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Mining 30 Years of Conifer Records at the Baker Arboretum

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MINING 30 YEARS OF CONIFER RECORDS FROM THE BAKER ARBORETUM

A Thesis
Presented to
The Faculty of the Department of Agriculture and Food Science
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
Of the Requirements for the Degree
Master of Science

By
Monika Decker

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MINING 30 YEARS OF CONIFER RECORDS FROM THE BAKER ARBORETUM

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Only limited data had been published on the survivability of specimens within public gardens. This may be due to not enough data collected or how vast the plant selections are in the gardens. The Baker Arboretum has collected data by accessioning plant collections over a period of 30 years. The Baker Arboretum has its specimens GIS mapped on the 115-acre property for easy location and detection of the the woody ornamental plants. However, little research is available to understand which coniferous specimens have the best success in the garden. In this study, six separate binomial logistic regressions were run to determine the odds of success. The dependent variable used in the regressions to measure survival, 0 being dead and 1 being alive, were of the 'quantity now' in each data set. The predictor variables in each regression were nativity, season planted and container size. The specimens that were analyzed were *Cupressaceae, Pinaceae, Cephalotaxaceae, Ginkgoaceae* families and also the *Picea* and *Chamacyparis* genus'. The odds ratio was used to determine what likelihood each significant predictive variable has in accordance to survival. Of the six taxa groups analyzed, only three of the regressions were found to be significant by using predictor variables to determine to the odds of survival. *Chamaecyparis, Cupressaceae* and *Pinaceae* were the three specimen groups that showed significance in survival with the predictor variables. The other three, *Cephalotaxaceae, Ginkgoaceae and Picea* groups were reported non-significant. The *Cupressaceae* family specifically had shown parallel predictions of the expected survival

with biological predictions. Completion of this study provides more knowledge on how to track and analyze survivability odds in public gardens, helping further *ex-situ* conservation.

CHAPTER I

INTRODUCTION

Historical records show that early gardens were used for apothecary and medicinal uses such as Padua, Italy which was founded in 1545 (Groover & Dosmann, 2012). As time passed, these living encyclopedias began to grow with broad taxonomic representation which were either diversified or specialized. The famous Kew Gardens in England opened in 1848 and diversified its collections of many temperate plants. A similar specialization was undertaken by Missouri Botanic Garden that has also diversified in woody and temperate species. Others such as the Arnold Arboretum at Harvard University became the first botanic garden in the US to specialize in woody plants (Groover & Dosmann, 2012). An arboretum focuses on the study and conservation of woody species, while a botanic garden focuses on herbaceous species as well as woody species. Botanic gardens often have a glass house, whereas an arboretum doesn’t.

Arboreta and botanic gardens have been developed all around the world to showcase botanical and horticultural diversity in one place. Some of these species are endangered and otherwise would be extinct or out of reach for the public without these gardens' *ex-situ* conservation techniques. These gardens have multiple purposes, but some of the most important features are to be a place of research, conservation, and scientific education.

Within these gardens, it is important and routine to keep a record of all plants introduced to the garden. This process of record keeping is a procedural act on every plant, known as accessioning. To say in other words, accessionists are the librarians of the gardens. To track an ongoing size of a collection, the number of new accessions compared to the number of deaths indicate how the collection is performing (Rae, 1970). A few key pieces to processing this information are recording the scientific name, place of purchase, size of container it came in and how much the plant had cost. It is important to extract the maximum data on each specimen in the garden, otherwise it would be a loss of opportunity and resource (Rae, 1970). The Royal Botanic Gardens at Edinburgh and Kew have kept meticulous plant phenology records since the 19th century that thoroughly aid in helping predict plant growth efficiency within their gardens (Primack & Miller-Rushing, 2009).

The resources that arboreta and botanical gardens have and include are that of research networks across the world (Primack & Miller-Rushing, 2009). This is helpful in research due to many of the same plants being grown and all being subjected to different environmental conditions. Scientists are able to examine these species in isolated environments and study the plant characteristics.

Another importance of these gardens is being able to observe variation in the plants under different ecological changes (Primack & Miller-Rushing, 2009). Gardens in large urban areas will undergo a more rapid warming, due to the urban heat island effect. Human modifications in cities, such as buildings, parking lots and roads all affect temperature leading to increased warming, in contrast to more rural areas. Urban areas have an increase of atmospheric gasses that create difficulty in discovering climate-driven changes in plant species (Primack & Miller-Rushing, 2009).

There are multiple arboreta in the state of Kentucky. Bernheim Arboretum and National Forest, in Clermont, Kentucky is the largest in the state, holding 16,137 acres. A survey of Kentucky arboreta and botanic gardens reveals a diversity of sizes (Table 1).

Table 1. Arboreta and Botanic Gardens in Kentucky

Public Garden	Location	Acreage
Bernheim Arboretum & Research	Clermont Ky	16137
Boone County Arboretum	Union Ky	121
The Baker Arboretum	Bowling Green Ky	114
The Arboretum State Botanical Garden of Kentucky	Lexington Ky	100
Yew Dell Botanical Garden	Crestwood Ky	60
Waterfront Botanical Garden	Louisville Ky	23
Western Kentucky Botanical Garden	Owensboro Ky	12
Nannie Clay Wallis Arboretum	Paris Ky	4

The Baker Arboretum, located in Bowling Green Kentucky, comes in as the third largest arboreta in Kentucky at 115 acres. Jerry E. Baker, the founder started heavily planting the 15-acre Arboretum in 1991. In 2013 he later purchased a neighboring 100-acre golf course to add onto the Arboretum. The 15 original acres are still the heaviest planted area, while the remaining 100 are used for natural prairies and hiking.

This study is focused on the findings of best performing conifers within the Baker Arboretums collection. The Arboretum is situated on a limestone hillside, which makes growing conifers difficult due to their preference for acidic soil less than 6.5 pH. To maintain acidity within the soil, elemental sulfur is applied annually to all garden beds. Over the years many tons of soil have been brought into the gardens, due to the lack of quantity of original soil. The many tons of soil all came from different origins; thus the gardens have a wide range of pH levels. The edaphic pattern is heterogonous. The plants are not growing in their native soil, making it difficult to generalize on the effects of soil pH on the conifers.

Conifers are an ancient taxa detected distinctly through fossil records that date back 300 million years old (Farjon, 2008). They have evolved and survived through the splitting and submerging of continents, ice age, and the Triassic and Jurassic era. Conifers diversity resulted in survival throughout extinction and evolution within the duration of their prehistoric history (Farjon, 2008). These resilient plants are still facing challenges of extinction in present day with ecological changes and deforestation making all the more reason to study them.

Brongniart, in 1849, was first to recognize the difference in three distinctive plant groups: angiosperms, gymnosperms and cryptogams (Hart, 1987). These were once thought to be of higher to lower forms within specimens that developed over time. A conifer is within the primitive gymnosperm group which bears cones, dating back before angiosperms. Angiosperms are specimens that have developed intact flowers for pollination. Angiosperms have ovaries within the flowers that produce fruits and seeds, while gymnosperms develop seeds that become from ovules, yet these are not in ovaries that develop into fruits (Farjon, 2008). Within the classification of gymnosperms, Ginkgo’s are recognized for having fleshy ovules that resemble a fruit, except they produce seeds without true flowers.

This study was focused on how the conifer collection at the Baker Arboretum has performed across various environmental and horticultural factors that may impact survival. These trees were analyzed by genera and family to determine the best survival within the garden and whether predictor variables had any significance with survival. The nativity of the trees was studied to detect any correlations for the best performing specimens. Another interesting evaluation was the container size of the plant at the time of purchase before planting. Also included among variables studied was the season the tree was planted. There are many more characteristics that are yet to be analyzed in the database correlating to survivability, but these were most focused in this study.

This study was unique in that the accessioned data in an arboreta were used to determine significance in plant survival in accordance to the specific variables. This uniqueness has made it difficult to make comparisons across gardens or to measure these results with those of other conifer collections. It is important that gardens keep a detailed record of accessioned data on these specimens for future needed studies. Hopefully these results will lead to further exploration of *ex-situ* conservation of conifers around the world.

CHAPTER II

LITERATURE REVIEW

CONIFER CONSERVATION. Across the world only 12% of the Global forests are protected (Wan et al, 2017). Ongoing global climate change may affect the structure of the World's forests in the future. Weakening of forest structure and stability have lead to vulnerability in forest biodiversity. When these protected areas formed, climate change was not considered in developing these areas of protection. Shifting climates have shown lack of protection in certain conservation areas, thus danger for certain species.

Dominant tree species need to be monitored due to the vast number and coverage of forests (Wan et al, 2017). These trees are key in forest stabilization, many compromised of coniferous species. In China, nature reserves were studies and evaluated along with multiple different climatic variables (Wan et al, 2017). Spatial distribution was taken into consideration in current conservation areas that were needed to be protected in the future. There were three designated ecoregions, that of tropical/sub-tropical broadleaf forests, temperate and mixed forests and temperate conifer forests. Of all the ecoregions, the temperate conifer forests resulted in having the fewest areas protected for future climate changes (Wan et al, 2017).

In Japan, a similar study was performed showing that 88-97% of the current habitat that *Tsuga diversifolia* and *Abies veitchii* are in will not be habitable under future climate change scenarios. This study showed that two focal subalpine conifers are highly vulnerable in the future give a glimpse at the upcoming survival problems conifers are facing (Tsuyama et al, 2013). The best climate for best developed conifers were during the Mesozoic era in a fair variable climate. Yet, for the existing conifers left, we might conclude that a suitable habitat for them would be moist mesophytic one (Li, 1953). It may be important in conservation to focus on the costal regions, as it will be easier to maintain such climate. Studying conifers in *ex-situ* conservation around the world in different climates will help in the future for *in-situ* conservation techniques.

NATIVITY IN CONIFERS. Conifers occur on all the continents around the world except Antarctica (Farjon, 2021). From the arctic to the equator, one can expect to see coniferous trees in every landscape. Conifers reflect their distribution in the ancient breaking of the continents, while other patterns that can be found in them are studied using the conifer database (Farjon, 2021).

There are 615 species of extant conifers, 540 belong in the families of *Pinaceae*, *Podocarpaceae* and *Cupressaceae* (Farjon, 2021). The other families include *Araucariaceae*, *Cephalotaxaceae, Phyllocladaceae, Sciadopityaceae* and *Taxaceae* family. The families are spread throughout the world. In the northern hemisphere, *Pinaceae* are exclusively growing with 11 genera. The *Podocarpaceae*, with 18 genera, are an exclusively tropical family, with the only other area outside of the tropics in the southern hemispheric mountains. The *Cupressaceae*, containing 30 genera, are the only family that is cosmopolitan (Farjon, 2021). Besides the *Taxaceae* family, all other families have a very limited distribution range. It is suggested that the species with most range is that of *Juniperus communis* L. covering most of Europe, northern Asia and north America (Li, 1953). Notable features of distribution in conifers are that most successfully grow in mountainous areas, with warm temperate climates and a preference in moisture (Li, 1953).

THE RELATIONSHIP BETWEEN GINKGO AND CONIFEROUS TREES. Ginkgo trees are also prehistoric and are considered to be a living fossil (Purcell, 2016). They are dubbed this nickname due to the way in which they still reproduce. Unlike conifers, the ginkgo tree has maintained its motile male gamete, where it takes place in the ovule before fertilization takes place (Jager et al, 2003). *Ginkgo biloba* is so ancient, it is the only surviving member in its own genus to this day, surpassing their large plant lineage that lived 150 million years ago (Purcell, 2016). It has been said that they were thought to be saved from extinction in the twelfth century by the Chinese Buddhist Monks that kept them around their temples (Jager et al, 2003).

The leaves of the ginkgo tree are fan-shaped, distinguishing two lobes and happen to be deciduous. Instead of bearing cones like conifers, ginkgo trees produce fleshy ovules. Ginkgo trees are set apart from other species, but are often grouped together with their close prehistoric relative the conifers.

RAINFALL AND PLANT PERFORMANCE. Within coniferous forests, rainfall accumulates to 12-35 inches per year (Przyborski, 2021). Water stress is one of the primary forces that drives evolution in plants (Brodribb et al, 2014). Conifers have evolved with water stress in different ways. A study found that there is an ancestral mechanism in *Pinaceae* and *Araucariaceae* species that rely on high levels of the abscisic acid hormone (ABA) to close the stomata during stress (Brodribb et al, 2014). In the *Cupressaceae* family, a mechanism for leaf desiccation is used to close their stomata, instead of increased ABA (Brodribb et al, 2014).

One very distinct physiological characteristic conifers have adapted due to drought stress is that of the shape of their needles. On the under side of the needle, it is shaped like a horseshoe. This is so that the stomates located on the under side are insulated within the needle. These modified leaves have evolved in such a way to be able to store more water. The needle curling under gives the stomates shade and increased relative humidity so that the plant will not diffuse its water supply from a high concentration to a low concentration.

The waxy coating on these needles are called the cuticle also help prevent water loss and the leaching of nutrients (Strieby, 2013). Developing the cuticle means more output of photosynthesis to develop this extra protection. Another disadvantage of these modified leaves is that the photosynthetic rates decrease due to less surface area of these modified leaves (Strieby, 2013). They combat this by keeping their needles year-round, constantly photosynthesizing keeping up with their deciduous counterparts. Although it takes more energy to keep these needles during all seasons, drought stress also has an impact on active photosynthetic nutrients (He et al, 2016). This could lead to a quick decline in the plants health. Conifers are consistently proving to be in a balancing act of cost and survival (Strieby, 2013).

SEASON PLANTED AND PLANT PERFORMANCE. It is commonly known in horticulture that when a specimen is planted in the ground its important to plant within a mild season so that the plant can establish its root system. If planted in the growing season during the summer, survival of the plant will be hard due to the excessive heat and transpiration process within the plant. It is best to transplant trees during the fall or spring to allow for root establishment (Mendocino Coast Botanical Gardens, 2021). Little metabolic activity occurs in conifers when temperatures hit below 40°F. Studies show that soil temperature around 68°F produces optimum plant growth (Heron, 1986).

Conifer roots do not continue to grow rapidly when winter months in colder climates reach freezing temperatures (Bigrass 1996; Sutinen 1998). The main time of root growth is when the soil temperature is steadily decreasing, after the growing season (Lyr and Hoffmann 1967; Weiser 1970; Smit-Spinks et al. 1985; Rikala and Huurinainen 1990; Ryyppö et al. 1998). At this time is where the plant stops focusing on the reproductive aspects of growth and reverts back to plant establishment for the next growing season. Even though the shoots may be dormant during the transplanting seasons, the roots can continue to grow if soil temperatures allow (Lyr and Hoffmann 1967; Burr 1990).

CONTAINER SIZE AND PLANT PERFORMANCE. The variable of container size is important to look at in the horticulture industry in relevance to success of transplanting. Container sizes vary in volume for allowed root growth and development (NeSmith and Duval, 1998). To producers, container size has an impact on the number of plants that can be produced per square foot. Yet, the customer is interested on the performance their plant will have after transplanting (NeSmith and Duval, 1998). The smaller the container, the more restricted the roots are for plant growth. Increased root mass leads to greater competition for depleting nutrients and oxygen due to less pore space in soil (NeSmith and Duval, 1998). The decreased pore space in the medium results in less aeration and water holding capacity, leading to the plant suffering from water shortage (NeSmith and Duval, 1998).

Root volume in a container greatly affect shoot growth (Latimer, 1991). Studies have shown that in vegetable production, transplants from smaller containers result in reduced early crop yield (Latimer, 1991). Within hard wood species, the effect of container size and transplanting success has shown that larger containers result in higher shoot growths within the trees (Graber, 1978).

CHAPTER III

MATERIALS AND METHODS

PLANT SELECTION AND EXCEL COMPOSITION. The Baker Arboretums' original Access database consisted of 5,237 existing and mapped woody specimens accessioned over the past 30 years. Native trees 12 inches in diameter at breast height and greater have been cataloged in the main 15 acres of the arboretum, but thousands remained unmapped in the remainder 100 acres. The coniferous tree collection data were selected because it is a primary focus of the plant collections. This collection consisted of 1,092 existing trees that were mapped using Global Information Systems (GIS), with 549 cultivars. A summary of the conifer collection is listed in table two.

Table 2: The Baker Arboretum’s summary of the conifer collection.

	Genus	Species	Cultivar	Family
Total	31	105	549	7

Conifers were examined based on whether they were alive and dead. There was no attempt made to determine the status of their health. Some of the characteristics focused on in this study were that of the specimen’s genus, species, family, nativity, month planted, container size, quantity now, original quantity. Plant characteristics were compared to determine which, if any, influenced survival at the Baker Arboretum for the past 30 years.

DATA SITE The site where the data have been collected over the past 30 years is at the Baker Arboretum. The coordinates of the Baker Arboretum are located at 36.9942° N, 86.5183° W. The Arboretum is located in Bowling Green, Kentucky on a hill overlooking Western Kentucky University. The property consists of 114 acres, 14 of which are heavily landscaped. This area is located within the USDA site as hardiness zone 7b.

STANDARDIZATION OF EXPERIMENTAL COMPONENTS. The original data were imported into an Access database and exported to an excel sheet to be refined for only the components being analyzed. The quantity now column was made dichotomous for each plant, 0 being dead and 1 being alive. To standardize the data within the nativity column, these were grouped within the seven geographical continents. Of these continents included the groupings of Asia, North America, Europe, Europe/Asia, Europe/Asia/Africa, North America/Europe/Asia/Africa and Hybrid. These were standardized in SPSS numbered one through seven. Container size was standardized in the data set by making three groups of sizes. All containers equal or below 1 gallon were coded as 1, containers greater than 1 gallon coded as 2 and ball and burlap trees coded as group 3. The months planted column had been grouped in seasons. The seasons have been divided into groupings of three months. The season of Spring included the months March, April and May. Summer included the months of June, July and August. Fall included the months of September, October and November. The month of Winter included months of December, January and February. A general survival rate column was created as shown below in Equation 1. This shows the overall survival rates in a percentage of the conifers by comparing the quantity now column with the original quantity.

Equation 1:

$$\% \text{ Survival} = \frac{Quantity\ Now}{Original\ Quantity} \text{ x } 100$$

The conifer taxa I examined were *Pinaceae*, *Cupressaceae*, *Cepholotaxaceae*, *Ginkgoaceae* families. The two genera, *Picea* and *Chamacyperus* were analyzed for more specific interpretation.

Each group had to be put into dummy variables, due to being categorical data. All seasons were analyzed with the omitted baseline comparison variable being the season of winter. Container sizes were analyzed in comparison to the baseline comparison variable of container size equal or below one gallon. The nativity had been analyzed to different baseline comparison variables in each regression, due to variability in nativity. The odds ratio was analyzed in the significant variables to signify the likelihood of survival. All odds ratios below 1 signify a decline in survival in comparison to the baseline comparison variable. Odds ratios that are higher than 1 signify an increase in survival compared to the baseline comparison variable. If the odds ratio is equal to 1, the variable has no affect on the odds of an outcome.

STATISTICAL ANALYSIS. There were both binary linear and nominal components within the experiment to be tested. Nominal data that were accounted for as predictor variables include the nativity, season planted and container size. The binary data that accounted for the dependent variable in each regression was the "quantity now" of survival in the excel sheet. In order to measure the alive and dead conifers in accordance to these variables, multiple binary logistic regressions were used. This measures the presence or absence of a specimen, alive being 1 and dead 0. This was done by using IMB SPSS, Version 26 (IMB SPSS, 2016). The dichotomous dependent variable in the model was the "quantity now". In order to run all nominal predictor variables, dummy variables were implemented for nativity, season planted and container size. Within each dummy variable, one was omitted due to referencing to the others and redundancy. This variable was referred to as the baseline comparison variable. Included in the model were the Hosmer-Lemeshow 'Goodness-of-Fit' test, 95% confidence intervals, frequency statistics, probabilities and group membership. There were a total of 6 binary logistic regressions examined in this study.

LIMITING ASSUMPTIONS. One limiting assumption about the data is that there are not container sizes for every accounted specimen. This may have an effect on the overall success rate within container size, as well as accuracy with the baseline comparison variable. Other limiting assumptions include other predictor variables not being present in the data sets, due to decreasing accuracy of logistic regression models.

CHAPTER IV

RESULTS

The following results are broken up into six different sections for each regression. This is to ensure organization and easy access for the corresponding tables for each regression.

BINARY LOGISTIC REGRESSION I: *CHAMAECYPARIS*

Within this data set, 199 trees (N) were included within this analysis that showed no missing cases (Table 3). Within the classification table (Table 4) the null classification accuracy assumed all specimens that lived was 58.8%. Within this null classification table (Table 4), it is suggested that 117 specimens were alive, while 82 of them were dead. The overall model of the *Chamaecyparis* binary logistic regression as seen in Table 5 showed highly significant ($p<0.001$). Whereas within the Hosmer and Lemeshow test (Table 6) was not significant (IMB SPSS, 2016). This test was different in analyzing of the Omnibus test of model coefficients, that indicated that this number ($p>0.001$) resulted in a good fit model (IMB SPSS, 2016).

The classification table (Table 7) for the model proved to be different than the null. There were 72.6% of specimens who lived that were not predicted by the model. The predictive capacity had increased from 58.8% (Table 4) to 66.3% (Table 7). The predictive capacity had increased 7.5% from the null model.

In the Variables in the Equation (Table 8), five out of the seven variables had been proven to be significant ($p<0.05$). Container size above 1 gallon and ball and burlap were not significant to survival in this model, yet the odds ratio was greater in the ball and burlap size. There were 32 containers above 1 gallon that spoke for 16.1% of the total specimens (Table 13). Ball and burlap size included 41 specimens, that proved to be 20.6% of the total sizes (Table 12).

Nativity of North America showed greater odds of survival at an odds ratio 0.128 (Table 8) compared to the nativity of Asia. North America nativity had a frequency of 11 specimens, out of the total 199 (Table 14). North America nativity only accounted for 5.5% of the total (Table 8). All other 188 specimens were within the baseline comparison variable from Asia.

Spring, Summer and Fall seasons planted showed significance. Spring planted specimens had a frequency of 35 within the data set, also accounted for 17.6% of all specimens (Table 9). Summer plantings had 34 specimens, that also accounted for 17.1% of the total (Table 10). Fall plantings had 63 specimens, this accounted for 31.7% (Table 11). Winter plantings were calculated for 67 specimens.

All dummy variables were measured in comparison to the omitted variable (. The odds ratio (Exp[B]) had shown that within the *Chamaecyparis* genus, fall plantings were the highest survival, which were 0.209 (Table 8) times more likely to survive than to the baseline comparison variable, winter. The computed odds of a specimen survival in a fall planting was 2.155 times greater than the odds of survival in the spring or summer. While the computed odds of survival in the summer were 1.703 times greater than the odds of survival in the spring or fall plantings. The computed odds of the spring were 1.425 compared to survival of plantings in the summer or fall.

THE *CHAMAECYPARIS* TABLES

Table 3. The case processing summary for *Chamaecyparis* genera.

		N	Percent
Selected Cases	Included in Analysis	199	100.0
	Missing Cases	0	.0
	Total	199	100.0
Unselected Cases		0	.0
Total		199	100.0

Table 4. The null classification table for *Chamaecyparis* genera.

Observed		Predicted			
		Qty now		Percentage Correct	
		0	1		
	Qty now	0	0	82	.0
		1	0	117	100.0
	Overall Percentage				58.8

a. Constant is included in the model.
b. The cut value is .500

Table 5. The omibus tests of model coefficients for *Chamaecyparis* genera.

	Chi-square	df	Sig.[1]
Step	33.544	6	.000***
Block	33.544	6	.000***
Model	33.544	6	.000***

Sig.[1]: *= $p < 0.05$, **= $p < 0.01$, *** = $p < 0.001$

Table 6. The hosmer and lemeshow test for *Chamaecyparis* genera.

Chi-square	df	Sig.
6.975	6	.323

Table 7. The classification table for *Chamaecyparis* genera.

Observed		Predicted		
		Qty now		Percentage
		0	1	Correct
Qty now	0	47	35	57.3
	1	32	85	72.6
Overall Percentage				66.3

a. The cut value is .500

Table 8. The variables in the equation for *Chamaecyparis* genera.

	B	S.E.	Wald	df	Sig.[1]	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
Spring	-1.929	.497	15.089	1	.000***	.145	.055	.384
Summer	-1.790	.482	13.774	1	.000***	.167	.065	.430
Fall	-1.564	.443	12.471	1	.000***	.209	.088	.499
ContainerAbove	.539	.459	1.376	1	.241	1.714	.697	4.218
BB	.638	.418	2.322	1	.128	1.892	.833	4.296
Nativity=North America	-2.052	.859	5.707	1	.017*	.128	.024	.692
Constant	1.448	.333	18.954	1	.000***	4.256		

Sig.[1]: *= $p< 0.05$, **= $p<0.01$, *** = $p<0.001$

Table 9. Spring season frequency for *Chamaecyparis* genera.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	164	82.4	82.4	82.4
Spring	35	17.6	17.6	100.0
Total	199	100.0	100.0	

Table 10. Summer season frequency for *Chamaecyparis* genera.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	165	82.9	82.9	82.9
Summer	34	17.1	17.1	100.0
Total	199	100.0	100.0	

Table 11. Fall season frequency for *Chamaecyparis* genera.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	136	68.3	68.3	68.3
Fall	63	31.7	31.7	100.0
Total	199	100.0	100.0	

Table 12. Ball and burlap frequency for *Chamaecyparis* genera.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	158	79.4	79.4	79.4
BB	41	20.6	20.6	100.0
Total	199	100.0	100.0	

Table 13. Container above one gallon frequency for *Chamaecyparis* genera.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	167	83.9	83.9	83.9
Container Above	32	16.1	16.1	100.0
Total	199	100.0	100.0	

Table 14. North America nativity frequency for *Chamaecyparis* genera.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	188	94.5	94.5	94.5
NorthAmerica	11	5.5	5.5	100.0
Total	199	100.0	100.0	

BINARY LOGISTIC REGRESSION II: *CEPHALOTAXACEAE*

In the *Cephalotaxaceae* data set, 184 (N) specimens had been observed (Table 15). The null classification accuracy (Table 16), has shown 97.8% without the independent variables present. The predicted values in the null have suggested 180 specimens that were alive and 4 specimens that were dead (Table 16). The overall model *in Cephalotaxaceae* binary logistic regression in the Omnibus test (Table 17) showed to be highly significant ($p<0.001$). This showed that the model fits better than the null with its predictors present. In the Homer and Lemeshow test (Table 18), significance was shown at 1.000, signifying a good model ($p>0.001$) (IMB SPSS, 2016). Within the classification table (Table 19), showed no change than the null classification table (Table 16). The model showed 97.8% classification accuracy, considering the independent variables. There was no significance shown ($P<0.05$) in any of the variables of the equation (Table 20) between the baseline comparison variable.

The total frequency of spring planted specimens within this data set were 56 (Table 21), containing 30.4% of all specimens. Summer planted specimens had a frequency of 11 (Table 22), containing only 6.0% of the data set. Fall planted specimens had a frequency of 86 (Table 23) throughout the data set, compromising 46.7% of specimens. The calculated value for specimen plantings than had occurred in the winter were 31.

Containers above one gallon concluded with a frequency of 109 (Table 24), that showed 59.2% of the data set. There were no ball and burlap variables to be had in this data set. The nativity of each specimen in this data set were 100% from Asia (Table 25).

THE *CEPHALOTAXACEAE* TABLES

Table 15. The case processing summary for the *Cephalotaxaceae* family.

		N	Percent
Selected Cases	Included in Analysis	184	100.0
	Missing Cases	0	.0
	Total	184	100.0
Unselected Cases		0	.0
Total		184	100.0

Table 16. The null classification table for the *Cephalotaxaceae* family.

Observed		Predicted			
		Qty now			Percentage Correct
		0	1		
	Qty now	0	0	4	.0
		1	0	180	100.0
	Overall Percentage				97.8

a. Constant is included in the model.

b. The cut value is .500

Table 17. The omnibus tests of model coefficients for the *Cephalotaxaceae* family.

	Chi-square	df	Sig.[1]
Step	24.121	4	.000***
Block	24.121	4	.000***
Model	24.121	4	.000***

Sig.[1]: *= p< 0.05, **= p<0.01, *** = p<0.001

Table 18. The hosmer and lemeshow test for the *Cephalotaxaceae* family.

Chi-square	df	Sig.
.000	3	1.000

Table 19. The classification table for the *Cephalotaxaceae* family.

Observed		Predicted			
		Qty now		Percentage Correct	
		0	1		
	Qty now	0	0	4	.0
		1	0	180	100.0
	Overall Percentage				97.8

a. The cut value is .500

Table 20. The variables in the equation for the *Cephalotaxaceae* family.

							95% C.I.for EXP(B)	
	B	S.E.	Wald	df	Sig.[1]	Exp(B)	Lower	Upper
Spring	.000	9716.146	.000	1	1.000	1.000	.000	.
Summer	-20.643	9947.643	.000	1	.998	.000	.000	.
Fall	.000	8844.117	.000	1	1.000	1.000	.000	.
ContainerAbove	.000	6844.225	.000	1	1.000	1.000	.000	.
Constant	21.203	9947.643	.000	1	.998	1615477019.167		

Sig.[1]: *= $p< 0.05$, **= $p<0.01$, *** = $p<0.001$

Table 21. Spring season frequency for the *Cephalotaxaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	128	69.6	69.6	69.6
Spring	56	30.4	30.4	100.0
Total	184	100.0	100.0	

Table 22. Summer season frequency for the *Cephalotaxaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	173	94.0	94.0	94.0
Summer	11	6.0	6.0	100.0
Total	184	100.0	100.0	

Table 23. Fall season frequency for the *Cephalotaxaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	98	53.3	53.3	53.3
Fall	86	46.7	46.7	100.0
Total	184	100.0	100.0	

Table 24. Container above one gallon frequency for the *Cephalotaxaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	75	40.8	40.8	40.8
ContainerAbove	109	59.2	59.2	100.0
Total	184	100.0	100.0	

Table 25. Asia nativity frequency for the *Cephalotaxaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Asia	184	100.0	100.0	100.0

BINARY LOGISTIC REGRESSION III: *CUPRESSACEAE*

The *Cupressaceae* data set included 1,630 (N) specimens within the analysis (Table 26). Within the classification table for the null model (Table 27), the overall correct percentage that was predicted was 78.3%. The values within null model (Table 27) predicted that 1,277 of the specimens survived, while 353 specimens died. In the Omnibus test of model coefficients (Table 28), showed to be highly significant ($p<0.001$). The Omnibus test of model coefficients showed that the model had fit better with the predictor variables, compared to just the null model (IMB SPSS, 2016). Homer and Lemeshow test (Table 29) depicted a significance of 0.000, proving that although this model had fit better with the variables than the null, the overall model was not good (IMB SPSS, 2016). A significance above 0.001 signifies a good model within this test. In the classification table including predictor variables (Table 30), the overall correct predicted percentage was 78.4%. The predictive capacity had increased by 0.1% from the null model.

In the variables in the equation (Table 31), seven out of the 9 variables showed to be significant ($p<0.05$). Container size above one gallon showed more significance at 0.001, than that of the ball and burlap at 0.005 compared to the baseline comparison variable that is container size equal or below one gallon (Table 31). There was a frequency of 67 specimens (Table 32) planted from ball and burlap that composed of only 4.1% out of the data set. The specimens from containers above one gallon had a frequency of 468 out of the 1,630 specimens in total (Table 33). The percent of one gallon and above containers was at 28.7%. The container size above one gallon had a higher odds ratio of 1.765 (Table 31), indicating that this container size increases in odds of survival 1.765 times than that of containers equal to or below one gallon.

All variables of seasons planted had shown to be statistically significant within this model. The variable that is highly significant in the model at 0.000 was the specimens planted in the fall season (Table 31). All seasons (spring, summer, fall) have a higher likelihood of survival compared to the baseline comparison model of winter. Fall comes in at the highest likelihood of survival. Fall planted specimens are 2.305 (Table, 31) times more likely to survive, than that of winter specimens. The frequency of fall specimens within the data set are shown to be 626, with a percentage of 38.4 (Table 34). Summer specimens showed to have a frequency of 230, composed of only 14.1% within the data set (Table 35). The frequency of spring specimens in the data set are 418, with the percentage at 25.6 (Table 36). Winter was calculated to have a total of 356 specimens planted in this season.

Only two out of the four variables of nativity had shown to be significant. The highest significance shown in survival was the "North America" nativity at a significance of 0.000 (Table 31). The other statistically significant variable in nativity was the grouping of 'North America, Europe, Asia, Africa' at 0.031 (Table 31). The 'North America, Europe, Asia, Africa' nativity was 0.160 less likely to survive than the baseline comparison variable, Asia. The 'North America' nativity was 2.439 times more likely to survive than Asia (Table 31). The 'North America, Europe, Asia, Africa' nativity had a very low frequency within the data set of 7 (Table 37). 'North America' nativity specimens had a frequency within the table of 1,087, that composed 66.7% of the data set (Table 38). The 'Hybrid' specimen occurred 49 times in the data set at only 3% (Table

39). The 'Europe' nativity only occurred once in the data set (Table 40). The baseline comparison variable, Asia was calculated to occur 486 times in this data set.

THE *CUPRESSACEAE* TABLES

Table 26. The case processing summary for the *Cupressaceae* family.

		N	Percent
Selected Cases	Included in Analysis	1630	100.0
	Missing Cases	0	.0
	Total	1630	100.0
Unselected Cases		0	.0
Total		1630	100.0

Table 27. The null classification table for the *Cupressaceae* family.

Observed	Predicted			
	Qty now		Percentage Correct	
	0	1		
Qty now	0	0	353	.0
	1	0	1277	100.0
Overall Percentage				78.3

a. Constant is included in the model.
b. The cut value is .500

Table 28. The omnibus tests of model coefficients for the *Cupressaceae* family.

	Chi-square	df	Sig.
Step	128.851	9	.000
Block	128.851	9	.000
Model	128.851	9	.000

Sig.[1]: *= p< 0.05, **= p<0.01, *** = p<0.001

Table 29. The hosmer and lemeshow test for the *Cupressaceae* family.

Chi-square	df	Sig.[1]
27.947	8	.000***

Sig.[1]: *= p< 0.05, **= p<0.01, *** = p<0.001

Table 30. The classification table for the *Cupressaceae* family.

Observed		Predicted Qty now		Percentage Correct
		0	1	
Qty now	0	17	336	4.8
	1	16	1261	98.7
Overall Percentage				78.4

Table 31. Variables in the logistic regression equation for *Cupressaceae* family.

							95% C.I.for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Nativity=Europe	20.152	40192.969	.000	1	1.000	565019406.547	.000	.
Nativity=Hybrid	.229	.345	.440	1	.507	1.257	.640	2.470
Nativity=North America	.892	.138	41.710	1	.000	2.439	1.861	3.197
Nativity=North America, Europe, Asia, Africa	-1.831	.848	4.658	1	.031	.160	.030	.845
Spring	.368	.170	4.673	1	.031	1.445	1.035	2.016
Summer	.429	.202	4.536	1	.033	1.536	1.035	2.281
Fall	.835	.172	23.510	1	.000	2.305	1.645	3.231
ContainerAbove	.568	.163	12.115	1	.001	1.765	1.282	2.431
BB	-.777	.274	8.062	1	.005	.460	.269	.786
Constant	.215	.147	2.142	1	.143	1.240		

Table 32. Ball and burlap frequency for the *Cupressaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	1563	95.9	95.9	95.9
BB	67	4.1	4.1	100.0
Total	1630	100.0	100.0	

Table 33. Container above one gallon frequency for the *Cupressaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	1162	71.3	71.3	71.3
ContainerAbove	468	28.7	28.7	100.0
Total	1630	100.0	100.0	

Table 34. Fall season frequency for the *Cupressaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	1004	61.6	61.6	61.6
Fall	626	38.4	38.4	100.0
Total	1630	100.0	100.0	

Table 35. Summer season frequency for the *Cupressaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	1400	85.9	85.9	85.9
Summer	230	14.1	14.1	100.0
Total	1630	100.0	100.0	

Table 36. Spring season frequency for the *Cupressaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	1212	74.4	74.4	74.4
Spring	418	25.6	25.6	100.0
Total	1630	100.0	100.0	

Table 37. North America/Europe/Asia/Africa nativity frequency for the *Cupressaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	1623	99.6	99.6	99.6
NorthAmerica,Europe,Asia,Africa	7	.4	.4	100.0
Total	1630	100.0	100.0	

Table 38. North America nativity frequency for the *Cupressaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	543	33.3	33.3	33.3
NorthAmerica	1087	66.7	66.7	100.0
Total	1630	100.0	100.0	

Table 39. Hybrid nativity frequency for the *Cupressaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	1581	97.0	97.0	97.0
Hybrid	49	3.0	3.0	100.0
Total	1630	100.0	100.0	

Table 40. Europe nativity frequency for the *Cupressaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	1629	99.9	99.9	99.9
Europe	1	.1	.1	100.0
Total	1630	100.0	100.0	

BINARY LOGISTIC REGRESSION IV: *GINKGOACEAE*

This binary logistic regression included 72(N) specimens within this analysis (Table 41). Within the classification table for the null model (Table 42), the overall correct percentage that was predicted was 55.6%. In the Omnibus test of model coefficients (IMB SPSS, 2016), the overall model showed to be insignificant at 0.217 when adding the variables into the model (Table 43). Hosmer and Lemeshow test (Table 44) had shown a significant overall model at 0.995 ($p<0.001$). The classification table containing all variables (Table 45) had an overall correct predictive capacity at 63.9%. There was an 8.3% increase in predictive capacity from the null model.

The variables in the equation (Table 46), had shown no significance in predictor variables of survival within this analysis. The planting season spring had shown an overall frequency in the data set at 19, having an overall percentage of 26.4 (Table 47). Summer had a frequency of 12 specimens, having 16.7% accounted for in the data set (Table 48). Fall plantings had a frequency of 18 and had a percentage of 25.0 in the data set (Table 49). The baseline comparison variable, winter, was calculated to held 23 of the planted specimens. Containers above one gallon was shown to have a frequency at 14 and percentage of 19.4 in the data set (Table 50). There were only two ball and burlap specimens at 2.8% in this analysis (Table 51). Nativity for all 72 specimens were Asia (Table 52).

THE *GINKGOACEAE* TABLES

Table 41. The case processing summary for the *Ginkgoaceae* family.

		N	Percent
Selected Cases	Included in Analysis	72	100.0
	Missing Cases	0	.0
	Total	72	100.0
Unselected Cases		0	.0
Total		72	100.0

Table 42. The null classification table for the *Ginkgoaceae* family.

Observed		Predicted			
		Qty now		Percentage Correct	
		0	1		
	Qty now	0	0	32	.0
		1	0	40	100.0
	Overall Percentage				55.6

a. Constant is included in the model.

b. The cut value is .500

Table 43. The omnibus tests of model coefficients for the *Ginkgoaceae* family.

	Chi-square	df	Sig.
Step	8.579	5	.127
Block	8.579	5	.127
Model	8.579	5	.127

Table 44. The hosmer and lemeshow test for the *Ginkgoaceae* family.

Chi-square	df	Sig.
.217	4	.995

Table 45. The classification table for the *Ginkgoaceae* family.

Observed		Predicted			
		Qty now		Percentage Correct	
		0	1		
	Qty now	0	9	23	28.1
		1	3	37	92.5
	Overall Percentage				63.9

a. The cut value is .500

Table 46. The variables in the equation for the *Ginkgoaceae* family.

							95% C.I.for EXP(B)	
	B	S.E.	Wald	df	Sig.[1]	Exp(B)	Lower	Upper
Spring	.025	.649	.002	1	.969	1.026	.288	3.660
Summer	-1.392	.806	2.981	1	.084	.249	.051	1.207
Fall	-.184	.728	.064	1	.800	.832	.200	3.463
ContainerAbove	.743	.767	.938	1	.333	2.103	.467	9.458
BB	21.094	28420.721	.000	1	.999	1448581235.614	.000	.
Constant	.293	.453	.418	1	.518	1.341		

Sig.[1]: *= $p< 0.05$, **= $p<0.01$, *** = $p<0.001$

Table 48. Ball and burlap frequency for the *Ginkgoaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	70	97.2	97.2	97.2
BB	2	2.8	2.8	100.0
Total	72	100.0	100.0	

Table 49. Spring season frequency for the *Ginkgoaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	53	73.6	73.6	73.6
Spring	19	26.4	26.4	100.0
Total	72	100.0	100.0	

Table 50. Summer season frequency for the *Ginkgoaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent			
Valid			Other	60	83.3	83.3	83.3
Summer		12	16.7	16.7			100.0
Total		72	100.0	100.0			

Table 51. Fall season frequency for the *Ginkgoaceae* family.

		Frequency	Percent	Valid Percent	Cumulative Percent	
Other		54		75.0	75.0	75.0
Fall	18	25.0		25.0		100.0
Total	72	100.0		100.0		

Table 52. Asia nativity frequency for the *Ginkgoaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Asia	72	100.0	100.0	100.0

Table 47. Container above one gallon frequency for the *Ginkgoaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	58	80.6	80.6	80.6
ContainerAbove	14	19.4	19.4	100.0
Total	72	100.0	100.0	

BINARY LOGISTIC REGRESSION V: *PICEA*

Within the *Picea* binary logistic regression, the analysis included 67(N) specimens (Table 53). In the null classification table (Table 54), the model assumed 53.7% of specimens accuracy in the prediction of survival. The Omnibus tests of model coefficients (Table 55) had a significance of 0.208, concluding to no significance in the fit of variables added in the model (IMB SPSS, 2016). Hosmer and Lemeshow test (Table 56) showed a significance within the model at 0.842 ($p>0.001$). The classification table including the predictor variables (Table 57) had a 65.7% accuracy in prediction of survival, that indicated an increase from the null table by 12%.

The variables in the equation (Table 58) showed no significance. This concludes that the model is not predictive of survival. The specimens planted in the spring season (Table 59) had an overall frequency of 15 and composed 22.4% of the data set. Summer planted specimens (Table 60) had a frequency of 8 and had composed 11.9% of the data set. The fall planted specimens (Table 61) had a frequency of 34 and had 50.7% of the overall data set. The baseline comparison variable, winter, was calculated at a frequency of 10. Containers above one gallon had a frequency of 19 and percentage of 28.4 in this data set (Table 62). Whereas ball and burlap specimens had a frequency of 9 at a percentage of 13.4 (Table 63). The nativity of Europe had a frequency of 56 specimens, composed of 83.6% of the data set (Table 65). North America nativity only had a frequency of 3 at 4.5% (Table 64). The baseline comparison model, Asia, was calculated to have a frequency of 8.

THE *PICEA* TABLES

Table 53. The case processing summary for the *Picea* genera.

		N	Percent
Selected Cases	Included in Analysis	67	100.0
	Missing Cases	0	.0
	Total	67	100.0
Unselected Cases		0	.0
Total		67	100.0

Table 54. The null classification table for the *Picea* genera.

Observed		Predicted			
		Qty now			Percentage Correct
		0	1		
	Qty now	0	36	0	100.0
		1	31	0	.0
	Overall Percentage				53.7

a. Constant is included in the model.

b. The cut value is .500

Table 55. The omnibus tests of model coefficients for the *Picea* genera.

	Chi-square	df	Sig.
Step	9.664	7	.208
Block	9.664	7	.208
Model	9.664	7	.208

Table 56. The hosmer and lemeshow test for the *Picea* genera.

Chi-square	df	Sig.
3.439	7	.842

Table 57. The classification table for the *Picea* genera.

Observed		Predicted			
		Qty now		Percentage Correct	
		0	1		
	Qty now	0	27	9	75.0
		1	14	17	54.8
	Overall Percentage				65.7

a. The cut value is .500

Table 58. The variables in the equation for the *Picea* genera.

							95% C.I.for EXP(B)	
	B	S.E.	Wald	df	Sig.[1]	Exp(B)	Lower	Upper
Nativity=Europe	-.802	.995	.650	1	.420	.448	.064	3.150
Nativity=North America	-22.115	22992.307	.000	1	.999	.000	.000	.
Containersabove	-1.042	.622	2.807	1	.094	.353	.104	1.194
BB	-.587	.780	.566	1	.452	.556	.121	2.565
Spring	-.412	.887	.216	1	.642	.662	.116	3.769
Summer	-.720	1.171	.378	1	.539	.487	.049	4.830
Fall	.233	.760	.094	1	.760	1.262	.284	5.597
Constant	1.079	1.185	.830	1	.362	2.942		

Sig.[1]: *= $p< 0.05$, **= $p<0.01$, *** = $p<0.001$

Table 59. Fall season frequency for the *Picea* genera.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	33	49.3	49.3	49.3
Fall	34	50.7	50.7	100.0
Total	67	100.0	100.0	

Table 60. Summer season frequency for the *Picea* genera.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	59	88.1	88.1	88.1
Summer	8	11.9	11.9	100.0
Total	67	100.0	100.0	

Table 61. Spring season frequency for the *Picea* genera.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	52	77.6	77.6	77.6
Spring	15	22.4	22.4	100.0
Total	67	100.0	100.0	

Table 62. Ball and burlap frequency for the *Picea* genera.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	58	86.6	86.6	86.6
BB	9	13.4	13.4	100.0
Total	67	100.0	100.0	

Table 63. Containers above one gallon frequency for the *Picea* genera.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	48	71.6	71.6	71.6
ContainersAbove	19	28.4	28.4	100.0
Total	67	100.0	100.0	

Table 64. North America nativity frequency for the *Picea* genera.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	64	95.5	95.5	95.5
NorthAmerica	3	4.5	4.5	100.0
Total	67	100.0	100.0	

Table 65. Europe nativity frequency for the *Picea* genera.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	11	16.4	16.4	16.4
Europe	56	83.6	83.6	100.0
Total	67	100.0	100.0	

BINARY LOGISTIC REGRESSION V: *PINACEAE*

In the analysis of *Pinaceae*, the case processing summary (Table 66) showed 758(N) specimens included. The null classification table (Table 67) predicted 55.3% of the accuracy in model to be correct. Within the Omnibus test of model coefficients (Table 68), the model included a 0.003 significance level, indicating some significance ($p<0.05$). The Hosmer and Lemeshow test (Table 69) showed a 0.032 significance level, proving that this was not a good overall model by being under 1(IMB SPSS, 2016). The classification table that included all predictor variables (Table 70) had the percentage of correct predictions at 58.3, increasing from the null by 3%.

The only variable in the equation (Table 71) proving to be statistically significant was the spring planting season at a significance level of 0.049 ($p<0.05$). With this variable being significant, it is safe to interpret the odds ratio (Exp[B]) at its level of 0.623 (Table 71). This signifies that the odds of a specimen surviving after being planted in the spring season increased 0.623 than that of the baseline comparison variable, winter. The frequency of the spring planted specimens are 155 out of the 758 total specimens, at 20.4% of this data set (Table 72). Summer season had a frequency level of 144 holding 19.0% of the data set (Table 73). The specimens planted in the fall season had a frequency of 316, with 41.7% of the total data set. The baseline comparison variable, winter, was calculated to have a frequency of 143 in the data set. The ball and burlap frequency is at 182 specimens, that had 24.0% of the data set (Table 76). Specimens planted from containers above one gallon had a frequency of 195, with 25.7% of the data set (Table 75).

Nativity of 'Asia' had 193 specimens at a percentage of 25.5 (Table 78). 'Europe' nativity occurred 126 times in the data at 16.6% (Table 78). The nativity variable 'Europe, Asia' concluded with a frequency of 29 at a percentage of only 3.8 (Table 77). The nativity variable 'Europe, Asia, North America' had only 3 frequencies (Table 80). The 'Hybrid' nativity occurred 6 times in the data set (Table 81). 'North America' had a frequency of 385 specimens with a 50.8% included in the analysis (Table 82). The baseline comparison variable, Africa, was calculated to have a frequency of 16.

THE *PINACEAE* TABLES

Table 66. The case processing summary for the *Pinaceae* family.

		N	Percent
Selected Cases	Included in Analysis	758	100.0
	Missing Cases	0	.0
	Total	758	100.0
Unselected Cases		0	.0
Total		758	100.0

Table 67. The null classification table for the *Pinaceae* family.

Observed		Predicted		
		Qty now		Percentage Correct
		0	1	
Qty now	0	419	0	100.0
	1	339	0	.0
Overall Percentage				55.3

a. Constant is included in the model.

b. The cut value is .500

Table 68. The omnibus tests of model coefficients for the *Pinaceae* family.

	Chi-square	df	Sig.[1]
Step	28.169	11	.003**
Block	28.169	11	.003**
Model	28.169	11	.003**

Sig.[1]: *= p< 0.05, **= Sig.[1]: *= p< p<0.01, *** = p<0.001

Table 69. The hosmer and lemeshow test for the *Pinaceae* family.

Chi-square	df	Sig.[1]
15.370	7	.032*

Sig.[1]: *= p< 0.05, **= p<0.01, *** = p<0.001

Table 70. The classification table for the *Pinaceae* family.

Observed		Predicted		
		Qty now		Percentage Correct
		0	1	
Qty now	0	276	143	65.9
	1	173	166	49.0
Overall Percentage				58.3

a. The cut value is .500

Table 71. The variables in the equation for the *Pinaceae* family.

	B	S.E.	Wald	df	Sig.[1]	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
Spring	-.474	.241	3.878	1	.049*	.623	.389	.998
Summer	-.405	.246	2.703	1	.100	.667	.412	1.081
Fall	.035	.208	.029	1	.866	1.036	.689	1.558
ContainerAbove	-.290	.192	2.293	1	.130	.748	.514	1.089
BB	-.184	.195	.890	1	.346	.832	.567	1.220
Nativity=Asia	.660	.564	1.369	1	.242	1.934	.641	5.839
Nativity=Europe	.125	.578	.046	1	.829	1.133	.365	3.520
Nativity=Europe, Asia	1.008	.666	2.288	1	.130	2.739	.742	10.108
Nativity=Europe, Asia, North America	.080	1.349	.003	1	.953	1.083	.077	15.224
Nativity=Hybrid	2.391	1.225	3.809	1	.051	10.921	.990	120.495
Nativity=North America	.905	.557	2.644	1	.104	2.472	.830	7.359
Constant	-.648	.559	1.346	1	.246	.523		

Sig.[1]: *= $p< 0.05$, **= $p<0.01$, *** = $p<0.001$

Table 72. Spring season frequency for the *Pinaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	603	79.6	79.6	79.6
Spring	155	20.4	20.4	100.0
Total	758	100.0	100.0	

Table 73. Summer season frequency for the *Pinaceae* family.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Other	614	81.0	81.0	81.0
	Summer	144	19.0	19.0	100.0
	Total	758	100.0	100.0	

Table 75. Container above one gallon frequency for the *Pinaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	563	74.3	74.3	74.3
ContainerAbove	195	25.7	25.7	100.0
Total	758	100.0	100.0	

Table 74. Fall season frequency for the *Pinaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	442	58.3	58.3	58.3
Fall	316	41.7	41.7	100.0
Total	758	100.0	100.0	

Table 76. Ball and burlap frequency for the *Pinaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	576	76.0	76.0	76.0
BB	182	24.0	24.0	100.0
Total	758	100.0	100.0	

Table 77. Europe/Asia nativity frequency for the *Pinaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	729	96.2	96.2	96.2
Europe,Asia	29	3.8	3.8	100.0
Total	758	100.0	100.0	

Table 78. Asia nativity frequency for the *Pinaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	565	74.5	74.5	74.5
Asia	193	25.5	25.5	100.0

Table 79. Europe nativity frequency for the *Pinaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	632	83.4	83.4	83.4
Europe	126	16.6	16.6	100.0
Total	758	100.0	100.0	

Table 80. Europe/Asia/North America nativity frequency for the *Pinaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	755	99.6	99.6	99.6
Europe,Asia,NorthAmerica	3	.4	.4	100.0
Total	758	100.0	100.0	

Table 81. Hybrid nativity frequency for the *Pinaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	752	99.2	99.2	99.2
Hybrid	6	.8	.8	100.0
Total	758	100.0	100.0	

Table 82. North America nativity frequency for the *Pinaceae* family.

	Frequency	Percent	Valid Percent	Cumulative Percent
Other	373	49.2	49.2	49.2
NorthAmerica	385	50.8	50.8	100.0
Total	758	100.0	100.0	

CHAPTER V

DISCUSSION

Out of the six different binary logistic regressions tested, only three of the regressions were significant with predicting survival. *Chamaecyparis*, *Cupressaceae* and *Pinaceae* were the three taxa groups that showed significance in survival with the predictor variables. *Cephalotaxaceae, Ginkgoaceae and Picea* groups were not significant with the predictor variables.

In comparison of the statistically significant groups, the *Pinaceae* family and *Chamaecyparis* genus both showed a decreasing odds of survival when planted in the spring season, rather than the winter. The *Cupressaceae* family had shown greatest survival odds out of all the season predictor variables when being planted in the fall, rather than the winter. The *Cupressaceae* family had also shown in the nativity predictor variables that North America had the highest odds of survival compared to Asia. The *Chamaecyparis* genus also showed that North America had lesser odds of survival than Asia.

The *Cupressaceae* family specifically had shown parallel predictions of the expected survival with typical biological predictions. The odds of specimen survival are higher being planted in the fall season where humidity is low, rather than the spring planting season. This correlates biologically with root growth patterns of coniferous trees, being that fall is the time of root establishment and decreasing soil temperatures (Lyr and Hoffmann 1967; Weiser 1970; Smit-Spinks et al. 1985; Rikala and Huurinainen 1990; Ryyppö et al. 1998). Container size has also been analyzed in this family, showing containers above one gallon are linked with higher odds of survival than those of containers below or equal to one gallon. This also can be correlated biologically by allowing more root growth and development before planting (NeSmith and Duval, 1998). The *Cupressaceae* family had also shown higher survival odds with the nativity of North America, rather than Asia due to the specimens being native to the continent.

An explanation for the decline in survival in the *Chamaecyparis* genera is that these specimens do not perform well being transplanted. Also these genera prefer cool soil, which may explain the survival odds being greater in the winter months when planted (Groww, 2021). In 2007, the Baker Arboretum experiences a drought year. The water supply was cut from the grounds for water conservation, leading to dry soil and a higher soil temperature. In this year, the Arboretum experienced many *Chamaecyparis* deaths, which is also a huge factor in their decline of survival. *Chamaecyparis* had also shown less odds of survival with North American specimens rather than Asia, due to the reduced frequency of North American specimens in the model.

There are multiple explanations for the data that had shown to be significant. The *Cupressaceae* family had shown to be parallel to the biological predictions of survival, which explained the results well. The *Chamaecyparis* study had shown biological predictions through the seasons planted variable, but had the overall decrease in survival due to the drought that occurred in 2007. The model also had an effect on the nativity result due to the low frequency of North America. The *Pinaceae* result is an anomaly that may have resulted in collision with other predictor variables. Many variables were left out of this study due to the vast about of data, but need to be accounted for the survival. Studies like this need to be done more often in order to fully determine survival of arboreta specimens and how it correlates with important predictor variables. Accruing this data is important to the success of public gardens and also will contribute to public knowledge of these species. Future studies around the World in public gardens will aid in the success of *ex-situ* conservation that is growing more prevalent in the near future.

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