	72.9
1305	ACZA	Douglas-fir	No	3.5	26.3	27.8	56.7	3.5	26.2	32.9	62.9
1314	ACZA	Douglas-fir	No	3.5	29.6	33.6	70.6	16.6	30.5	33.7	68.1

1315	ACZA	Douglas-fir	No	3.5	28.8	31.8	66.5	3.5	29.7	32.1	66.0
1318	ACZA	Douglas-fir	No	3.5	26.2	29.7	63.3	85.7	45.2	61.4	84.0
1308	ACZA	Douglas-fir	Yes	3.5	27.5	31.0	66.4	16.8	27.5	31.0	63.8
1312	ACZA	Douglas-fir	Yes	3.5	28.2	31.7	64.4	12.8	28.4	35.9	72.3
1324	ACZA	Douglas-fir	Yes	3.5	24.2	26.2	55.4	23.6	31.3	38.0	66.2
1327	ACZA	Douglas-fir	Yes	3.5	23.7	26.2	55.3	20.9	28.6	37.1	61.0
1328	ACZA	Douglas-fir	Yes	3.5	24.5	27.0	55.4	3.5	28.2	31.0	65.2
1335	CA-C	Douglas-fir	No	3.5	28.9	405.1	197.1	23.7	27.2	85.8	116.5
1340	CA-C	Douglas-fir	No	3.5	27.6	30.5	64.0	3.5	22.8	22.1	50.4
1343	CA-C	Douglas-fir	No	3.5	27.4	30.4	62.4	3.5	21.0	27.2	53.9
1344	CA-C	Douglas-fir	No	3.5	25.9	30.4	63.8	3.5	23.3	26.3	56.9
1348	CA-C	Douglas-fir	No	3.5	29.8	33.8	65.1	3.5	22.4	24.9	53.6
1337	CA-C	Douglas-fir	Yes	3.5	28.3	27.8	57.6	3.5	22.8	22.3	68.7
1338	CA-C	Douglas-fir	Yes	3.5	23.8	27.3	55.0	3.5	22.0	23.8	72.7
1341	CA-C	Douglas-fir	Yes	3.5	25.7	27.7	58.4	3.5	23.2	24.0	57.7
1345	CA-C	Douglas-fir	Yes	3.5	26.3	30.7	63.4	3.5	22.0	25.5	55.7
1346	CA-C	Douglas-fir	Yes	3.5	28.9	31.3	62.2	3.5	21.9	24.1	48.4
1310	CCA	Lodgepole pine	No	3.5	26.4	29.9	61.7	3.5	26.8	31.1	61.2
1313	CCA	Lodgepole pine	No	3.5	29.0	32.0	67.1	3.5	33.3	34.9	65.9
1319	CCA	Lodgepole pine	No	3.5	28.6	29.6	62.7	3.5	28.3	30.3	61.8
1321	CCA	Lodgepole pine	No	3.5	25.4	55.9	59.4	3.5	27.1	33.4	62.0
1329	CCA	Lodgepole pine	No	3.5	28.6	36.1	62.6	3.5	30.4	33.1	63.0
1307	CCA	Lodgepole pine	Yes	3.5	24.9	28.4	59.9	3.5	28.9	27.7	58.3
1317	CCA	Lodgepole pine	Yes	3.5	30.0	33.0	70.5	3.5	28.6	31.0	65.1
1325	CCA	Lodgepole pine	Yes	3.5	26.3	28.8	59.1	3.5	28.8	30.1	58.9
1332	CCA	Lodgepole pine	Yes	3.5	29.2	32.7	64.9	3.5	29.2	30.2	63.6
1334	CCA	Lodgepole pine	Yes	3.5	28.5	33.0	65.5	3.5	31.7	32.2	64.8
1309	Control	Metal post	No	3.5	27.2	28.2	60.9	3.5	28.6	29.8	61.2
1316	Control	Metal post	No	3.5	30.0	34.5	65.4	3.5	30.3	31.3	63.0
1336	Control	Douglas-fir	No	3.5	24.8	27.9	55.2	13.6	25.8	39.1	66.1
1339	Control	Douglas-fir	No	3.5	23.4	24.9	51.3	3.5	22.5	21.5	52.1
1304	Control	Metal post	Yes	3.5	25.9	26.9	54.8	Lost sample			
1306	Control	Metal post	Yes	3.5	26.5	33.5	59.5	3.5	27.1	32.0	61.9
1342	Control	Douglas-fir	Yes	3.5	25.2	27.2	58.4	3.5	21.2	22.2	57.4
1347	Control	Douglas-fir	Yes	3.5	28.2	32.8	61.5	3.5	22.0	23.5	54.1

Table 1.1.4 Metal levels found in grapevine biomass one year after installation. Samples with metal levels below quantification limits are highlighted in blue and listed as 50% of the method quantification limit (3.5 PPM for As, 1.75 PPM for Cr and 3.5 PPM for Cu).

PPM Metal 12-months

Post Tag	Treatment	Material	Postsaver	As	Cr	Cu	Zn
1303	ACQ-d	Douglas-fir	No	3.5	1.75	8.4	290.5
1303	ACQ-d	Douglas-fir	No	3.5	1.75	9.1	34.3
1303	ACQ-d	Douglas-fir	No	3.5	1.75	3.5	29.4
1323	ACQ-d	Douglas-fir	No	3.5	1.75	11.2	44.8
1323	ACQ-d	Douglas-fir	No	3.5	1.75	11.2	53.2
1323	ACQ-d	Douglas-fir	No	3.5	1.75	9.8	49.7
1330	ACQ-d	Douglas-fir	No	3.5	1.75	31.5	37.1
1330	ACQ-d	Douglas-fir	No	3.5	1.75	115.5	39.9
1330	ACQ-d	Douglas-fir	No	3.5	1.75	9.8	29.4
1331	ACQ-d	Douglas-fir	No	3.5	1.75	3.5	30.8
1331	ACQ-d	Douglas-fir	No	3.5	1.75	3.5	34.3
1331	ACQ-d	Douglas-fir	No	3.5	1.75	3.5	37.1
1331	ACQ-d	Douglas-fir	No	3.5	1.75	3.5	39.2
1333	ACQ-d	Douglas-fir	No	3.5	1.75	3.5	46.2
1333	ACQ-d	Douglas-fir	No	3.5	1.75	3.5	32.2
1333	ACQ-d	Douglas-fir	No	3.5	1.75	3.5	32.9
1302	ACQ-d	Douglas-fir	Yes	3.5	1.75	11.2	35
1302	ACQ-d	Douglas-fir	Yes	3.5	1.75	3.5	35
1302	ACQ-d	Douglas-fir	Yes	3.5	1.75	10.5	41.3
1320	ACQ-d	Douglas-fir	Yes	3.5	1.75	7.7	58.8
1320	ACQ-d	Douglas-fir	Yes	3.5	1.75	9.8	30.1
1320	ACQ-d	Douglas-fir	Yes	3.5	1.75	7.7	29.4
1322	ACQ-d	Douglas-fir	Yes	3.5	1.75	3.5	32.2
1322	ACQ-d	Douglas-fir	Yes	3.5	1.75	3.5	28.7
1322	ACQ-d	Douglas-fir	Yes	3.5	1.75	3.5	36.4
1326	ACQ-d	Douglas-fir	Yes	3.5	1.75	8.4	44.8
1326	ACQ-d	Douglas-fir	Yes	3.5	1.75	11.2	62.3
1326	ACQ-d	Douglas-fir	Yes	3.5	1.75	19.6	333.9
1301	ACZA	Douglas-fir	No	3.5	1.75	9.8	48.3
1301	ACZA	Douglas-fir	No	3.5	1.75	9.1	41.3
1301	ACZA	Douglas-fir	No	3.5	1.75	7.7	52.5
1305	ACZA	Douglas-fir	No	3.5	1.75	9.1	46.9
1305	ACZA	Douglas-fir	No	3.5	1.75	3.5	44.8
1305	ACZA	Douglas-fir	No	3.5	1.75	3.5	28.7
1314	ACZA	Douglas-fir	No	3.5	1.75	3.5	65.8
1314	ACZA	Douglas-fir	No	3.5	1.75	8.4	44.1
1314	ACZA	Douglas-fir	No	3.5	1.75	9.1	31.5
1315	ACZA	Douglas-fir	No	3.5	1.75	7.7	58.8
1315	ACZA	Douglas-fir	No	3.5	1.75	3.5	52.5
1315	ACZA	Douglas-fir	No	3.5	1.75	3.5	59.5
1318	ACZA	Douglas-fir	No	3.5	1.75	3.5	35
1318	ACZA	Douglas-fir	No	3.5	1.75	8.4	33.6
1318	ACZA	Douglas-fir	No	3.5	1.75	9.1	25.9
1318	ACZA	Douglas-fir	No	3.5	1.75	9.8	51.1
1308	ACZA	Douglas-fir	Yes	50.4	53.9	21.7	33.6
1308	ACZA	Douglas-fir	Yes	3.5	1.75	9.1	36.4
1308	ACZA	Douglas-fir	Yes	3.5	1.75	9.8	55.3
1312	ACZA	Douglas-fir	Yes	3.5	1.75	8.4	53.9
1312	ACZA	Douglas-fir	Yes	3.5	1.75	9.8	35.7
1312	ACZA	Douglas-fir	Yes	3.5	1.75	9.1	31.5
1324	ACZA	Douglas-fir	Yes	3.5	1.75	9.1	44.8
1324	ACZA	Douglas-fir	Yes	3.5	1.75	8.4	36.4
1324	ACZA	Douglas-fir	Yes	3.5	1.75	8.4	37.1

1327	ACZA	Douglas-fir	Yes	3.5	1.75	8.4	46.2
1327	ACZA	Douglas-fir	Yes	3.5	1.75	9.1	36.4
1327	ACZA	Douglas-fir	Yes	3.5	1.75	7.7	30.8
1327	ACZA	Douglas-fir	Yes	3.5	1.75	3.5	67.2
1328	ACZA	Douglas-fir	Yes	3.5	1.75	8.4	392
1328	ACZA	Douglas-fir	Yes	3.5	1.75	3.5	37.1
1328	ACZA	Douglas-fir	Yes	3.5	1.75	9.1	136.5
1335	CA-C	Douglas-fir	No	3.5	1.75	3.5	46.9
1335	CA-C	Douglas-fir	No	15.4	16.8	12.6	58.1
1335	CA-C	Douglas-fir	No	3.5	1.75	9.1	45.5
1340	CA-C	Douglas-fir	No	3.5	1.75	7.7	30.1
1340	CA-C	Douglas-fir	No	3.5	1.75	8.4	38.5
1340	CA-C	Douglas-fir	No	3.5	1.75	3.5	37.8
1343	CA-C	Douglas-fir	No	3.5	1.75	3.5	42.7
1343	CA-C	Douglas-fir	No	3.5	1.75	3.5	32.2
1343	CA-C	Douglas-fir	No	3.5	1.75	3.5	45.5
1344	CA-C	Douglas-fir	No	3.5	1.75	3.5	102.9
1344	CA-C	Douglas-fir	No	3.5	1.75	3.5	36.4
1344	CA-C	Douglas-fir	No	3.5	1.75	3.5	182
1348	CA-C	Douglas-fir	No	3.5	1.75	3.5	26.6
1348	CA-C	Douglas-fir	No	3.5	1.75	9.1	35.7
1348	CA-C	Douglas-fir	No	3.5	1.75	3.5	32.9
1337	CA-C	Douglas-fir	Yes	3.5	1.75	3.5	28
1337	CA-C	Douglas-fir	Yes	3.5	1.75	8.4	32.2
1337	CA-C	Douglas-fir	Yes	3.5	1.75	8.4	37.1
1337	CA-C	Douglas-fir	Yes	3.5	1.75	3.5	35.7
1338	CA-C	Douglas-fir	Yes	3.5	1.75	9.1	46.9
1338	CA-C	Douglas-fir	Yes	3.5	1.75	11.9	42
1338	CA-C	Douglas-fir	Yes	3.5	1.75	9.1	34.3
1341	CA-C	Douglas-fir	Yes	3.5	1.75	7.7	558.6
1341	CA-C	Douglas-fir	Yes	3.5	1.75	7.7	44.8
1341	CA-C	Douglas-fir	Yes	Sample lost			
1345	CA-C	Douglas-fir	Yes	3.5	1.75	8.4	28.7
1345	CA-C	Douglas-fir	Yes	3.5	1.75	8.4	26.6
1345	CA-C	Douglas-fir	Yes	3.5	1.75	8.4	39.9
1346	CA-C	Douglas-fir	Yes	3.5	1.75	9.1	43.4
1346	CA-C	Douglas-fir	Yes	3.5	1.75	8.4	49
1346	CA-C	Douglas-fir	Yes	3.5	1.75	9.8	37.8
1310	CCA	Lodgepole pine	No	3.5	1.75	7.7	37.8
1310	CCA	Lodgepole pine	No	3.5	1.75	3.5	31.5
1310	CCA	Lodgepole pine	No	3.5	1.75	3.5	20.3
1313	CCA	Lodgepole pine	No	3.5	1.75	3.5	38.5
1313	CCA	Lodgepole pine	No	3.5	1.75	35.7	46.2
1313	CCA	Lodgepole pine	No	3.5	1.75	10.5	41.3
1313	CCA	Lodgepole pine	No	3.5	1.75	19.6	39.9
1319	CCA	Lodgepole pine	No	3.5	1.75	3.5	33.6
1319	CCA	Lodgepole pine	No	3.5	1.75	3.5	22.4
1319	CCA	Lodgepole pine	No	3.5	1.75	3.5	35
1321	CCA	Lodgepole pine	No	3.5	1.75	7.7	33.6
1321	CCA	Lodgepole pine	No	3.5	1.75	7.7	49
1321	CCA	Lodgepole pine	No	3.5	1.75	3.5	43.4
1321	CCA	Lodgepole pine	No	3.5	1.75	3.5	38.5
1329	CCA	Lodgepole pine	No	3.5	1.75	3.5	51.8
1329	CCA	Lodgepole pine	No	3.5	1.75	11.2	37.8

1329	CCA	Lodgepole pine	No	3.5	1.75	3.5	48.3
1307	CCA	Lodgepole pine	Yes	3.5	1.75	8.4	56
1307	CCA	Lodgepole pine	Yes	3.5	1.75	9.8	72.1
1307	CCA	Lodgepole pine	Yes	3.5	1.75	7.7	32.9
1317	CCA	Lodgepole pine	Yes	3.5	1.75	3.5	44.8
1317	CCA	Lodgepole pine	Yes	3.5	1.75	3.5	25.2
1317	CCA	Lodgepole pine	Yes	3.5	1.75	3.5	58.1
1325	CCA	Lodgepole pine	Yes	3.5	1.75	3.5	32.9
1325	CCA	Lodgepole pine	Yes	3.5	1.75	8.4	32.9
1325	CCA	Lodgepole pine	Yes	3.5	1.75	3.5	18.9
1332	CCA	Lodgepole pine	Yes	3.5	1.75	3.5	26.6
1332	CCA	Lodgepole pine	Yes	3.5	1.75	9.1	35.7
1332	CCA	Lodgepole pine	Yes	3.5	1.75	3.5	49
1334	CCA	Lodgepole pine	Yes	3.5	1.75	3.5	57.4
1334	CCA	Lodgepole pine	Yes	3.5	1.75	3.5	36.4
1334	CCA	Lodgepole pine	Yes	3.5	1.75	3.5	266
1309	Control	Metal post	No	3.5	1.75	11.2	43.4
1309	Control	Metal post	No	3.5	1.75	3.5	40.6
1309	Control	Metal post	No	3.5	1.75	3.5	39.9
1316	Control	Metal post	No	3.5	1.75	3.5	34.3
1336	Control	Douglas-fir	no	3.5	1.75	7.7	35.7
1336	Control	Douglas-fir	no	3.5	1.75	3.5	24.5
1336	Control	Douglas-fir	no	3.5	1.75	9.8	30.8
1339	Control	Douglas-fir	no	3.5	1.75	3.5	36.4
1339	Control	Douglas-fir	no	3.5	1.75	8.4	37.1
1339	Control	Douglas-fir	no	3.5	1.75	9.1	48.3
1304	Control	Metal post	Yes	3.5	1.75	8.4	47.6
1304	Control	Metal post	Yes	3.5	1.75	11.2	28.7
1304	Control	Metal post	Yes	3.5	1.75	9.8	34.3
1306	Control	Metal post	Yes	3.5	1.75	7.7	70
1306	Control	Metal post	Yes	3.5	1.75	3.5	27.3
1306	Control	Metal post	Yes	3.5	1.75	3.5	34.3
1342	Control	Douglas-fir	Yes	3.5	1.75	3.5	28
1342	Control	Douglas-fir	Yes	3.5	1.75	3.5	25.2
1342	Control	Douglas-fir	Yes	3.5	1.75	3.5	29.4
1347	Control	Douglas-fir	Yes	3.5	1.75	11.2	41.3
1347	Control	Douglas-fir	Yes	13.3	13.3	7.7	44.8
1347	Control	Douglas-fir	Yes	3.5	1.75	10.5	42.7

1.2.0 Metal migration from treated posts into soils, leave and apples in a certified organic apple orchard

1.2.1 Introduction

The USDA organic regulations (7 CFR part 205) state that treated wood is not permitted to be utilized new or replacement installations on certified organic farms. However, organic certification does not require the removal of existing structures provided it is not in direct contact with crops (NOP 5036, 2018). This is also the case for state-certification programs such as Oregon Tilth (https://tilth.org/help-center/treated-wood/). Because of this, many organic farms actually utilize treated wood for trellising despite prohibitions on its use in new construction. This situation ensures that in some cases treated wood can stay in service on organic farms for the decades-long lifespan of the treated wood. This raises the question: Does treated wood contaminate soil, plants or produce in certified organic agriculture? To answer this, the EPTW sought to identify cases where treated wood is used in organic agriculture to measure whether treated wood has an impact on organic soil, plant matter, or produce.

The EPTW identified an Oregon Tilth certified organic apple orchard at the Oregon State University Lewis Brown Horticultural farm which contains treated posts as part of an aging trellising system (Figure 1.5.1). The orchard was planted c.a. 1996 as a conventional apple orchard which utilized treated posts in its trellising system. In 2010 the orchard was certifed organic by Oregon Tilth and the treated posts remained in place and they are still in service today.

Figure 1.2.1: Photo of the Oregon Tilth Certified Organic apple orchard at the Lewis Brown Horticultural Farm

1.2.2 Methods

A sampling effort was initiated in the summer and fall of 2020 and 2021 to measure metal levels in orchard soils, leaves and apples in close proximity to posts as compared to controls much farther away from posts (Figure 1.5.2). This assessment was done to identify any long-term impacts on metal levels in orchard soils, plant biomass or fruit produced in the orchard resulting from the treated wood present in the orchard. The initial sampling in 2020 included soil, leaves and apples taken from five posts within three feet of the base of an apple tree. Control trees were selected throughout the orchard in areas that were at least 15 feet from the nearest posts. A second sampling effort in 2021 included an additional 10 posts and resampling of the original 5 posts with an altered sampling regime. Soil, leaves and apples were sampled from trees in the 2021 sampling as well.

Based on previous studies of poles treated with arsenicals, metal levels in soil surrounding poles drop to levels similar to background within a 2-foot distance from the pole surface, indicating that the control trees selected should not have any impact from other posts in the orchard (Coles et al., 2014; Zagury et al., 2003). Soil samples were taken 4 inches from the base of posts and 4 inches

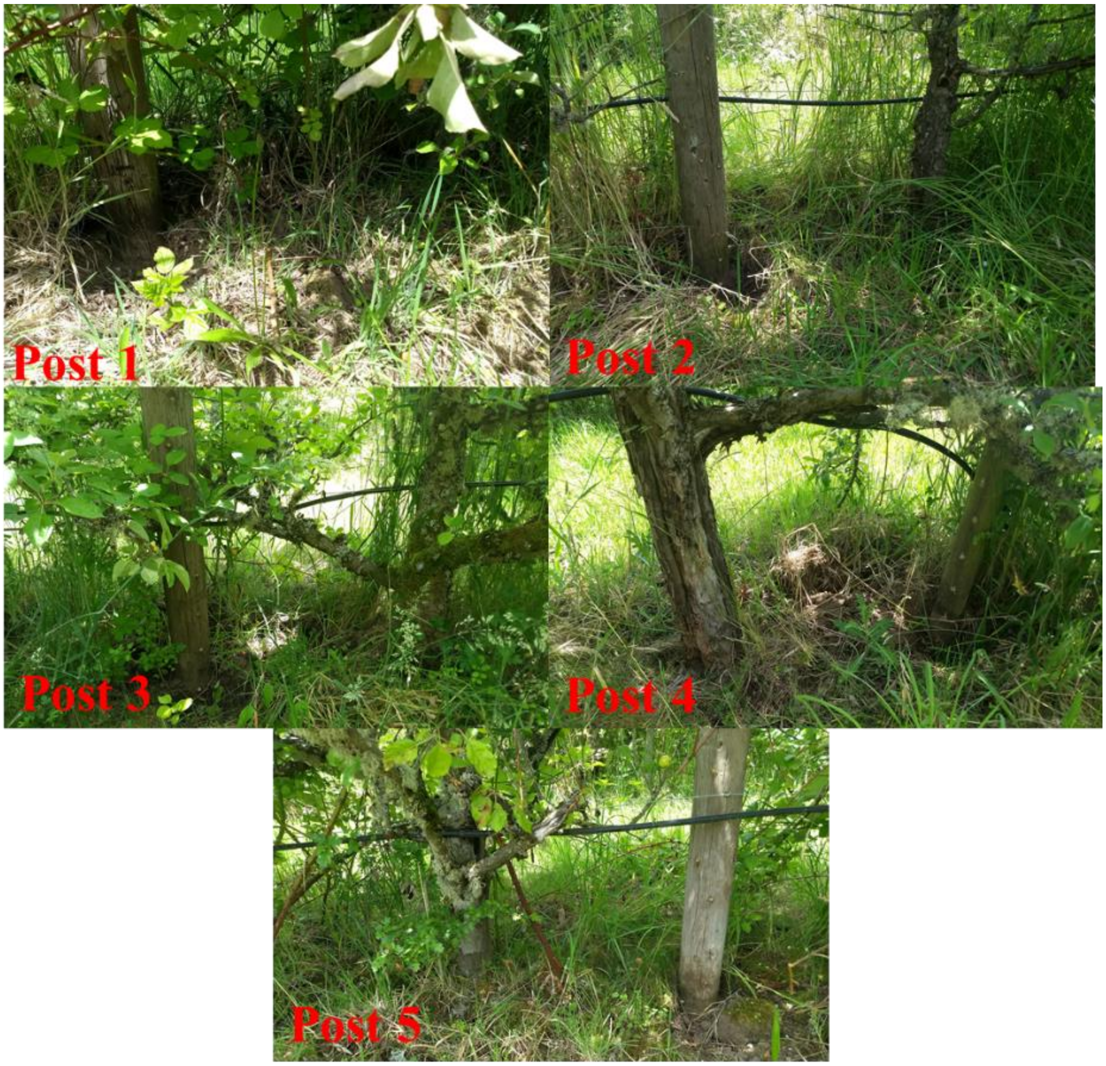

Figure 1.2.2: Five treated posts near apple trees that were sampled in this study. Posts 6-15 were similarly placed within 36 inches of an apple tree.

Posts selected for sampling were cored at 8 locations ranging from 0.15 m underground to 1.2 m above ground. Cores were pooled for each individual post and the assay zone was isolated for each prior to measuring metal concentration by X-ray fluorescence spectroscopy according to AWPA standard A9-18. The preservative treatment was unknown for these posts so a scanning protocol was done for each of the 15 posts. It was found that seven posts were treated with CCA and seven with ACZA and cores from one post were lost. Retentions for the posts selected for this study are listed in Table 1.5.1. Horticultural posts in this region are typically treated to UC4A retentions (6.4 kg/m^3/0.4 pcf) and the posts in this study contained 12.6-315.2% of the UC4A target level after about 25 years of service.

For the 2020 sampling, soil samples were taken 4 inches from the base of posts that were sampled. In addition, a second sample was taken 4 inches from the bas of the neighboring tree. Control trees were sampled 4 inches from the base of the tree. Soil samples were taken with a 1-inch diameter soil corer and approximately 6 inches of soil was sampled with the corer. Leaves were taken from each tree associated with a post or a control tree and apples were taken wherever they could be located at the sampling time.

For the 2021 sampling, soil samples were taken from the base of 15 posts, including posts that were sampled in the first round. Soil samples were taken 4 and 8 inches from the base of each post using the same coring methods described above. Leaves and apples were also sampled from trees assocated with each post. Apples were sampled randomly from the tree canopy as were a leaf sample for each tree resulting in a single apple or leaf sample per tree consisting of cominged biomass. A second sample of leaves that could have been in direct contact with the posts (within ~6 inches) was taken for each post and kept separate from leaf samples randomly taken from around the tree canopy (Figure 1.2.3).

Table 1.2.1: Preservative retention levels in posts sampled at the Lewis Brown Farm certified organic orchard.

Pole #	Preservative	Total Retention CCA/ACZA kg/m^3 (pcf)	UC4A retention kg/m^3 (pcf)	% Remaining vs UC4A
Post 1	ACZA	3.2 (0.2)	6.4 (0.4)	49.6
Post 2	ACZA	2.9 (0.18)	6.4 (0.4)	45.0
Post 3	ACZA	5.6 (0.35)	6.4 (0.4)	87.5
Post 4	CCA	7.3 (0.45)	6.4 (0.4)	113.5
Post 5	ACZA	3.6 (0.22)	6.4 (0.4)	56.1
Post 6	ACZA	1.5 (0.09)	6.4 (0.4)	23.1
Post 7	ACZA	4.2 (0.26)	6.4 (0.4)	65.0
Post 8	CCA	10.7 (0.67)	6.4 (0.4)	166.9
Post 9	CCA	13.9 (0.87)	6.4 (0.4)	216.7
Post 10	CCA	20.2 (1.26)	6.4 (0.4)	315.2
Post 11	CCA	1.6 (0.10)	6.4 (0.4)	24.8

Post 12	CCA	0.8 (0.05)	6.4 (0.4)	12.9
Post 13	CCA	0.8 (0.05)	6.4 (0.4)	12.6
Post 14				
Post 15	ACZA	7.1 (0.44)	6.4 (0.4)	111.1

Soil samples were homogenized prior to extraction. Samples were oven dried and ~0.5 g of soil and/or ~1.0 g of biomass was extracted according to EPA method 3052 as described in section 1.1.2 except that the final dilultion of extracts was into 10 ml instead of 35 ml for 2020 samples. This makes the method detection limit lower for this test those listed in Table 1.1.2. For the 2020 samples, copper chromium and arsenic levels were measured because at the time it was not known that ACZA-treated posts were in the orchard. Subsequent analyses of the 2021 samples included zinc in the analysis and extracts were diluted to 35 ml prior to measuring, bringing detection limits in line with section 1.1.2. Total metal content of the extract was calculated, was normalized to the mass of soil extracted or biomass and presented as ppm (mg/kg). The full analysis of the 2020 sampling is presented below in Figure 1.2.4 and Table 1.2.2. Only a partial analysis of leaf and apple samples from the 2021 sampling is available for this report and is presented in Figure 1.2.5 and Table 1.2.3.

Figure 1.2.3: Examples of areas around posts where leaves were sampled that could have come in direct contact with posts.

1.2.3 Results

For the 2020 sampling, copper, chromium and arsenic levels in leaf and apple tissue taken from trees near posts were indistinguishable from tissue sampled from control posts (Figure 1.2.4). Metal levels for all three metals were all below 8 ppm in leaf samples (Table 1.5.2). Copper levels in one of three technical replicates taken from leaves near one of the posts was ~4 times higher than the other two technical replicates, leading to the high variance in this sample. It is unknown why this occurred, but potentially indicates high within sample vairability. Leaf sampling was done randomly by picking leaves from a random selection of leaves around the tree canopy. This may indicate that leaves at different locations on the tree have different copper exposure, although in this sampling no leaves were obviously in contact with treated posts when they were sampled. Average metal levels in apples all below 3 ppm for all metals (Figure 1.2.4; Table 1.2.2). Most apples were sampled in the fall and all of these had metal levels below detection limit (counted as 0 ppm here). The only apples with detectable metal levels were harvested in the summer months before they were fully ripe. Metal levels in control leaves and apples were not statistically significantly different than their counterparts taken from near posts (p>>0.05) (Table 1.2.2).

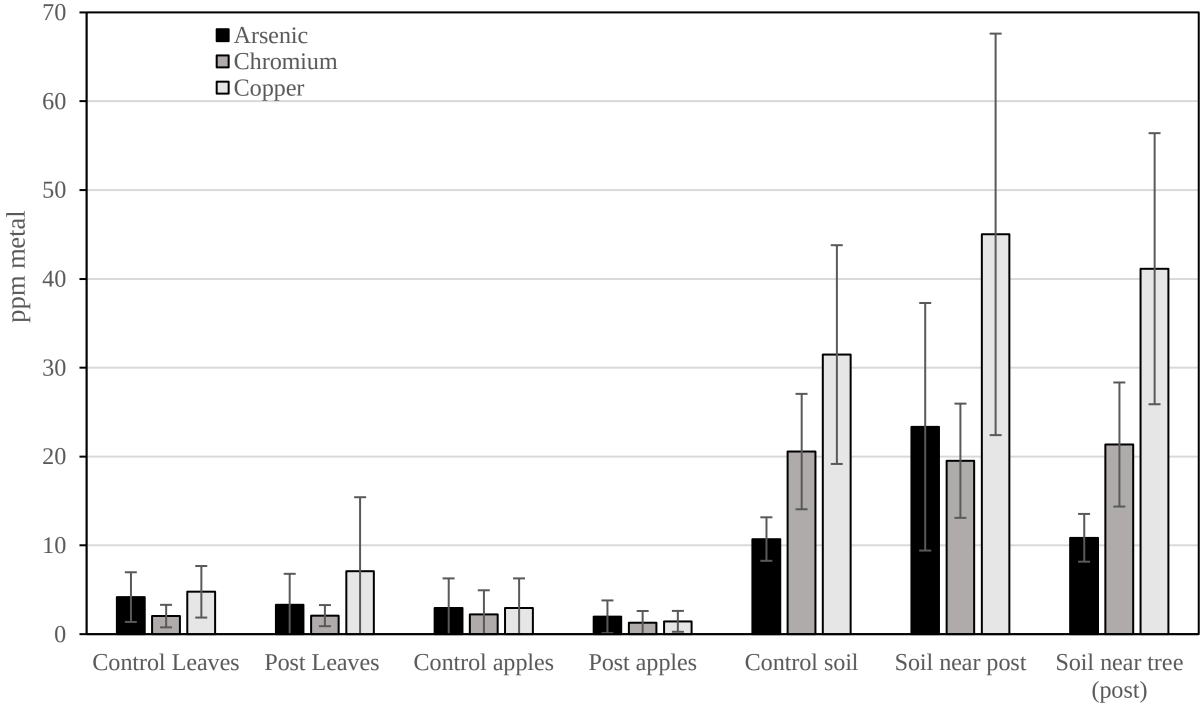

Figure 1.2.4: Arsenic copper and chromium levels in soil, leaves and apples taken from or near trees near treated posts or control trees far away from posts.

For samples taken in 2020, soil samples taken from near control trees contained an average of 10.7 ppm As, 20.6 ppm Cr and 31.5 ppm Cu. Soil samples near treated posts contained an average 23.3 ppm As, 19.5 ppm Cr and 45.0 ppm Cu indicating arsenic levels were elevated by over two-fold compared to controls (p<<0.05, Tukey's HSD). Copper levels also appeared elevated in the soil taken near treated posts compared to control soils, however elevation of copper levels was not significant with 95% confidence (p = 0.066) (Figure 1.2.4; Table 1.2.2). Soil samples taken from the base of trees near posts, ~20-32 inches from the base of the posts, contained similar metal levels to control posts and these were not statistically different. This indicates that arsenic likely did not accumulate above background levels much farther than a 4-inch radius from the treated posts.

There was a high degree of variability in metal levels among soil samples and even among technical replicate extracts of the same sample. This is particularly evident in arsenic levels from soils taken 4 inches from the treated posts, where some metal levels taken from one of the ACZA-treated posts varied by a factor of 4 between different technical replicates (Table 1.2.2). This high in-sample variability makes it difficult to resolve differences among the different sample types with confidence. Despite statistical testing indicating a significant difference in arsenic levels near the base of posts, an expanded sampling would improve the confidence we have in these measures. In addition, since we did see an arsenic signal in the 2021 dataset, further sampling also attempted to delineate the preservative migration boundary.

A limited number of the total samples taken in 2021 have been analyzed and we have some data from some leaf samples taken from control trees, trees near posts and leaves possibly in contact with posts. Copper, chromium, arsenic, and zinc levels found in leaves and apples from 2021 are shown in Table 1.2.3. Almost all of the samples had copper, chromium and arsenic levels below the quantification limit. Zinc was detectable in all leaf samples, but so far there was no apparent difference among the different sample types. Further analysis of samples taken in 2021 will be done on new atomic spectroscopy equipment acquired by the biodeterioration laboratory.

The metal levels measured in samples taken in 2020 are similar to or less than levels found in previous studies around posts in agricultural applications. For example, Robinson et al. 2006 measured arsenic levels in soils 50 mm (~2 inches) away from vineyard posts which were below 50 ppm on average for posts that are only a few years old. Levels found 4 inches from posts in this study were about half of those found in Robinson et al. 2006. This may be due to the greater distance away from the posts or the advanced age of posts in this study which provided time for metal content of soils to dissipate via further migration. The lower arsenic levels found in this study after ~25 years of service in the apple orchard may be a result of leaching stabilizing over time, stopping accumulation sometime during the life of the post. Preservative retentions in the orchard posts show significant amounts of metals remain in posts indicating that there is a risk for further leaching. However previous work shows that accumulation of metals in soils is not necessarily related to the preservative retention levels in wood (Lebow et al. 2004). In addition, most leaching occurs in the early stages of treated wood exposure to water whereafter metal migration dissipates (Ye, 2013). Leaching from posts ~25 years old should have stabilized barring any damage to them.

Table 1.2.2 Metal concentration (all replicates) in samples taken from the organic apple orchard in summer and fall of 2020. Values of zero indicate below quantification limit.

			ppm (µg/g) metal[1]			
Sample	Sample date	Replicate #	As[3]	Cr[4]	Cu[5]	Zn[2,6]
Control 1 leaf	5/28/2020	1	6.3	4.5	9.9	
Control 1 leaf	5/28/2020	2	4.5	2.7	8.1	
Control 1 leaf	5/28/2020	3	4.5	2.7	7.2	
Control 1 leaf	9/30/2020	1	0.0	0.0	0.0	0.0
Control 2 leaf	5/28/2020	1	4.5	3.6	7.2	
Control 2 leaf	5/28/2020	2	3.6	2.7	5.4	
Control 2 leaf	5/28/2020	3	4.5	2.7	8.1	
Control 2 leaf	9/30/2020	1	0.0	0.0	0.0	0.0
Control 3 leaf	5/28/2020	1	3.6	2.7	3.6	
Control 3 leaf	5/28/2020	2	4.5	2.7	7.2	
Control 3 leaf	5/28/2020	3	4.5	2.7	5.4	
Control 3 leaf	9/30/2020	1	0.0	0.0	0.0	0.0
Control 4 leaf	5/28/2020	1	3.6	2.7	5.4	
Control 4 leaf	5/28/2020	2	3.6	2.7	6.3	
Control 4 leaf	5/28/2020	3	3.6	2.7	9.0	
Control 4 leaf	9/30/2020	1	0.0	0.0	0.0	0.0
Control 5 leaf	5/28/2020	1	3.6	2.7	5.4	
Control 5 leaf	5/28/2020	2	4.5	2.7	3.6	
Control 5 leaf	5/28/2020	3	4.5	2.7	3.6	
Control 5 leaf	9/30/2020	1	0.0	0.0	0.0	0.0
Post 1 leaf	5/28/2020	1	4.5	3.6	7.2	
Post 1 leaf	5/28/2020	2	4.5	2.7	4.5	
Post 1 leaf	5/28/2020	3	2.7	2.7	46.8	
Post 1 leaf	9/30/2020	1	0.0	0.0	0.0	0.0
Post 2 leaf	5/28/2020	1	4.5	2.7	10.8	
Post 2 leaf	5/28/2020	2	2.7	2.7	9.0	
Post 2 leaf	5/28/2020	3	4.5	2.7	9.0	
Post 2 leaf	9/30/2020	1	0.0	0.0	0.0	0.0
Post 3 leaf	5/28/2020	1	4.5	2.7	6.3	
Post 3 leaf	5/28/2020	2	4.5	2.7	5.4	
Post 3 leaf	5/28/2020	3	3.6	2.7	2.7	
Post 3 leaf	9/30/2020	1	0.0	0.0	0.0	0.0
Post 4 leaf	5/28/2020	1	5.4	1.8	4.5	
Post 4 leaf	5/28/2020	2	3.6	2.7	1.8	
Post 4 leaf	5/28/2020	3	4.5	2.7	14.4	
Post 4 leaf	9/30/2020	1	0.0	0.0	0.0	0.0
Post 5 leaf	5/28/2020	1	5.4	2.7	6.3	
Post 5 leaf	5/28/2020	2	4.5	2.7	7.2	
Post 5 leaf	5/28/2020	3	4.5	2.7	3.6	
Post 5 leaf	9/30/2020	1	0.0	0.0	0.0	0.0
Control 1 apple	5/28/2020	1	9.0	7.2	9.0	
Control 1 apple	5/28/2020	2	3.6	2.7	3.6	
Control 1 apple	5/28/2020	3	3.6	2.7	3.6	

Control 1 apple	9/30/2020	1	0.0	0.0	0.0	0.0
Control 4 apple	9/30/2020	1	0.0	0.0	0.0	0.0
Control 5 apple	9/30/2020	1	0.0	0.0	0.0	0.0
Post 1 apple	5/28/2020	1	4.5	2.7	2.7	
Post 1 apple	5/28/2020	2	3.6	2.7	2.7	
Post 1 apple	5/28/2020	3	3.6	2.7	2.7	
Post 1 apple	9/30/2020	1	0.0	0.0	0.0	0.0
Post 2 apple	9/30/2020	1	0.0	0.0	0.0	0.0
Post 4 apple	9/30/2020	1	0.0	0.0	0.0	0.0
Post 5 apple	9/30/2020	1	0.0	0.0	0.0	0.0
Control 1 soil	5/28/2020	1	8.9	19.7	57.2	
Control 1 soil	5/28/2020	2	7.2	9.0	16.2	
Control 1 soil	5/28/2020	3	9.0	18.1	50.6	
Control 2 soil	5/28/2020	1	8.8	12.4	15.9	
Control 2 soil	5/28/2020	2	10.8	21.6	30.6	
Control 2 soil	5/28/2020	3	10.7	25.1	37.6	
Control 3 soil	5/28/2020	1	12.6	23.3	34.1	
Control 3 soil	5/28/2020	2	10.8	28.8	36.1	
Control 3 soil	5/28/2020	3	9.1	21.8	30.9	
Control 4 soil	5/28/2020	1	18.2	18.2	23.7	
Control 4 soil	5/28/2020	2	10.9	9.1	10.9	
Control 4 soil	5/28/2020	3	10.9	20.0	27.3	
Control 5 soil	5/28/2020	1	10.9	23.6	29.1	
Control 5 soil	5/28/2020	2	10.8	28.7	34.1	
Control 5 soil	5/28/2020	3	10.9	29.0	38.0	
Post 1 soil near post	5/28/2020	1	60.4	23.1	95.9	
Post 1 soil near post	5/28/2020	2	50.7	23.5	76.1	
Post 1 soil near post	5/28/2020	3	16.2	7.2	16.2	
Post 2 soil near post	5/28/2020	1	17.7	14.1	37.1	
Post 2 soil near post	5/28/2020	2	30.9	25.5	67.3	
Post 2 soil near post	5/28/2020	3	19.8	21.7	50.5	
Post 3 soil near post	5/28/2020	1	24.8	24.8	60.3	
Post 3 soil near post	5/28/2020	2	14.2	8.9	21.3	
Post 3 soil near post	5/28/2020	3	18.1	12.7	32.6	
Post 4 soil near post	5/28/2020	1	12.7	16.4	23.6	
Post 4 soil near post	5/28/2020	2	16.0	26.7	44.5	
Post 4 soil near post	5/28/2020	3	16.1	25.0	41.0	
Post 5 soil near post	5/28/2020	1	20.0	16.3	18.1	
Post 5 soil near post	5/28/2020	2	16.2	21.6	41.5	
Post 5 soil near post	5/28/2020	3	16.3	25.4	49.0	
Post 1 soil near tree	5/28/2020	1	12.8	23.7	56.6	
Post 1 soil near tree	5/28/2020	2	9.0	25.1	55.5	
Post 1 soil near tree	5/28/2020	3	10.6	23.0	53.1	
Post 2 soil near tree	5/28/2020	1	17.7	31.9	47.9	
Post 2 soil near tree	5/28/2020	2	9.1	27.2	47.2	

Post 2 soil near tree	5/28/2020	3	9.0	9.0	16.2
Post 3 soil near tree	5/28/2020	1	10.7	23.2	37.4
Post 3 soil near tree	5/28/2020	2	9.0	7.2	9.0
Post 3 soil near tree	5/28/2020	3	9.0	19.8	30.5
Post 4 soil near tree	5/28/2020	1	8.9	24.8	49.7
Post 4 soil near tree	5/28/2020	2	10.7	24.9	48.0
Post 4 soil near tree	5/28/2020	3	9.1	23.6	41.7
Post 5 soil near tree	5/28/2020	1	10.6	10.6	23.0
Post 5 soil near tree	5/28/2020	2	10.8	21.5	41.3
Post 5 soil near tree	5/28/2020	3	15.9	24.8	60.1

[1] A value of zero equates to below detection limit
[2] Four metal analysis was only run for samples taken in the fall of 2020
[3] Method quantification limit for chromium in leaf/apple samples is 0.5 PPM, in soils 1.0 PPM
[4] Method quantification limit for chromium in leaf/apple samples is 0.25 PPM, in soils 0.5 PPM
[5] Method quantification limit for copper in leaf/apple samples is 0.5 PPM, in soils 1 PPM
[6] Method quantification limit for zinc in leaf/apple samples is 0.25 PPM, in soils 0.5 PPM

Table 1.2.3: Metal concentration (all replicates) in samples taken from the organic apple orchard in 2021. Values of zero indicate below quantification limit.

				ppm (µg/g) metal[1]			
Post/Control #	Sample date	Replicate extract	Description	As	Cr	Cu	Zn
Post 1	9/15/2021	1	Leaf-near post	0	0	0	14
Post 3	9/15/2021	1	Leaf	0	0	0	17
Post 3	9/15/2021	1	Leaf-near post	0	0	0	12
Post 4	9/15/2021	1	Leaf	0	0	0	14
Post 5	9/15/2021	1	Leaf-near post	0	0	0	20
Post 6	9/15/2021	1	Leaf-near post	0	0	0	16
Post 8	9/15/2021	1	Leaf	0	0	0	24
Post 14	9/15/2021	1	Leaf	0	0	0	12
Post 14	9/15/2021	2	Leaf	0	0	0	12
Post 14	9/15/2021	3	Leaf	0	0	0	13
Control 4	9/15/2021	1	Leaf	0	0	0	14
Control 4	9/15/2021	2	Leaf	0	4.9	0	15
Control 4	9/15/2021	3	Leaf	0	0	0	16

[1] A value of zero equates to below detection limit
[2] Method quantification limit for Arsenic is 7.0 PPM
[3] Method quantification limit for Chromium is 3.5 PPM
[4] Method quantification limit for Copper in leaf/apple samples is 7.0 PPM
[5] Method quantification limit for Zinc is 3.5 PPM

1.3.0 Copper migration from treated wood garden boxes into soil and vegetable biomass

1.3.1 Introduction

Wood is commonly used in the construction of garden boxes for residential flower beds and vegetable gardens. Garden boxes are by their nature a high decay hazard application because wood used for this application is kept in ground contact and the soil it is in contact with is intentionally kept wet to support plant growth. For this reason, the use of pressure treated lumber is an excellent way to extend the life of garden boxes, saving the user money and hassle in the long term. However, the safety of pressure treated garden boxes for the production of vegetables is still widely questioned by the general public and this is a perennial question faced by sellers of pressure treated lumber. Some of the concerns arise from the past use of chromated copper arsenate (CCA) as a wood preservative for residential applications and the associated fears of arsenic contamination of vegetable matter. Some arsenic is known to migrate from CCA treated wood (Hingston et al., 2001; Lebow, 1996; Lebow et al., 2004) and while to our knowledge no direct evidence of vegetable contamination from CCA-treated garden boxes exist, the risk of exposure through soil contact and direct contact was enough to concern residential users.

It has been almost 20 years since CCA-treated lumber was voluntarily removed from the residential market (EPA 2002). Since then, non-arsenical copper-based preservative systems such as copper azole (CA-C), micronized copper azole (MCA), and alkaline copper quaternary (ACQ) have been used for residential applications including the construction of garden boxes. Despite the absence of arsenic in current preservative formulations, numerous online blogs recommend avoiding pressure treated wood in garden boxes because of the risk of contaminating produce with hazardous chemicals. None of these that we have seen to date use any scientific data in supporting their claims. These sentiments are reflected in the general public where sellers of pressure treated wood often face questions about the safety of these products for gardens.

There is a surprisingly small amount of published scientific investigation into the impacts of pressure treated wood on garden vegetables. A small study produced by Jeff Morrell and colleagues investigated this topic using copper azole-treated Douglas-fir as a test material (Love et al., 2014). This study showed that there was no difference in the metal content of the edible portions of vegetable biomass whether it was grown in a treated or untreated box. There was, however, a significant increase in copper content of carrot tops sourced from treated boxes as compared to untreated boxes. This study was small but indicated that there may be the potential for metal exposure for the aboveground portions of plants.

We sought to investigate this topic further and have established a long-term study to measure the impact of using pressure treated wood in the construction of raised beds on metal content of garden soil and vegetables.

1.3.2 Methods

In 2021, two beds each were constructed out of untreated or pressure treated Douglas-fir 2 x 12-inch lumber for a total of four garden boxes (Figure 1.3.1). The raised beds were basic 4 x 10 ft frames made from three pieces of lumber each, a single 8-ft piece of lumber that was halved for the box ends and two

10-foot pieces of lumber for the sides which were held together with exterior screws. No additional remedial treatment was applied to the cut surfaces of the pressure treated lumber. After the beds were constructed, the native soil was excavated 18-24 inches below the ground as the native “soil” was unsuitable for plant growth. Compost was mixed in with native soil as the beds were filled in to increase the organic matter content of the soil. The raised beds were then topped with a ~2-inch layer of compost and a soil sample was taken from center of each bed to indicate background metal levels present in the soil for the first year. Soil samples were taken with a 1-inch diameter soil corer and approximately 6-inches of soil were taken per core sample.

Figure 1.3.1 Raised bed construction from the construction of boxes (top left) to bed digging (top right) to finished (bottom left) and in the summer of 2021 with tomato trellising installed (bottom right).

Beds were planted with the same garden plan in 2021 diagrammed in Figure 1.3.2 and vegetable varieties used are summarized in Table 1.3.1. A mixture of common vegetables was seeded or planted into the beds at appropriate times based on their hardiness. The beds were watered with a combination of overhead hose and irrigation which was installed in the early summer. Irrigation consisted of 1/4-inch soaker hoses fed from a standard ¾-inch garden hose. Watering was done in response to weather and during the summer months was done daily. A trellis made from either galvanized 8-foot cattle panels or repurposed steel shelves (Figure 1.3.3). No copper input was expected from any of the trellising materials that would confound results.

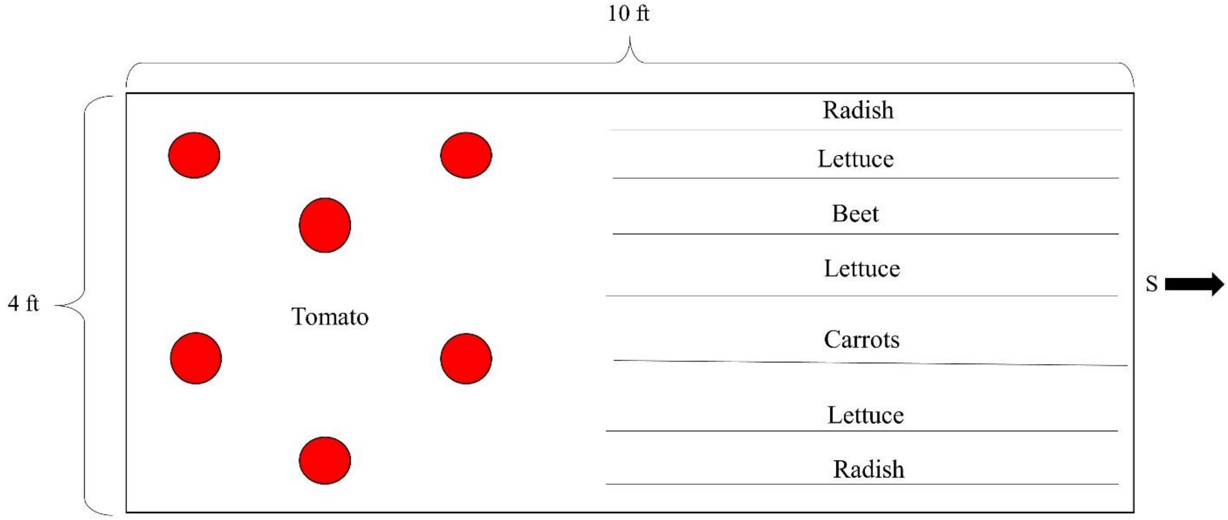

Figure 1.3.2: Planting Diagram for 2021 followed for treated and control raised beds. Varieties grown for each vegetable are listed in Table 1.3.1 and in 2021 basil was succession planted after beets were harvested.

Produce was collected from the gardens as it matured. For each type of vegetable, a comingled sample of vegetable biomass was collected from each of the four beds. This was done to ensure that enough biomass was available for each bed for metal analysis. The size and productivity of vegetables varied in different boxes and because of this, the total number or each plant harvested for analysis differed for each box. These are listed in Table 1.3.2. For root crops such as carrots and beets, the leafy tops were separated from the roots and were analyzed separately. Similar analyses were done with Tomato and Basil where the edible fruits or leaves were analyzed separately from the inedible stems.

Table 1.3.2: Description of vegetable samples harvested from the raised beds in 2021 including the number of plants or fruits that each sample was harvested from.

Plant	Variety	Bed	Treatment	Number of plants/fruits in sample
Basil	Italian Sweet Leaf	A	Treated	5
Basil	Italian Sweet Leaf	B	Treated	5
Basil	Italian Sweet Leaf	C	Untreated	5
Basil	Italian Sweet Leaf	D	Untreated	5
Tomato	Rutgers	A	Treated	6/12
Tomato	Rutgers	B	Treated	6/12
Tomato	Rutgers	C	Untreated	6/12
Tomato	Rutgers	D	Untreated	6/12
Radish	Cherry Belle	A	Treated	5
Radish	Cherry Belle	B	Treated	5
Radish	Cherry Belle	C	Untreated	5
Radish	Cherry Belle	D	Untreated	5

Lettuce	Mixed Greens Gourmet	A	Treated	Several
Lettuce	Mixed Greens Gourmet	B	Treated	Several
Lettuce	Mixed Greens Gourmet	C	Untreated	Several
Lettuce	Mixed Greens Gourmet	D	Untreated	Several
Beet	Early Wonder Tall Top	A	Treated	9
Beet	Early Wonder Tall Top	B	Treated	9
Beet	Early Wonder Tall Top	C	Untreated	11
Beet	Early Wonder Tall Top	D	Untreated	13
Carrot	Giants of Colmar	A	Treated	8
Carrot	Giants of Colmar	B	Treated	12
Carrot	Giants of Colmar	C	Untreated	11
Carrot	Giants of Colmar	D	Untreated	14

Vegetable and soil samples were processed and analyzed for metal content as described in section 1.1.2. Metal measurements were done using an Agilent 5110 ICP-OES housed in the Soil Health Laboratory at OSU. Copper is the only metal of interest for this study, so it is the only one reported in the data. Most samples analyzed in this study showed a copper content above the quantification limit of the method utilized here.

1.3.3 Results

Copper levels from the 2021 growing season are shown in Figure 1.3.4. Copper levels were generally similar in all types of vegetable biomass presented. In some samples, copper levels appeared to be higher in biomass taken from untreated garden boxes such as tomato fruit and beet tops. However, the dataset presented has limited replication and further samples need to be extracted and analyzed for copper content. Based on this dataset it is unlikely that copper content differs in vegetable biomass grown in treated or untreated garden boxes after one year or growth.

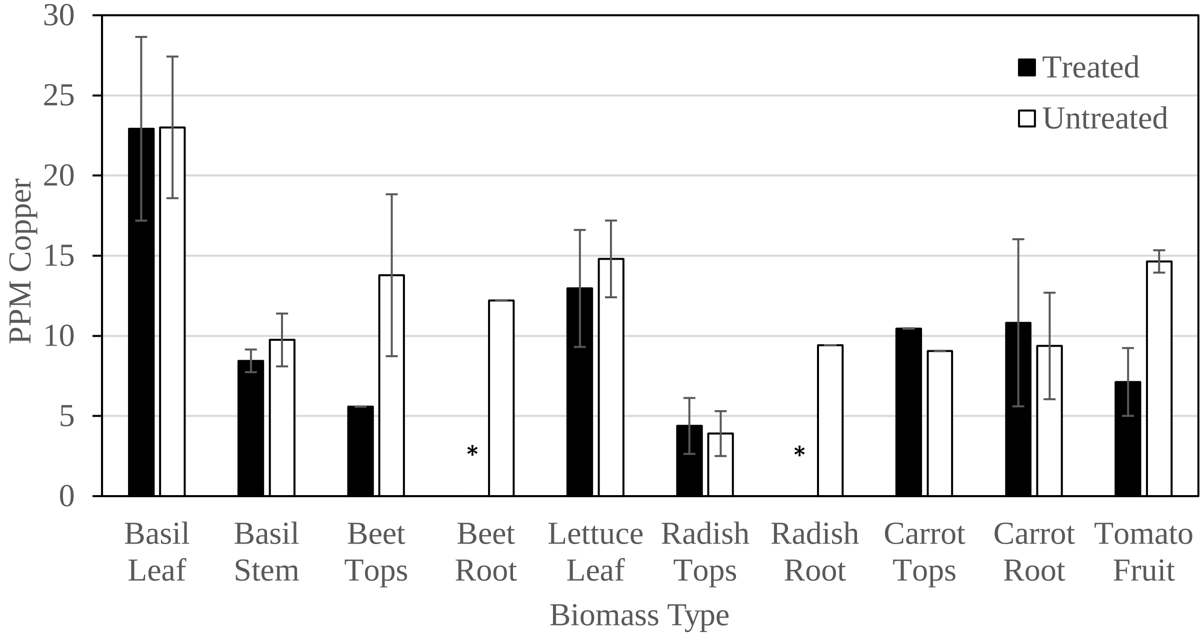

Figure 1.3.3: Copper levels found in vegetable biomass taken from the raised beds in the 2021 season. Error bars are plus or minus one standard deviation. *Indicates samples have not been analyzed yet.

In March 2021, one year after installation and before any soil amendments for the 2022 season were added, soil samples were taken. Soil samples were taken 0-1 inch from the bed edge, 3-4 inches from the bed edge and in the bed center (Figure 1.3.5). Four samples of each type were isolated from each bed and were comingled for a total of three different sample types per bed. Additional samples from the same locations were taken after the addition of new soil for the 2022 in March 2022. These soil samples will serve as a baseline for the 2022 season. During the soil sampling, obvious signs of decay were identified on the untreated wood beds, but not on the treated wood beds (Figure 1.3.5).

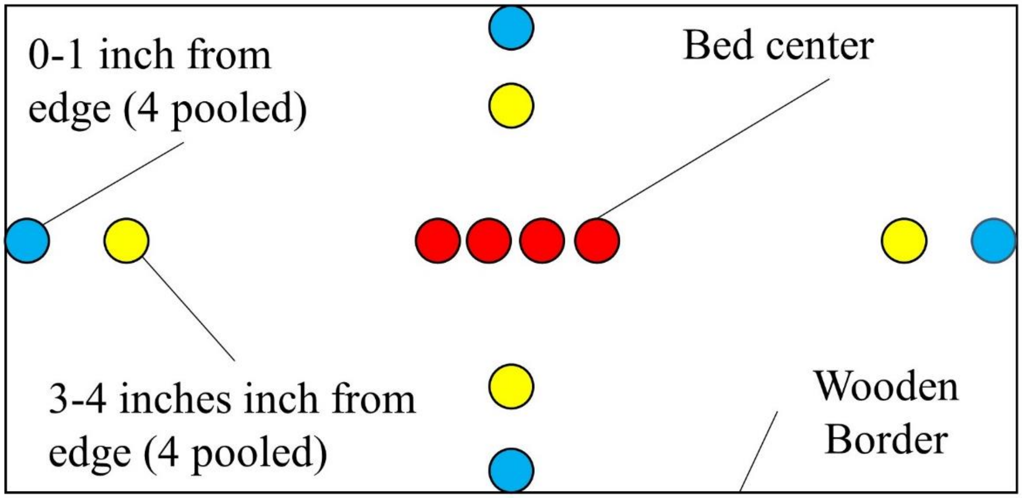

Figure 1.3.5: Soil sampling diagram (Top) illustrating where soil samples were taken from in March 2021 before and after the addition of new soil for the 2022 growing season and signs of fungal decay on wood on one of the untreated raised beds (Bottom).

Planting began in March of 2022 for the 2022 season and growth has begun. Photos of the garden boxes after the addition of new soil in March of 2022 and after some new growth in April of 2022 are shown in Figure 1.3.6. A new suite of vegetables in a new planting design has been selected for the 2022 season. We will continue to manage this project and collect vegetable biomass samples as they mature for metal analysis. Like all our other studies, further metal analysis is awaiting the installation of our new atomic spectroscopy equipment.

Figure 1.3.6: Photos of garden boxes in March 21st, 2022 (Left) and April 29, 2022 (Right).

1.4.0 Monitoring the migration of polyaromatic hydrocarbons in soil from creosote-treated Douglas-fir and southern pine posts

1.4.1 Introduction

Creosote is a widely used wood preservative for heavy duty applications including critical infrastructure such as utility poles, railroad ties, and marine pilings (Webb, 2014). It has a long history of effective use and is the oldest wood preservative originating from the industrial age (Rhodes, 1951). Creosote contains a variety of polycyclic aromatic hydrocarbons (PAHs) that provide it with fungicidal activity and several of these are on the Environmental Protection Agency's (EPA) priority pollutant list and are regulated by the EPA (Nestler 1974; 40 CFR Part 423, Appendix A). PAH migration from creosote treated wood has been extensively studied, particularly in aquatic environments (Brooks 2011b). These and other data have led to the environmental assessment modelling tool hosted on the EPTW website, which helps predict the impact of treated wood on preservative levels in water bodies.

Aquatic environments are not the only environment creosote is utilized in and it is often utilized in terrestrial applications where migration risk is into soil rather than water. The understanding of PAH migration from treated wood in soils is less well understood than aquatic environments and we do not possess the capacity to model leaching from creosote-treated wood in contact with soils. One of the most common applications for creosote on land is for the treatment of railroad ties. Creosote migration from railroad ties into the surrounding ballast and soils has been studied previously showing minor vertical migration and statistically insignificant migration into surrounding wetlands (Brooks 2004). However, the available leaching data for terrestrial systems is limited compared to that which has been generated for aquatic exposure of creosote treated wood particularly for utility poles where creosote treated wood set in direct contact with soil.

1.4.2 Methods

The EPTW initiated a study to measure rates of PAH migration from creosote-treated posts at the Peavy Arboretum to better understand the migration of PAHs in a soil medium. A total of ten 6-7″x 8′ creosote-treated posts, 5 Douglas-fir and 5 southern pine, were installed at the Peavy Arboretum field site in August 2020 (Figure 1.4.1). Posts were installed 2 feet in the ground in a primarily level area. Two untreated Douglas-fir posts were installed as controls and background soils samples were taken upon installation at the top of a slight grade on the site to preclude any cross contamination into the control soils. Soil samples were taken at installation in August of 2020 and 3, 6, 12, and 18 months after installation. The study is continuing to be sampled every 6 months.

Background soil samples were taken from each site where the post was to be installed in addition to continuous sampling of soils around untreated control posts. At the three-and six-month sampling point soil samples were taken 4 inches away from the posts only as it was expected that not much migration had occurred at this time. Soil cores were taken down to an 18-inch depth and the soil cores were divided into three 6-inch sections representing different soil horizons. The full 24-inch depth of the underground portion of the post could not be sampled because the clay consistency of the soil inhibited obtaining a deep soil sample. Samplings that occurred 12 and 18 months after installation included soil cores 4 inches and 8 inches from the base of posts. The wider sampling was meant to attempt to delineate a PAH migration boundary as the study matures.

Figure 1.4.1: Photos of the creosote-treated Douglas-fir and southern pine posts at the Peavy Arboretum

Soil samples were extracted and analyzed for PAHs using methods described previously (Forsberg et al., 2011). Briefly; soil samples were homogenized and 10 g subsamples were weighed into centrifuge tubes. Twenty mL of a 2:2:1 acetone:ethyl acetate:iso-octane mixture was added to the centrifuge tubes. The tubes were sonicated for 5 minutes to ensure that sediment was in intimate contact with solvent. The samples were then treated with a salt mixture containing 6 g of magnesium sulfate and 1.5 g of sodium acetate. The mixture was again sonicated for 5 minutes and then centrifuged for 5 minutes. The supernatant was separated from the remaining mixture and was concentrated under an air stream. The volume of the remaining solvent was recorded. A 1.5 mL aliquot of concentrated supernatant was removed and added to a 2 mL dispersive solid-phase micro-extraction tube (SPME) and sonicated further for 5 minutes. These dual procedures were used to precipitate polar compounds, lipids, fatty acids, sterols and other compounds that could interfere with analyses. Tubes were then centrifuged again for 5 minutes and a 1 mL aliquot of the supernatant was removed for and analyzed for EPAs 16 PAH priority pollutants on a Shimadzu GC-MS (Anastassiades et al., 2003; Forsberg et al., 2011; Martinez et al., 2004).

Samples were analyzed using a Shimadzu QP2010S GC-MS operated in scan mode, mz range 50-300, with a splitless injection. One µL of sample was injected and analyses were performed with the following conditions: Oven temperature: 70 °C held for 2 minutes then increased to 265 at 10 °C a min. and held at 265 °C for 15.5 min until Benzo(ghi)perylene eluted (total run time 37 minutes), ion source temperature: 225 °C, interface temperature: 275 °C, injection temperature 275 °C. The samples were analyzed on an RXI-5ms column (0.25 mm inner diameter by 30 mm long) at a flow rate of 2.5 mL/min.

PAHs measured in the soil samples are listed in Table 1.4.1 with their abbreviations and quantification limits on the GC-MS. It was common for higher molecular weight PAHs to be below quantification limits (BQL) of this method likely due to their low abundance in creosote. All PAH levels where all replicate samples are BQL are depicted as zero with an asterisk. Where some replicate measures are BQL and others are above the quantification limit, BQL samples are included in calculations as 50% of the quantification limit for our GC-MS for that compound.

Table 1.4.1: 16 PAHs and their abbreviations measured in this study with quantification limits and approximate detection limits in soil samples at the Peavy Arboretum. Abbreviations are used in tables and figures describing PAH data.

			Approximate method detection limit range (µg/g soil)*	
PAH name	Abbreviation	Quantification Limit (µg/ml)	Low	High
Naphthalene	NAP	0.010	0.002	0.014
Acenaphthylene	ACY	0.010	0.002	0.014
Acenaphthene	ACE	0.010	0.002	0.014
Fluorene	FLU	0.010	0.002	0.014
Phenanthrene	PHE	0.025	0.005	0.035

Anthracene	ANT	0.025	0.005	0.035
Fluoranthene	FLA	0.010	0.002	0.014
Pyrene	PYR	0.010	0.002	0.014
Benz[a]anthracene	BaA	0.075	0.015	0.105
Chrysene	Chry	0.075	0.015	0.105
Benzo[b]fluoranthene & Benzo[k]fluoranthene	BbF & BkF	0.025	0.005	0.035
Benzo[a]pyrene	BaP	0.050	0.010	0.070
Indeno[1,2,3-cd]pyrene	IP	0.100	0.020	0.140
Benzo[g,h,i]perylene	BghiP	0.050	0.010	0.070
Dibenz[a,h]anthracene	DahA	0.100	0.020	0.140

*Estimates based on carrying detection limit through calculations with “good” and “poor” solvent concentration to improve detection shown under “low” and “high” method detection limits, respectively.

1.4.3 Results

In this report we present PAH levels in soils sampled around creosote treated posts three months and 6 months after installation. PAH levels from soil samples taken 3 months after installation (4 inches from the base of posts) are shown in Figures 1.4.2 and 1.4.3 for Douglas-fir and southern pine posts, respectively. PAH concentrations in soil samples taken 6 months after installation of creosote treated Douglas-fir and southern pine posts are shown in Figures 1.4.4 and 1.4.5, respectively. Three- and six-month samplings only included soil taken from one distance from the posts to test for initial migration close to the posts. A second sampling point was included in later samplings taken 12 and 18 months after installation.

PAH levels measured in soils 4 inches from creosote treated posts three months after installation were highly variable and it was common for some replicate extracts to have PAH levels below the quantification limit while others were just above the quantification limit. Most high molecular weight PAHs heavier than benzo b and benzo k fluoanthene were not detected in this study. Several PAHs were detected above the levels found in soils around untreated control posts as well, notably naphthalene which was found around control posts at levels that were not statistically distinguishable from soils taken around creosote treated posts. FLU, ANT, FLA, PYR, BaA, Chry, BbF and BkF were all found in some replicate samples around creosote treated posts, but not around controls. Additionally, it appeared that the highest concentrations of PAHs around treated posts were in the upper 6 inches of soil. This was likely due to migration from the posts caused by rainwater washing down the posts. Although this impact was noticeable in the data, it is likely not significant due to the high variability in the data.

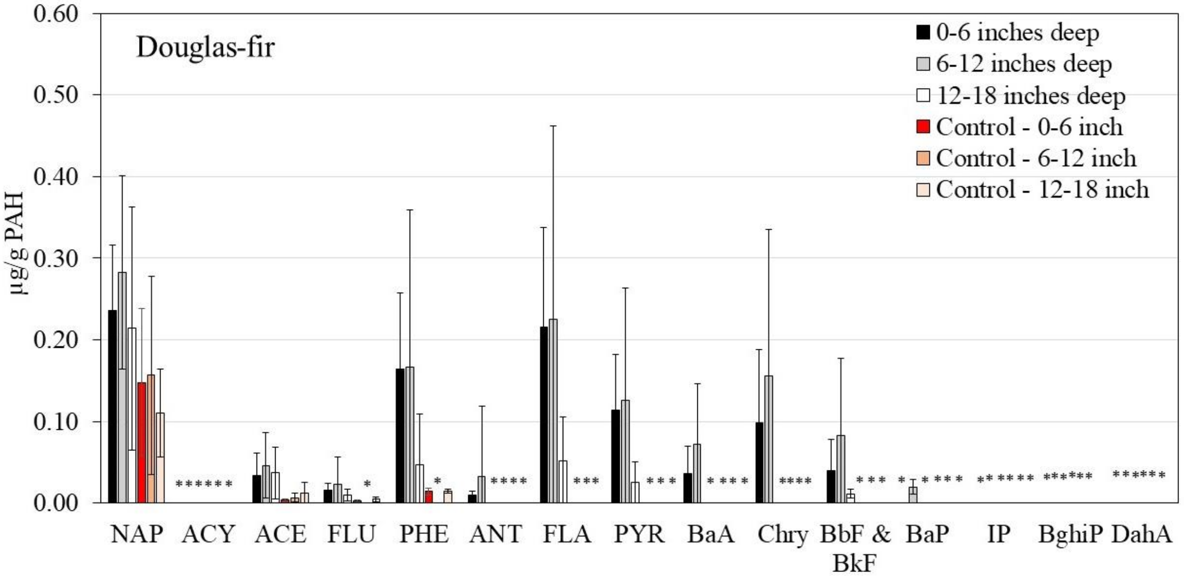

Figure 1.4.2: Average PAH concentrations (PPM) in soil taken 4 inches from the base of creosote-treated Douglas-fir posts and untreated control posts 3 months after installation. * indicates all replicate samples were below the detection limit.

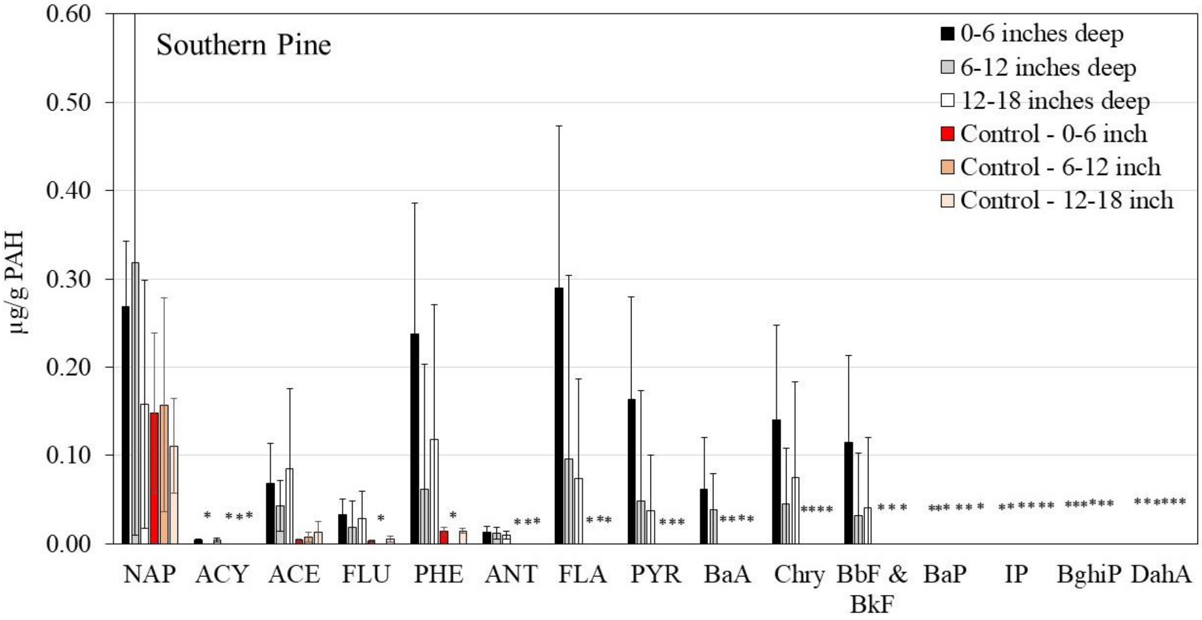

Figure 1.4.3: Average PAH concentrations (PPM) in soil taken 4 inches from the base of creosote-treated southern pine posts and untreated control posts 3 months after installation. * indicates all replicate samples were below the detection limit.

.

After 6 months, PAH levels 4 inches from posts showed similar patterns as after 3 months and if anything were slightly lower overall than the concentrations found in 3-month samples. The high variability of the samples prevented any concrete conclusions about whether levels were elevated significantly. In the six-month sampling there were more instances of higher molecular weight PAHs being detected, particularly BaA and Chry around controls and IP and BaP around some of the creosote treated posts. These were generally only observed in one or a few of the replicate extracts for each treatment and thus were considered to be at very low levels in the soil. As seen previously, the upper 6 inches of soil tended to have higher PAH concentrations than the other soil samples, indicating an impact of rain runoff on soil PAH content.

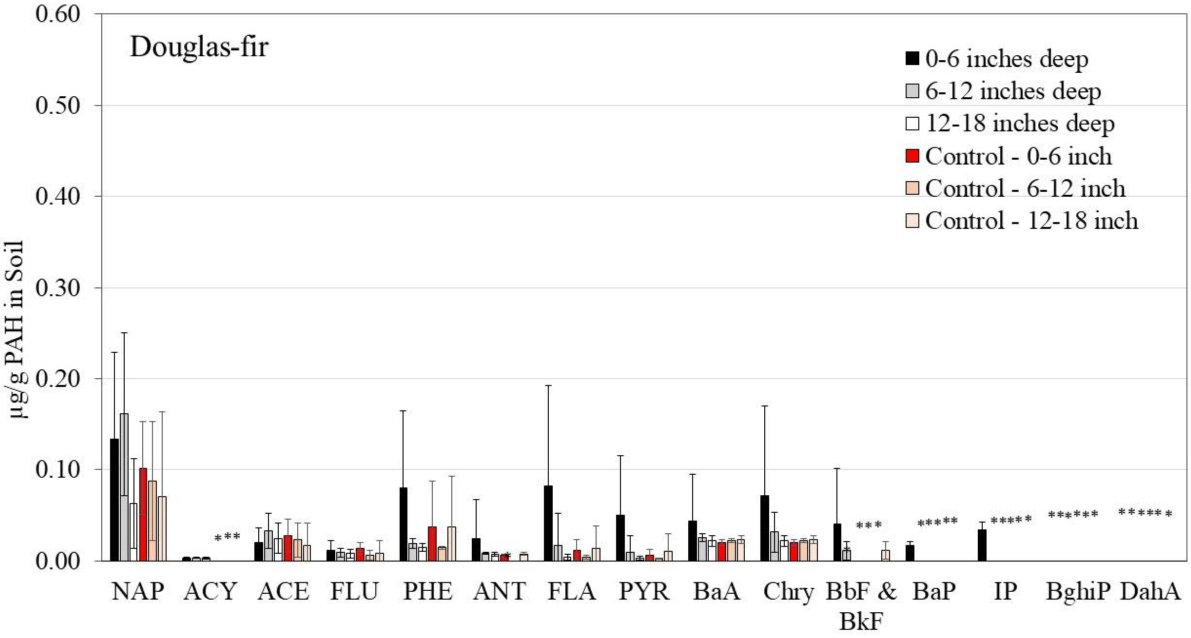

Figure 1.4.4: Average PAH concentrations (PPM) in soil taken 4 inches from the base of creosote-treated Douglas-fir posts and untreated control posts 6 months after installation. Starred values indicate all replicate samples were below detection limit.

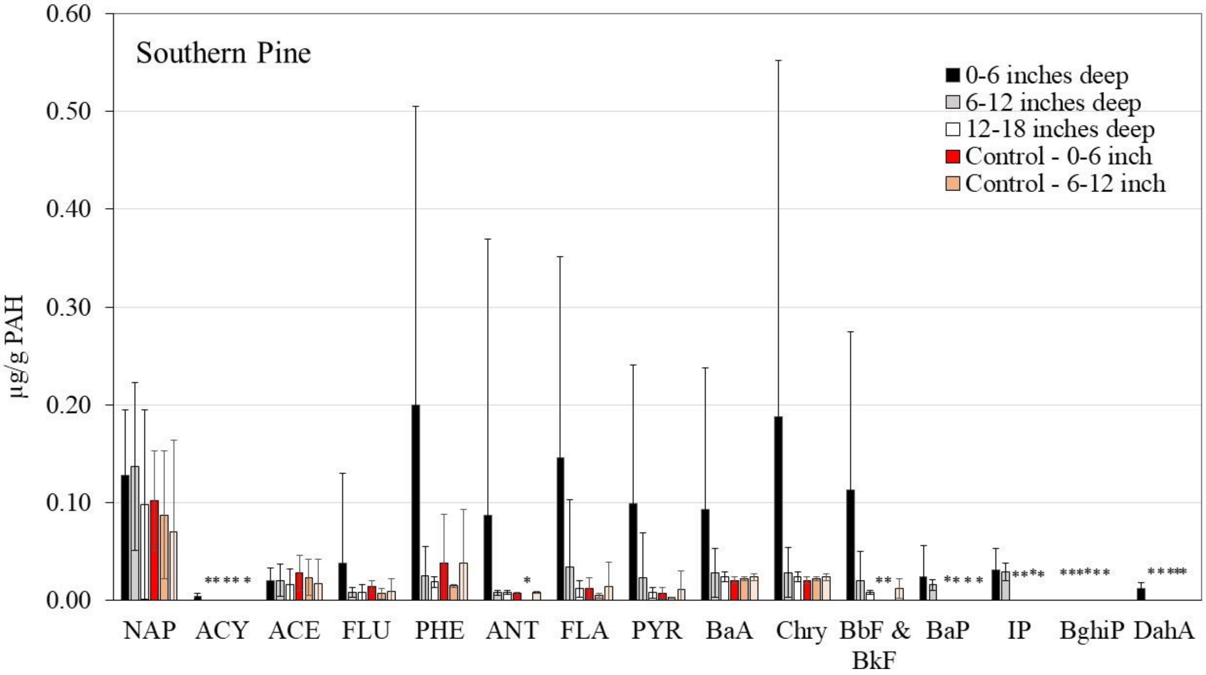

Figure 1.4.5: Average PAH concentrations (PPM) in soil taken 4 inches from the base of creosote-treated southern pine posts and untreated control posts 6 months after installation. Starred values indicate all replicate samples were below detection limit.

This study is continuing to be sampled. 12-and 18-month samplings have been taken and these include a second distance, 8 inches from the posts in addition to the 4-inch distance. These samples are being analyzed currently.

1.5.0 Monitoring metal migration from a pressure-treated and sealed deck

1.5.1 Introduction

The cooperative has performed extensive study of preservative migration from treated decking. Earlier work attempted to quantify metal migration from small-scale decks contained in collection basins. Additionally, extensive validation work for best management practices promulgated by the Western Wood Preservers Institute focused on treated decking material. These studies provide a concrete understanding of how metals migrate from treated wood when it is exposed to water. Generally, an initial impulse of relatively high levels of metal migrate from the wood as any residual surface deposits are washed away. These surface deposits are generally minimized by best management practices. As successive volumes of water are applied to treated decking, concentrations of metals generally decrease and stabilize at very low levels unless fresh surfaces are exposed.

We sought to continue our study of metal migration from decking by monitoring copper migration from a newly constructed deck attached to Peavy Lodge in the Peavy Arboretum. The deck was constructed from materials donated by one of the Cooperative members and construction began over the summer of 2021. Most of the deck surface was constructed by October of 2021 and this enabled us to set up a monitoring study just as the first autumn rains returned to the area, and we are continuing to collect samples through the cessation of rains for the summer of 2022. The deck was fully constructed by April of 2022. Here we present the first month of metal migration data from rainwater runoff collections that were taken from under the deck.

1.5.2 Methods

The deck surface was constructed with CA-C treated Douglas-fir treated to UC3B above ground specifications. The original joists that were present were re-used for most of the deck surface. These were likely CCA-treated joists and were still in good condition. However, all collections were done beneath a newly constructed portion of the deck with all-new wood. Joists were made incised 2 x 10-inch lumber. All decking material was sealed with Messmer's UV plus Natural Cedar prior to installation.

Three collection points were installed underneath the newly constructed portion of the bed, and these consisted of two collection basins each for a total of 6 collection basins (Figure 1.5.1). Collection basins were 24″ wide x 16″ long x 6″ high. At each of three collection points, one basin was placed directly under the decking surface while a second basin was placed under decking and a joist. Water was collected from the basins with each significant rain event. At the time of sampling the mass of the filled basins was measured to measure the total volume of water in the basin for calculation of total metal lost from the deck.

Figure 1.5.1: Placement of water collection basins under the all-new portion of the Peavy Lodge deck at collection site 1 (left), site 2 (middle) and site 3 (right).

A sample of water from each collection was reserved for metal analysis by ICP-OES. Samples were prepared for analysis according to EPA method 200.7 to measure total dissolved copper. Briefly, samples were acidified to a pH below 2 by acidifying 80 ml of each sample with 150 µl of concentrated nitric acid. Samples were then filtered with a 0.45 µm filter prior to being sent to the soil health laboratory at Oregon State University for ICP-OES analysis as described in section 1.1.2. Copper levels in the samples were measured and were used to calculate total µg of copper lost from the decking material.

1.5.3 Results

Copper concentrations in deck runoff showed a predictable pattern of relatively higher concentrations in the first few water collections, followed by a steady dropoff over time (Figure 1.5.2). Copper concentrations in rainwater runoff tended to be higher in collections beneath joists, which is expected due to the higher wood surface area exposed to rainwater. Total copper loss followed a different trend and increased as the deck was exposed to more water (Figure 1.5.3). This is primarily due to the larger volumes of water collected as rains increased. As the concentration continues to decline, it is expected that total average copper loss from the deck will also stabilize and begin to decline in subsequent months of sampling. The cumulative copper detected in rainwater runoff versus cumulative water volume showed rapid increase over the first few samplings (Figure 1.5.4). Increases in cumulative copper slowed as greater volumes of water were added to the deck by rainfall and the curve appeared to be heading toward an asymptote where copper loss from the deck has stabilized. This trend will likely reveal itself completely over the next few months.

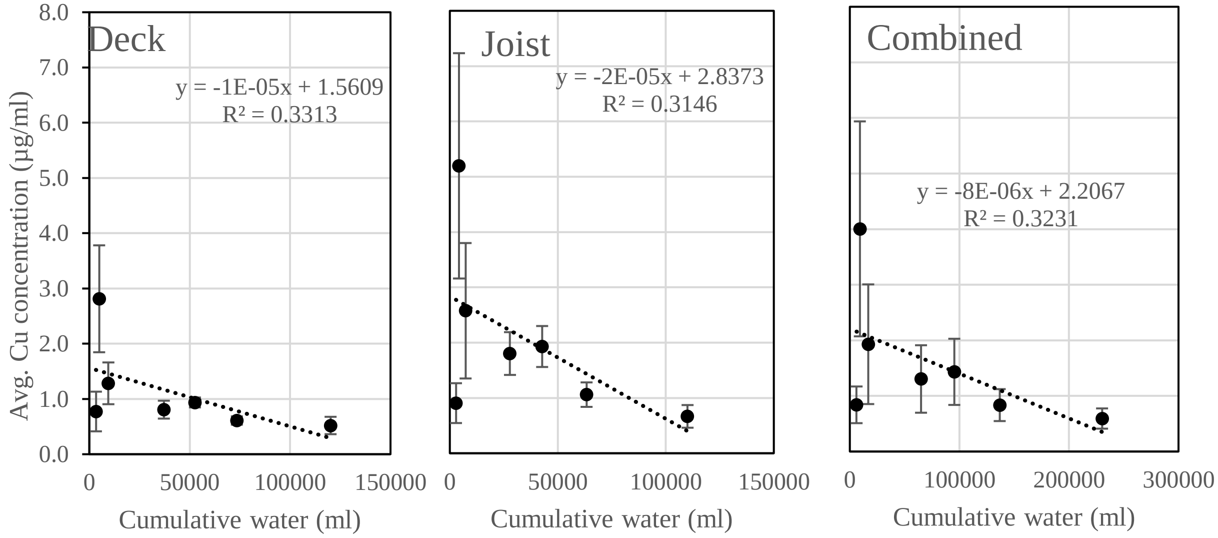

Figure 1.5.2: Average copper concentrations measured in deck runoff from collection points below decking alone (left), decking+joists (middle), and average over all collection areas (right). Error bars are standard deviations of three replicate collections.

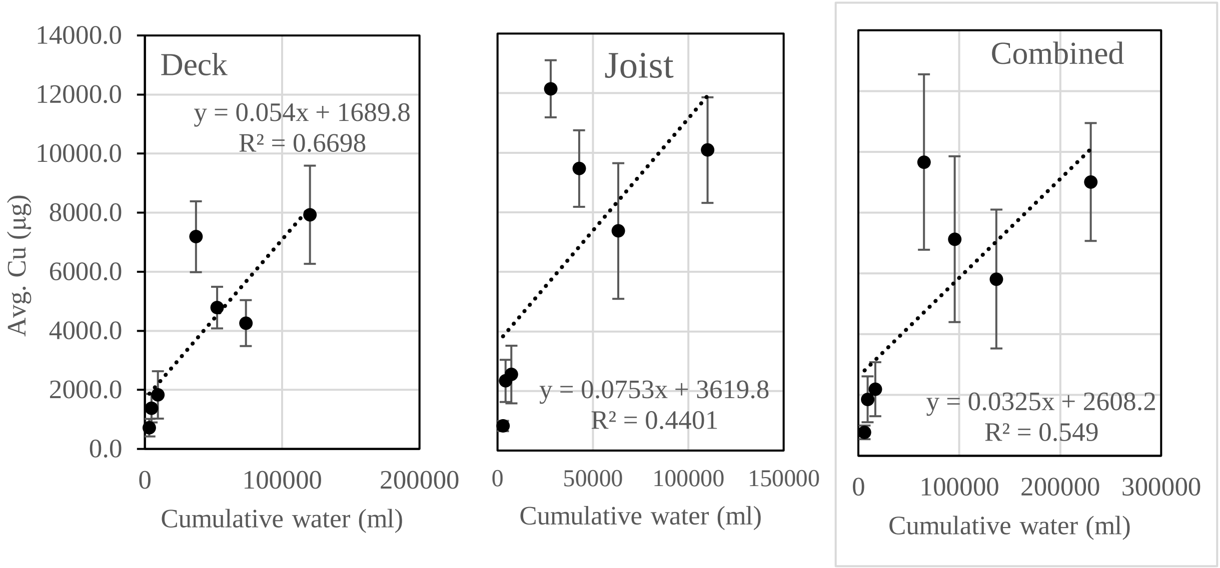

Figure 1.5.3: Average total copper (µg) collected in deck rainwater runoff collected beneath decking alone (left), decking plus joists (middle), and average over all collection areas (right). Error bars are one standard deviations of three replicate collections.

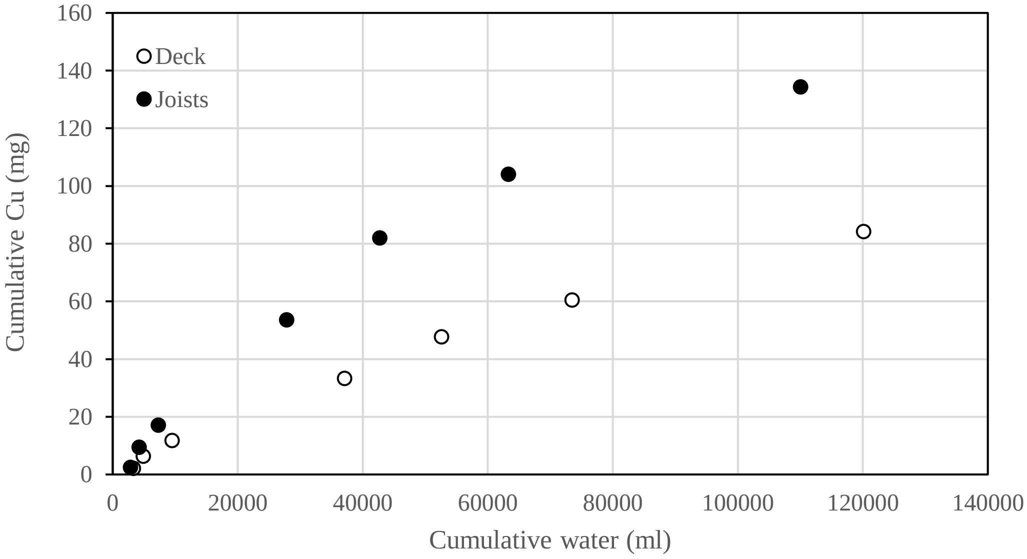

Figure 1.5.4: Cumulative mg copper collected in rainwater runoff versus cumulative rainwater collected in ml for water collected beneath decking only and decking+joists.

This study will continue to be sampled through late spring 2022 when rains stop for the spring season of 2022.

Objective 2: Develop Standardized Accelerated Methodologies for Assessing Treated Wood Risks

2.1.0 Using a commodity scale leaching apparatus for environmental assessment tool validation

The EPTW is developing a commodity scale leaching apparatus that can simulate a variety of leaching conditions representative of types of exposure conditions encountered by treated wood in the environment. The current prototype is loosely modeled off of leaching tests done by Dr. Kenneth Brooks. The leaching apparatus is designed to simulate a low-flow lake or stagnant seawater which would be considered an environment where treated wood would have the most impact on the surrounding environment. This leaching apparatus is going to be used to validate or revise model predictions made by the environmental assessment modelling tool hosted on the EPTW website.

2.1.1 Introduction

Treated wood is known to lose some of its active ingredients after it is installed when it is exposed to the environment (Lebow, 1996; Lebow et al., 2004). Chemical migration can be mitigated through the use of best management practices at the treatment plant which function to minimize surface residues of active chemicals. The EPTW has extensively characterized the impacts of BMPs on reducing the mobility of treated wood active ingredients and through this work has characterized migration patterns (M. Konkler et al., 2018; Konkler et al., 2020; M. J. Konkler et al., 2020; Konkler and Morrell, 2019).

This work has identified common preservative migration patterns in response to water exposure for metal-containing preservative systems. Generally, concentrations of metal in runoff water are initially high as surface deposits are mobilized by water. Then metal runoff rapidly decreases with subsequent water additions and eventually stabilize to very low levels of metal (Morrell, 2017). This chemical migration pattern was also noted by work done by Dr. Kenneth Brooks that was used to develop the Environmental Assessment Modelling Tool (Brooks, 2011). The model hosted on the EPTW website enables the user to toggle date since installation where this effect is observable in the model predictions.

The Environmental Assessment Modelling Tool is promoted by the EPTW as a tool for construction engineers to use for identifying appropriate treated wood structure size for construction in or around specific water bodies. To improve the robustness of this model we sought to validate its predictions using our own experimental leaching apparatus with the goal of improving the model where any discrepancies arise. The EPTW has constructed a prototype commodity scale leaching apparatus for measuring chemical migration rates from treated wood commodities. The leaching apparatus is in a prototype form and two initial leaching experiments were done to prove the functionality of the test. We invite any commentary from members on how to improve this design.

2.1.2 Methods

A leaching apparatus was constructed out of a 15-gallon cone bottom tank with fittings from the bottom directing water to an overflow that allowed collection of water from the tank when subsequent volumes are added (Figure 2.1.1). Water was pumped into the tank using a transfer pump. Water was transferred from a 55-gallon drum of deionized water and was pumped through flow meter that regulated water flow to the tank. The lowest flow rate that could be achieved with this setup was 100-200 ml/min, with rates most often settling at 200 ml/min. Water was added from the open top of the tank for leaching tests.

Figure 2.1.1: Commodity scale leaching apparatus made out of a cone-bottom tank with an overflow collection point with a flow meter above the tank.

For the initial tests with the leaching apparatus, small sections of treated posts were affixed with clamps in the water to a defined depth. Post sections were treated with either ACQ or CA-C and this was the same material sourced for the vineyard trellis study described in Table 1.1.1. This allowed the surface area of the treated wood exposed to leaching to be measured for calculation of metal migration rates. Initial testing was done to determine whether a copper signal could be detected from treated wood commodities with the existing setup and whether any pattern could be detected over the course of an initial leaching period.

Deionized water was continuously pumped into the leaching apparatus and water was collected in one-liter increments for a total of 80 liters for the ACQ treatment and 66 liters for the CA-C treatment. A sample of water from each collection was reserved for metal analysis by ICP-OES to establish whether a signal could be detected. Samples were prepared for analysis according to EPA method 200.7 to measure total dissolved copper. Briefly, samples were acidified to a pH below 2 by acidifying 80 ml of each sample with 150 µl of concentrated nitric acid. Samples were then filtered with a 0.45 µm filter prior to being sent to the soil health laboratory at Oregon State University for ICP-OES analysis as described in section 1.1.2. The detection limit for copper was 0.1 µg/ml and samples below the detection limit were included in calculations as 0.05 µg/ml. Copper levels in the samples were measured and were used to calculate total µg/min of copper passing through the outlet at the bottom of the leaching tank. Total submerged surface area of the treated posts was then used to calculate a running leach rate from the post surface throughout the leaching test. Given the physical separation of the outlet from the post surface we understand that this is not an exact leach rate at the post surface, but this method is still able to capture all metals originating from the post surface. This physical separation also enables an inbuilt control during a leaching test where the void space between the tank bottom and the sampling port contain water that functions as a zero before the tank equilibrates with the introduction of a new sample of treated wood. Copper migration rates in µg/min were calculated based on the concentration of samples and the flow rate of water through the system and these were used to calculate leachability as µg/min/cm^2.

2.1.3 Results

Initial tests were done to measure whether a metal signal could be detected with the leaching apparatus and to identify an appropriate assay timeline to measure leaching rates. As expected copper concentrations in the first one-liter sample representative as the void space in the leaching tank were very low and were at or below the detection limit for this method. Copper leach rates increased in subsequent samplings, reaching 2.5 times the void volume rate by the third liter in the ACQ leaching experiment (Figure 2.1.2). Copper leach rates dropped off rapidly and then rebounded after 16 liters of water addition before dropping lower to levels that did not exceed 76% of the levels measured at 3 liters of water added. In most cases copper levels remained above the detection limit of our method, however some levels were below the detection limit of our method and all samples were within three times the detection limit. This experiment would be improved by more sensitive analytical methods.

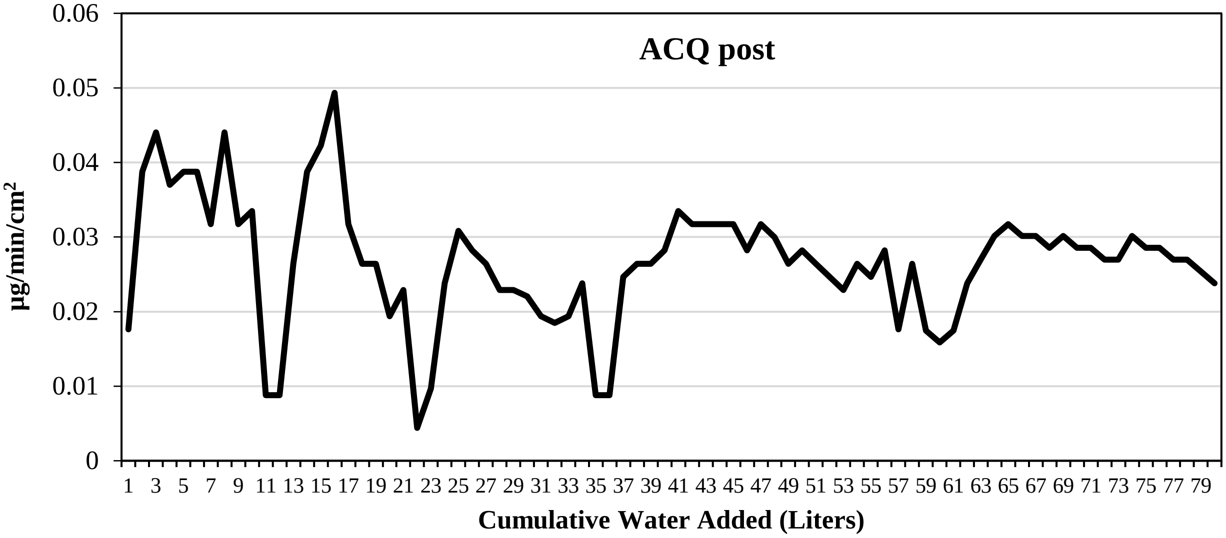

Figure 2.1.2: Copper leach rates measured from ACQ-treated posts in a single replicate leaching test. Samples were collected every liter for 80 liters. Detection limit for this experiment was about 0.01 µg/min/cm^2 and varied depending on the specific flow rate measured for each sample.

Leaching rates increased rapidly in the CA-C leaching experiments as well, reaching 5.4 times the void volume rate in the sixth liter the CA-C leaching experiment. The 6th liter leach rate was the highest measured in the experiment and leaching rates declined with further water addition, although there was fluctuation up and down. There were a greater number of samples for the CA-C experiment that were below detection limit which limited the utility of this first dataset.

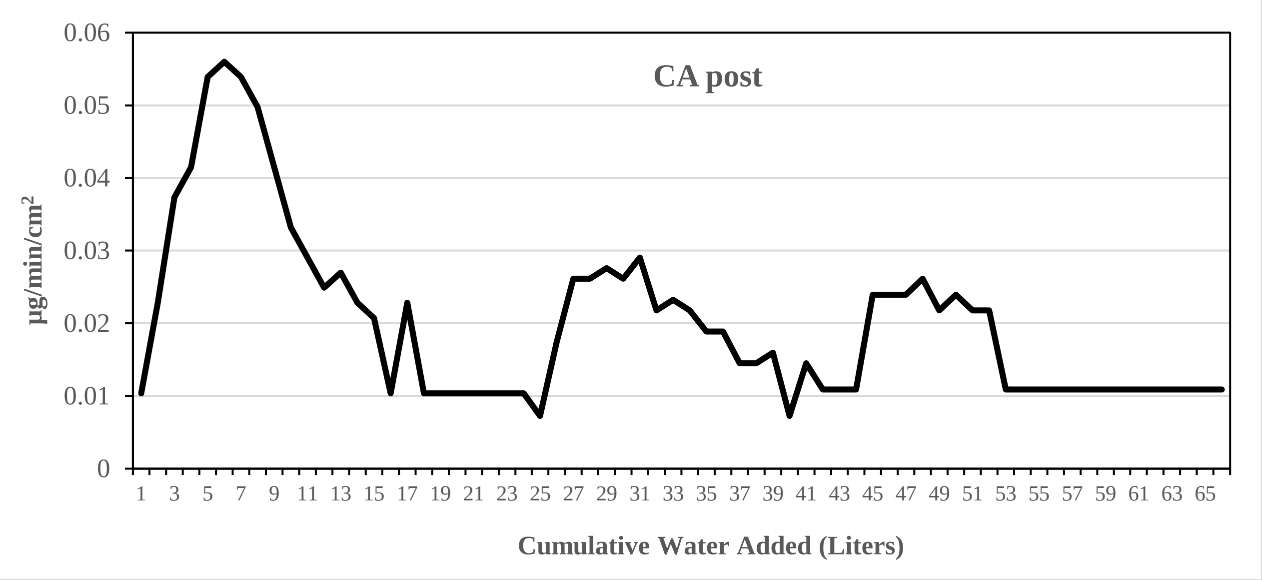

Figure 2.1.3: Copper leach rates measured from CA-C-treated posts in a single replicate leaching test. Samples were collected every liter for 66 liters. Detection limit for this experiment was about 0.01 µg/min/cm^2 and varied depending on the specific flow rate measured for each sample.

The data collected so far are supportive of previous observations of chemical leaching rates from treated wood. Initial water exposures result in the highest concentration of chemical runoff which tapers off with subsequent additions. This initial data consisted of a single replicate experiment and was meant to prove the functionality of the test. In addition, treated posts with sub-AWPA standard retentions was used to test the sensitivity of the method. While the leaching apparatus did function well, this experiment did inform some future modifications our protocol that will be used in a second round of experiments. A longer leaching time is needed where more spaced water samples will be collected for analysis. This will enable the measurement of greater leach rate losses and stabilization of chemical loss from the commodities. As with all other experiments measuring metals described in this report, the detection limit of the analytical equipment we are currently using is not sufficient for this research and subsequent experiments will be improved by the use of our own atomic spectroscopy equipment.

Objective 3: Work Cooperatively to Develop and Improve Models to Predict the Risk of Using Treated Wood in Various Applications

The EPTW is developing a lab-based leaching test designed to measure leaching rates under various controlled conditions that simulate real-world exposure described in Objective 2. This testing apparatus will be used to validate and improve the existing aquatic risk model hosted on the EPTW website. Once the leaching apparatus is developed, we will use this test to measure preservative migration rates from submerged treated commodities normalized to surface area of the treated wood under specific flow rates and water chemistry conditions. Chemical migration rates measured in the simulated flow apparatus will be compared to representative predictions by the aquatic risk model hosted on the OSU website. Disparities identified will be used to improve the existing model.

Objective 4: Identify Improved Methods for Reducing the Potential for Migration

As part of our study to monitor the migration of preservative chemicals into plant tissue, we have included Postsaver sleeves in this study to determine if barriers below groundline reduce the migration of preservatives into soil and plant tissue. Early data taken 6 months from the installation of the study indicate that there may be a positive impact of utilizing postsaver wraps in limiting migration of metals in vineyard soils (see section 1.1.0). However, it is too early to definitively state whether the wraps were effective

Objective 5: Evaluate the Environmental Impacts and Identify Methods for Reuse, Recycling, and/or Disposal of Preserved Wood that is Removed from Service

5.1.0 Measuring carbon emissions from landfilled treated wood

The EPTW recognizes that wood disposal plays an important role in determining overall lifecycle impacts, particularly from a carbon lifecycle assessment perspective. We are planning a federal grant submission in partnership with Mississippi State University to study the fate of carbon in disposed wood commodities. The proposed research will investigate methane emissions from wood stored in anaerobic conditions with the aim of improving wood life cycle assessments. Proposal submission is planned for 2022.

Existing literature on methane emissions from disposed wood is being researched and a summary will be included in subsequent reports for reference. Currently both the EPA and the IPCC estimate that significant quantities of the carbon in wood Methane emissions from disposed wood could be a deciding factor in determining whether wood products are considered as a lower carbon alternative to steel and concrete and we believe this issue is important to investigate.

5.1.1 Introduction

Wood is generally considered a carbon neutral or carbon negative building material especially compared to more carbon-intensive alternatives such as steel or concrete. Along with its predominantly domestic supply chain, carbon neutrality or sequestration make treated wood commodities attractive for carbon pollution reduction initiatives outlined by various governmental bodies around the world. Life cycle assessments range in their boundaries and for wood products these often do not incorporate disposal in the overall assessment of carbon emissions. Where landfilling is taken into account, the impact on overall lifecycle carbon emissions is negative for wood products (Petersen and Solberg, 2005). Landfilling is the most common end use for treated wood and greater consideration of end-of-life disposal in life cycle assessment may have negative consequences on wood being considered a carbon neutral material.

This is due to the fact that cellulose and other structural components in wood can be anaerobically digested by certain bacteria and eventually broken down into methane. According to the US Environmental Protection Agency, methane is a potent greenhouse gas with a 100-year warming potential of 27-30 times that of CO_2 (https://www.epa.gov/ghgemissions/understanding-global-warming-potentials). Methane emissions originating from landfilled wood can therefore have an outsized impact on its overall lifecycle carbon emissions. According to the International Panel on Climate Change Guidelines for National Greenhouse Gas Inventories, 50% of landfilled wood is decomposed and converted into greenhouse gasses (Eggelston et al., 2006). In this accounting, wood is treated in the same way as other “degradable organic carbon” such as food waste. Without accounting for the fact that lignin is not biodegradable under anaerobic conditions, this estimate by the IPCC is likely overstated and unfairly attributes greenhouse gas emissions to landfilled wood where they do not exist.

Evidence for limited biodegradation landfilled wood comes from landfill excavation. Study of wood samples excavated from a landfill in Sydney, Australia estimated that wood samples had lost from 8.7-9.1% of the original carbon when buried for 46 years (Ximenes et al., 2008). Wood samples from another study of Australian landfills in Cairns and Sydney showed an estimated 0-37.1% carbon loss, with many showing no carbon loss at all (Ximenes et al., 2015). These estimates are drastically different from IPCC estimates. A recent comparative life cycle assessment of landfilled wood indicated the IPCC estimate of landfill emissions originating from wood overestimates emissions from this source by as much as 56 times over the real number (O’Dwyer et al., 2018). These studies suggest that current accounting methods depict landfilled wood products in an unfair light not grounded in reality that inflates their overall environmental impact.

We are pursuing funding to research this topic further and will continue to review the existing literature on this topic. Carbon emissions are becoming a more pressing issue for regulators and will likely play a grater role in determining the cost of disposal of materials in the future.

Ensuring wood products are accurately represented in these regulations is going to be an important factor in enabling economical use by the general public.

Objective 6: Deliver Educational Outreach Programs on the Proper Use of Treated Wood in Relation to the Best Management Practices (BMPs)

6.1.0 Review of the existing literature describing the environmental impacts of oilborne preservative systems

In January 2020, the EPTW traveled to Olympia, WA for a meeting with WWPI and representatives from several Washington State departments on the regulatory status of oil borne preservatives in that state. We utilized the WWPI environmental assessment modelling tool to help educate the attendees about environmental risk mitigation for preservative treated wood structures. As a result of this meeting the EPTW will be reviewing the environmental impacts of oilborne preservatives. This effort will serve in part to update a whitepaper from 2001 used by the Washington departments to inform policy through the publication of a series of peer-reviewed publications. The review will include current research on oilborne preservatives occurring since 2001 and any other information on the environmental performance of oilborne-treated wood available from EPTW members. No significant progress has been made toward the completion of this objective.

6.2.0 Publication of EPTW research

A summary of OSU’s work testing BMPs over several years was disseminated in the 2020 Proceedings of the Canadian Wood Preservation Association which was submitted to the group in early 2021 as a summary document. This document is a comprehensive summary of BMP testing results and can be made available to cooperative members upon request.

References

Environmental Protection Agency (2002). Notice of Receipt of Requests to Cancel Certain Chromated Copper Arsenate (CCA) Wood Preservative Products and Amend to

Terminate Certain Uses of CCA Products. Federal Registerm February 22, 2002, OPP-66300.

Anastassiades, M., Lehotay, S.J., Stajnbaher, D., Schenck, F.J., 2003. Fast and easy multiresidue method employing acetonitrile extraction/partitioning and ``dispersive solid-phase extraction{''} for the determination of pesticide residues in produce. J. AOAC Int. 86, 412–431.

Brooks, K.M., 2011. Modeling the environmental risks associated with pressure treated wood used in sensitive environments, in: Morrell, J.J., Brooks, K.M., Davis, C.M. (Eds.), Managing Treated Wood in Aquatic Environments. Forest Products Society.

Coles, C.A., Arisi, J.A., Organ, M., Veinott, G.I., 2014. Leaching of Chromium, Copper, and Arsenic from CCA-Treated Utility Poles. Appl. Environ. Soil Sci. 167971, 11.

Eggelston, S., Buendia, L., Miwa, K., Ngara, T., Tanabe, K., 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Institute for Global Environmental Strategies, ISBN 4-88788-032-4.

Forsberg, N.D., Wilson, G.R., Anderson, K.A., 2011. Determination of Parent and Substituted Polycyclic Aromatic Hydrocarbons in High-Fat Salmon Using a Modified QuEChERS Extraction, Dispersive SPE and GC-MS. J. Agric. Food Chem. 59, 8108–8116. https://doi.org/10.1021/jf201745a

Greven, M., Green, S., Robinson, B., Clothier, B., Vogeler, I., Agnew, R., Neal, S., Sivakumaran, S., 2007. The impact of CCA-treated posts in vineyards on soil and ground water. WATER Sci. Technol. 56, 161–168. https://doi.org/10.2166/wst.2007.485

Hingston, J.A., Collins, C.D., Murphy, R.J., Lester, J.N., 2001. Leaching of chromated copper arsenate wood preservatives: a review. Environ. Pollut. 111, 53–66. https://doi.org/10.1016/S0269-7491(00)00030-0

Ko, B., Vogeler, I., Bolan, N.S., Clothier, B., Green, S., Kennedy, J., 2007. Mobility of Copper, Chromium and Arsenic from Treated Timber into Grapevines. Sci. Total Environ. 388, 35–42.

Konkler, M., Cappellazzi, J., Morrell, J.J., 2018. Ability of Best Management Practices to Reduce Preservative Migration from ACQ or CA-treated Southern Pine or Spruce-Pine-Fir. Proc. Am. Wood Prot. A 114, 108–115.

Konkler, M.J., Cappellazzi, J., Morrell, J.J., 2018. Ability of Best Management Practices to Reduce Preservative Migration from ACQ- or CA-Treated Southern Pine or Spruce-Pine-Fir. Proc. Am. Wood Prot. Assoc. 114, 108–115.

Konkler, M.J., Cappellazzi, J., Presley, G., Morrell, J.J., 2020. Migration of creosote components from timbers treated with creosote and processed using Best Management Practices. J. Environ. Manage. 276, 111270. https://doi.org/https://doi.org/10.1016/j.jenvman.2020.111270

Konkler, M.J., Cappellazzi, J., Presley, G.N., Morrell, J.J., 2020. Assessing the Effectiveness of the Best Management Practices for Preventing the Migration of Copper from Decking Treated with one of two Micronized Copper Azole Formulations. Proc. Am. Wood Prot. Assoc. 116, 146–157.

Konkler, M. J., Cappellazzi, J., Presley, G.N., Morrell, J.J., 2020. Assessing the Effectiveness of Best Management Practices for Preventing the Migration of Copper from Decking Treated with One of Two Micronized Copper Azole Formulations. Proc. Am. Wood Prot. Assoc. 116, 146–157.

Konkler, M.J., Morrell, J.J., 2019. Effect of post-treatment steaming on preservative migration from pentachlorophenol-treated wood. Int. Wood Prod. J. 10, 70–77. https://doi.org/10.1080/20426445.2019.1622238

Lankone, R.S., Challis, K., Pourzahedi, L., Durkin, D.P., Bi, Y., Wang, Y., Garland, M.A., Brown, F., Hristovski, K., Tanguay, R.L., Westerhoff, P., Lowry, G., Gilbertson, L.M., Ranville, J., Fairbrother, D.H., 2019. Copper release and transformation following natural weathering of nano-enabled pressure-treated lumber. Sci. Total Environ. 668, 234–244. https://doi.org/10.1016/j.scitotenv.2019.01.433

Lebow, S., 1996. Leaching of Wood Preservative Components and their Mobility in the Environment: Summary of Pertinent Literature. USDA Forest Products Laboratory, General Technical Report FPL-GTR-93.

Lebow, S., Foster, D., Evans, J., 2004. Long-term soil accumulation of chromium, copper, and arsenic adjacent to preservative-treated wood. Bull. Environ. Contam. Toxicol. 72, 225–232. https://doi.org/10.1007/s00128-003-9055-y

Levi, M.P., Huisingh, D., Nesbitt, W.B., 1975. Uptake by grape plants of preservatives from pressure-treated posts not detected. Proc. IRG Annu. Meet. IRG/WP/350, 2 p.

Love, C.S., Gardner, B., Morrell, J.J., 2014. Metal accumulation in root crops grown in planters constructed from copper azole treated lumber. Eur. J. WOOD WOOD Prod. 72, 411–412. https://doi.org/10.1007/s00107-014-0789-5

Martinez, E., Gros, M., Lacorte, S., Barcelo, D., 2004. Simplified procedures for the analysis of polycyclic aromatic hydrocarbons in water, sediments and mussels. J. Chromatogr. A 1047, 181–188. https://doi.org/10.1016/j.chroma.2004.07.003

Morrell, J.J., 2017. Environmental performance of treated wood research cooperative 7th annual report Oregon State University, Corvallis, Oregon.

Morrell, J.J., Miller, D.J., Schnelder, P.F., 1999. Service Life of Treated and Untreated Fence Posts: 1996 Post Farm Report. Research Contribution 26, Oregon State University, Corvallis, OR.

NOP 5036 (2016). Treated Lumber (Draft Guidance). United States Department of Agriculture Agricultural Marketing Service National Organic Program, Washington, DC.

O’Dwyer, J., Walshe, D., Byrne, K.A., 2018. Wood waste decomposition in landfills: An assessment of current knowledge and implications for emissions reporting. WASTE Manag. 73, 181–188. https://doi.org/10.1016/j.wasman.2017.12.002

Petersen, A.K., Solberg, B., 2005. Environmental and economic impacts of substitution between wood products and alternative materials: a review of micro-level analyses from Norway and Sweden. For. POLICY Econ. 7, 249–259. https://doi.org/10.1016/S1389-9341(03)00063-7

Rhodes, E.O., 1951. History of Changes in Chemical Composition of Creosote. Proc. Am. Wood Preserv. Assoc. 47, 12–17.

Robinson, B., Greven, M., Green, S., Sivakumaran, S., Davidson, P., Clothier, B., 2006. Leaching of copper, chromium and arsenic from treated vineyard posts in Marlborough, New Zealand. Sci. Total Environ. 364, 113–123. https://doi.org/10.1016/j.scitotenv.2005.07.012

Schwer III, D.R., McNear, D.H., 2011. Chromated Copper Arsenate-Treated Fence Posts in the Agronomic Landscape: Soil Properties Controlling Arsenic Speciation and Spatial Distribution. J. Environ. Qual. 40, 1172–1181. https://doi.org/10.2134/jeq2010.0455

Webb, D.A., 2014. Creosote-Preservative of Choice by American Railroads. Proc. IRG Annu. Meet. IRG/WP 14-30658, 6 p.

Ximenes, F., Bjordal, C., Cowie, A., Barlaz, M., 2015. The decay of wood in landfills in contrasting climates in Australia. WASTE Manag. 41, 101–110. https://doi.org/10.1016/j.wasman.2015.03.032

Ximenes, F.A., Gardner, W.D., Cowie, A.L., 2008. The decomposition of wood products in landfills in Sydney, Australia. Waste Manag. 28, 2344–2354. https://doi.org/https://doi.org/10.1016/j.wasman.2007.11.006

Ye, M., 2013. Effects of Best Management Practices on Copper Migration from Douglas-fir Lumber with ACZA, CA or ACQ. MS Thesis Oregon Sta, 78.

Zagury, G.J., Samson, R., Deschenes, L., 2003. Occurrence of metals in soil and ground water near chromated copper arsenate-treated utility poles. J. Environ. Qual. 32, 507–514.