

PERFORMANCE STANDARDS FOR MUNICIPAL TREE MAINTENANCE

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Abstract. A database of 6272 municipal work records collected over a 31 month period were analyzed to establish performance standards for various types of tree maintenance. Man-hours required for tree removal, trimming and stump removal are presented. Interactions between man-hours required, diameter class, season, overhead electric wires and species were examined. Diameter class influenced all work types. Season influenced tree removal and stump removal. Overhead electric lines influenced the trimming operation. Tree species did not influence any of the work types studied.

The placement of trees and shrubs along city streets has been a common practice. Today the size of America's collective urban forest is an estimated 61 million trees (9). Given the pace of expansion and development in many American cities, it is indeed refreshing to learn that, on average, 30% of urban land is forested (13). These forests contribute greatly to the quality of life in our nation's larger metropolitan areas where they have become a valuable component of municipal infrastructure.

Despite the size and value of this resource, only an estimated seven percent of United States cities have effective tree maintenance programs (5). All too often municipal services that care for trees are viewed as expendable during tough financial times. In many cities this practice has contributed to the development of tree populations that are poorly maintained and, as such, are hazardous to both people and property.

Boers (3) noted that "A time and efficiency study might result in guidelines from which the industry could adopt standards for equipment and personnel necessary to remove a tree of an average size". Performance standards can be effective tools to encourage cost reductions, thus

enhancing productivity (2).

Tangible, measurable and verifiable performance standards will assist the urban forest manager in identifying those operational areas that need improvement. At the same time, standards can identify areas of excellence or expertise (6). Standards provide a yardstick for letting workers know what is expected of them and how well it is to be done (2). In addition, standards enable supervisors to rate their own effectiveness by measuring the productivity of their workers (2). Over and above the work evaluation benefits, standards allow the urban forester an opportunity to forecast future work loads, plan for personnel and equipment and justify tree care budgets (18). However, very little published material exists on performance standards for the tree care industry. This may in part be due to the absence of sizeable work history database collections. This may change as municipalities with computer based inventories become more sophisticated.

Traditionally, references to tree work have been expressed as a job cost (9,4). However, some studies (18,15) suggest that cost might not be the best operational parameter on which to base tree care standards. Job costs can vary from year to year, the result of fluctuating wage rates from personnel changes or new union contracts. As a result, cost figures are awkward for establishing a level of performance a crew should attain. Man-hour figures, on the other hand, tend to be constant and can take into consideration variations in the size and character of each job. These factors suggest that man-hours, not cost, are better units on which to base performance.

Most municipalities engage in four principal

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types of tree care: removal, trimming, stump removal and planting. Performance standards need to reflect these specific types of work in order to give an accurate accounting on how crews perform over a given period of time.

Performance standards may be influenced by many factors. Nowak (11) concluded that removal and trimming needs increased with diameter of the tree. Species may play a role as well. The system developed by Nowak (11) factors in diameter, maintenance and species to create a list of street trees and their corresponding maintenance expectations. According to his table, species such as honeylocust (*Gleditsia triacanthos*) and London planetree (*Platanus x acerifolia*) require less overall maintenance than trees such as boxelder (*Acer negundo*) and American elm (*Ulmus americana*). This suggests that species may influence the over-all time needed to perform a given type of tree maintenance. Size and species may not be the only factors. Other considerations include how overhead electric lines and season affect the time needed to complete a trim or removal.

The primary focus of this study was to establish realistic man-hour performance standards for tree removal, tree trimming and stump removal using a database derived from municipal work history records. Further analysis attempted to clarify what role diameter class, tree species, overhead wires, and season played in influencing these man-hour values.

The Study Site

The study site was Toledo, Ohio; a community of approximately 340,000 people located in northwestern Ohio. An urban forest of 112,000 trees and shrubs grows along Toledo's 1000 miles of street giving it the distinction of having the largest concentration of street trees in the state of Ohio.

A field staff of eighteen arborists and a support staff of nine collectively comprise the Forestry Section of the Division of Parks and Forestry. Forestry has an annual budget of 1.9 million dollars and is the municipal organization responsible for the care and maintenance of the city's trees.

A computerized inventory is utilized within the

division to track the care and maintenance of each street tree. The inventory documents and catalogs street trees along with work histories and service requests. *Tree Manager*, the licensed software program utilized by the city, operates within the Clipper Data Management System (Nantucket Industries, Los Angeles, CA) and was developed by ACRT, Inc. Urban Forestry Specialist of Kent, Ohio.

Methods

Scope of the Work. The City of Toledo provides continuous and comprehensive maintenance for trees in the public right-of-way. As part of this comprehensive maintenance the Division of Forestry conducts a variety of operations to improve the over-all health of the tree population. These services include tree removal, stump removal, and trimming.

Tree removal is a frequently requested service. As trees age, weaken and die, tree removal becomes necessary to insure public safety. In 1990 alone, tree removal accounted for 16% of the total man-hours expended by the Division. While no specific educational text is followed as an operational standard for performing this type of work, the techniques and principles illustrated in the Ontario Hydro Electric Forestry Manual (12) are similar to the Toledo operation.

Tree removal also necessitates an active stump grinding program. Toledo Forestry staff grind the stumps and flare roots of trees 5 in. dbh and larger to a depth of 6 in. below grade. The affected area is then backfilled with a sufficient quantity of wood chips to allow for natural settling and biodegradation of the woody material. Stump cutting equipment is operated in accordance with guidelines of the manufacturer (16). Stumps under 6 in. do not require grinding. Instead, at the time of removal, the final cut on the tree is made below grade. The root system is then allowed to decompose naturally.

Trimming is performed on municipal street trees to improve form, to reduce potential hazards and to insure that the trees fit the constraints of the site. In all cases, trim work corresponds to the National Arborist Association Class II pruning specification (10). Techniques employed in doing this work

parallel those of Jacobs and Abbott (7,8).

Personnel and equipment used for each of the tasks described above are referenced in Table 1. All forestry operations follow the safety requirements outlined by ANSI Z.133 (1).

Data Collection. The establishment of a database from which to derive job performance standards was accomplished through the continuing accumulation of daily crew work history records. One of the most critical aspects of this data accumulation process was the accurate transfer of work information from the field crews to the forestry office. This transfer was made possible by well documented work cards. Information such as tree location, work type, and time over which the work occurred were carefully recorded daily by each crew leader.

Upon receipt of work cards from the field, a data entry clerk calculated clock-hours and man-hours for each job. Man-hours were totalled for each work card as a check to insure over-all accuracy of the calculation. Following tabulation of each day's work cards, date, type of work, crewleader and man-hours were transferred to the computer (Compaq 386-20) for permanent storage. Transfer was accomplished largely by keypunching or scanning work serial numbers. Scanning was done with a commercial bar code reader (E Z Barcode, Time keeping Systems, Inc., Cleveland, Ohio). Each work record was added to a field corresponding to the tree on which work was performed. The man-hours entered for a given job reflect only the time accumulated on that job. Travel and downtime are tallied; however, they are stored in a separate computer file.

The presence of overhead electrical lines was documented for each site. The height of these lines varied. Most lines were positioned between 25 and 45 ft. above the ground. Pole height was an important factor determining utility line position.

Recording the date of work allowed for the evaluation of possible interactions with season. Records were grouped by dates corresponding to the four traditionally recognized seasons.

The work history database was sorted on only twelve species. Data was gathered on additional species; however, they were excluded from the analysis because of low representation in the tree

population. Species in the database include: Norway maple (*Acer platanoides*), silver maple (*Acer saccharinum*), green ash (*Fraxinus pennsylvanica*), little leaf linden (*Tilia cordata*), red maple (*Acer rubrum*), honeylocust (*Gleditsia triacanthos x inermis*), sugar maple (*Acer saccharum*), London planetree (*Platanus x acerifolia*), callery pear (*Pyrus calleryana*), crabapple (*Malus* spp.), sweetgum (*Liquidambar styraciflua*), and hawthorne (*Crataegus* spp.).

Analysis of the Data. Work history data were collected over a 31 month period starting May 1, 1989 and concluding December 31, 1991. Statistical analysis on this experimental data set was performed using SAS/STAT statistical software (SAS Institute Inc., Cary, NC).

Analysis of variance was employed to test for differences in the dependent variable man-hours attributable to the independent variables of diameter class, species, overhead wires and season of the year. Some interactions between independent variables were examined. The Tukey-Kramer multiple comparison test was used, where appropriate, throughout the study to highlight where differences within main effect occurred.

Results

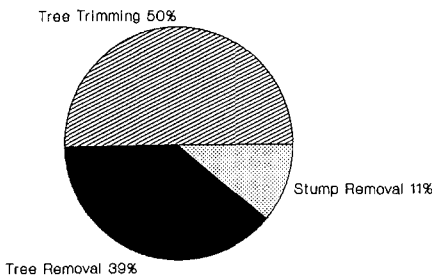
A database comprised of 6272 work records was collected from May 1, 1989 to December 31, 1991. Figure 1 presents this database in graphic format.

Tree removal and tree trimming collectively make up 89% of the records in the database. The remaining records are stump removal entries. Tree work occurred over a variety of diameter classes. However, 81% of the database reflects work performed on trees less than 25 in. dbh. This mirrors Toledo's tree population as a whole.

Twelve tree species defined the database. Fifty-six percent of the trimming and removal work was performed on two species: Norway maple, *Acer platanoides* and silver maple, *Acer saccharinum*. Ten species make up the remaining 44% of the sample.

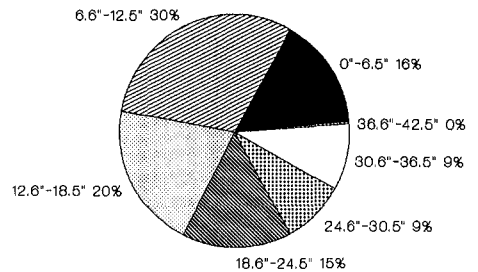
Year-round street tree care is a feature of the Toledo urban forestry operation. However, the majority of tree maintenance (64%) is performed in the summer and autumn months.

MAINTENANCE DISTRIBUTION



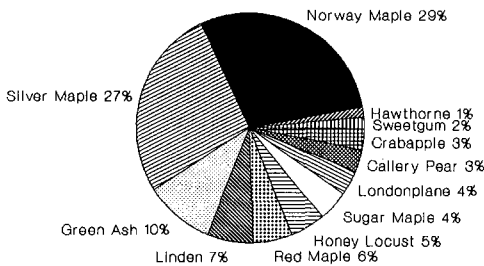
N = 6272

DIAMETER DISTRIBUTION



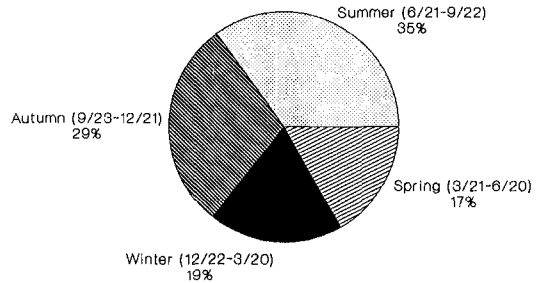
N = 6272

SPECIES DISTRIBUTION



excludes stump removal n = 5583

SEASONAL DISTRIBUTION



N = 6272

Figure 1. Graphic representation of Toledo's work history database; May 1 1989 to December 31, 1991.

The occurrence of overhead electric wires near tree removal and tree trimming assignments is indicated in Figure 2. Wires were present on slightly more than one quarter of these records. Eighty percent of the observations near wires were from trees under 25 in. dbh. Fifty-two percent of the observations on wires came from trees between 7 to 18 in. dbh.

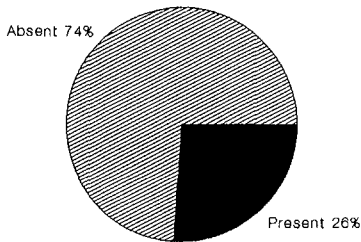
Results of statistical testing, using analysis of variance, are presented in Table 5. Mean man-hour values for each of the three work types, along with 95% confidence interval for each mean, are tabulated and presented in Tables 2 through 4. Results from the Tukey-Kramer multiple comparison test are included in Tables 2 through 4 and highlight where differences within main effects

occur.

Main Effects. Diameter class was the most influential effect. It was significant at the .01 probability level for every work type. Man-hour values, regardless of work type, tended to be positively correlated with diameter. The lone exception to this appears to be removal values for stumps under 22 in. In this particular situation, differences between man-hours were not statistically significant.

Season was also an important effect. The analysis of variance showed that season influenced all work types except trimming where its effect was not significant. Tree removal man-hours tended to be higher during the spring and summer months, particularly for trees greater than 12 in.

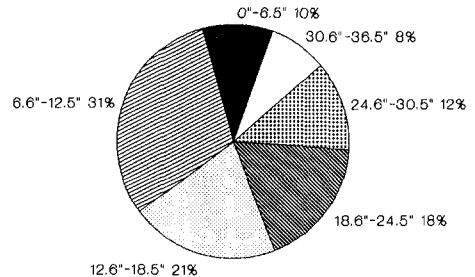
OVERHEAD WIRES



excludes stump removal n = 5583

OVERHEAD WIRES

Tree Diameter Distribution



excludes stump removal n = 1452

Figure 2. Graphic representation of Toledo's work history database as characterized by overhead wires.

dbh. Stump removal man-hours were similar in the spring, summer and autumn but tended to increase during the winter months particularly where stump diameter exceeded 15 in.

Overhead electrical wires influenced only the trimming operation. Man-hour values for trimming small diameter trees, under 12 in. dbh, tended to be similar regardless of whether wires were present or not. Values for moderate sized trees, 12 to 25 in. dbh, tended to be greater on sites where wires were absent, while values for larger diameter trees, over 25 in. dbh, tended to be greater on sites where wires were present.

Species did not significantly influence any of the work types studied.

Significant interactions between main effects occurred from both the tree removal and trimming operations. These interactions and the correlation coefficients (R^2) are noted in Table 5.

Discussion

A goal of this study was to establish man-hour performance standards for municipal crews engaged in tree maintenance. The values presented in Tables 2 through 4 are unique in that they are based on work performance over 31 months rather than speculation. There are indications that these man-hour standards could assist urban forest managers in projecting future equipment and personnel needs, in addition to assisting with the establishment of work evaluation programs.

However, it should be kept in mind that these values reflect man-hours and not actual job time. To obtain the correct job time, the man-hour value from Tables 2 through 4 must be divided by the crew size in Table 1.

An additional aim of this study was to examine how diameter class, season, species and overhead wires influenced the man-hours required by each job. Diameter class had a significant effect on man-hour values associated with tree removal, trimming and stump removal. Diameter is usually an indicator of a tree's over-all size. As trees grow and develop, their maintenance needs increase (11). Since a tree's biomass is usually proportional to its over-all size this likely accounts for the positive correlation between man-hours and diameter class.

Failure to distinguish between man-hour values of smaller stumps may suggest that a minimum set-up time, independent of stump size, may be required for each job.

Seasonal effects in the data appear strongest with regard to stump removal. The additional time needed to grind stumps in January, February, and March is likely linked to several factors brought on by colder temperatures. Frozen ground and wood undoubtedly slow the operation and may contribute to equipment problems brought on by increased vibration in the system. Locating the stump is an additional concern where snow is present. This factor, alone, could add a significant amount of

Table 1. Personnel and equipment used in Toledo's tree maintenance operation.

Work type	Diameter (dbh)	Personnel		Equipment
		No.	Pos.*	
Removal	0.0"-12.5"	1	CL	Chipper truck and chipper
		1	TSW	
	12.6"-42.5"	1	CL	54" Aerial Bucket truck and knuckle boom log loader
		2	TSW	
Trimming	0.0"-6.5"	1	CL	Chipper truck and chipper
		1	TSW	
	6.6"-12.5"	1	CL	20' Aerial bucket truck, chipper truck and chipper
		1	TSW	
	12.6"-24.5"	1	CL	35' Aerial bucket truck w/box and chipper
		1	TSW	
	24.6"-30.5"	1	CL	45' Aerial Bucket truck w./box and chipper
		2	TSW	
30.6"-36.5"	1	CL	54' Aerial bucket truck and knuckle boom log loader	
	2	TSW		
Stump removal		1	TMW	Stump cutter and one ton dump truck
		1	SEA	

*CL=Crewleader, TSW=Tree Service Worker, TMW=Tree Maintenance Worker, SEA=Seasonal Employee.

Table 2. Average man-hours required for tree removal by Toledo personnel at various times of the year.[^]

Work Type	Diameter class (dbh)	Season**			
		Spring 3/21-6/20	Summer 6/21-9/22	Autumn 9/23-12/21	Winter 12/22-3/20
Removal	0.0"-6.5" *	0.55+/-0.10	0.45+/-0.06	0.70+/-0.14	0.81+/-0.20
	6.6"-12.5"**	1.68+/-0.25	1.87+/-0.27	1.76+/-0.18	2.00+/-0.24
	12.6"-18.5"**	4.19+/-0.62	3.95+/-0.38	3.63+/-0.42	3.98+/-0.59
	18.6"-24.5"**	5.54+/-0.58	5.66+/-0.55	5.16+/-0.48	5.18+/-0.80
	24.6"-30.5"**	9.17+/-01.23	8.75+/-1.07	8.50+/-1.11	7.91+/-0.95
	30.6"-36.5"**	11.08+/-1.44	14.31+/-1.52	14.13+/-1.42	12.41+/-1.68
	36.6"-42.5"**	25.57+/-4.79	40.46+/-	18.62+/-5.38	13.71+/-4.96

**The Tukey-Kramer multiple comparison test found that seasonal values differed significantly ($P < .05$) between the following; Spring/Autumn, Spring/Summer, Summer/Winter.

*Values, within diameter class, differ significantly ($P < .05$) from values in adjacent diameter classes; using the Tukey-Kramer multiple comparison test.

[^]95% confidence interval.

Table 3. Average man-hours required for Toledo personnel to trim trees in the presence or absence of electric utility lines.[^]

Work type	Diameter class (dbh)	Average man-hours	
		Present	Absent
Trimming	0.0"- 6.5" *	0.99±0.18	0.79±0.05
	6.6"-12.5"**	1.49±0.10	1.44±0.15
	12.6"-18.5"**	2.07±0.18	2.39±0.14
	18.6"-14.5"	2.90±0.43	3.26±0.25
	24.6"-30.5"	3.69±0.70	3.38±0.38
	30.6"-36.5"**	6.24±1.58	4.43±0.50

[^]95% confidence interval.

*values, within diameter class, differ significantly (P<.05) from values in adjacent diameter classes; using the Tukey-Kramer multiple comparison test.

time to each job.

Tree removal man-hours likewise displayed seasonal effects. However, clear patterns in seasonal performance did not emerge as in the stump removal data. The presence of foliage may account for somewhat higher removal values in the spring and summer months. Foliage represents

an additional item to be hauled away from the job site and its volume may be sufficient to affect over-all job time.

The trimming operation was the only area where overhead electric wires played a significant role. Man-hour values for trimming trees under 13 in. dbh were similar whether wires are present or not. One would expect this since the trees in this category are well below the conductors, and as a result are not impacted by them. Man-hours for trimming trees between 13 to 25 in. dbh did exhibit some differences. In general, man-hours were greater in the absence of electrical wires. A possible explanation for this difference may involve trimming by utility crews. Trees of this size class are at a stage of development where their upper limbs begin interfering with electric lines. As a result they are targets for topping by the utility. Since topping significantly reduces tree biomass, subsequent trimming by municipal crews would take less time. Trees larger than 25 in. dbh took longer to trim when associated with electric utility wires. It is likely that these trees escaped prior trimming by the utility and, as such, grew within and beyond the existing conductors creating situations which warranted more thoughtful place-

Table 4. Average man-hours required for Toledo personnel to perform stump removal at various times of the year.[^]

Work type	Diameter class (dbh)	Diameter class (stump)~	Season			
			Spring 3/21-6/20	Summer 6/21-9/22	Autumn 9/23-12/21	Winter*** 12/22-3/20
Stump grinding	4.5"- 6.6	6.0"- 8.3"	0.64+/-0.14	0.80+/-0.17	— — —	1.08+/-0.82
	6.6"-12.5"	8.4"-15.2"	1.16+/-0.29	1.16+/-0.27	1.34+/-0.23	1.38+/-0.42
	12.6"-18.5"	15.3"-22.1"	1.52+/-0.35	1.40+/-0.23	1.74+/-0.30	2.40+/-1.01
	18.6"-24.5***	22.2"-29.0"	1.93+/-0.29	2.46+/-0.42	2.25+/-0.34	3.20+/-0.58
	24.6"-30.5**	29.1"-35.9"	3.29+/-0.62	3.42+/-1.12	3.39+/-0.66	3.26+/-0.53
	30.6"-36.5**	36.0"-42.8"	3.67+/-0.44	4.24+/-1.55	3.71+/-0.59	5.75+/-1.26
	36.6"-42.5**	42.9"-49.7"	10.70+/-1.37	— — —	3.25+/-4.73	9.17+/- —

[^]Values, within diameter class differ significantly (P<.05) from values in adjacent diameter classes; using the Tukey-Kramer multiple comparison test.

**Values within 18.6"-24.5" diameter class are statistically similar to those in 12.6"-18.5" diameter class. They are however, different (P<.05) from others in the data set; using the Tukey-Kramer multiple comparison test.

***Winter values differ significantly (P<.05) from spring, summer and autumn values; using Tukey-Kramer multiple comparison test.

[^]95% confidence interval.

~(Vimmerstedt, 1957).

Table 5. Results of ANOVA performed on work history data from the Toledo forestry operation, May 1, 1989 to December 31, 1991.¹

Source	Removal		Work Type		Stump removal	
	F	P	F	P	F	P
Main effects:						
Season	2.41	<.05	1.58	NS	4.94	<.01
Diameter	27.00	<.01	5.30	<.01	5.12	<.01
Wires	0.00	NS	3.85	<.05	0.26	NS
Species	1.03	NS	0.31	NS	0.45	NS
Interactions:						
Diameter*						
Wires	2.00	<.05	2.50	<.01	0.09	NS
Diameter*						
Species	1.39	<.10	1.76	<.01	0.20	NS
Species*						
Wires	0.52	NS	0.61	NS	0.43	NS
R ²		0.59		0.27		0.30

1. F. values from the ANOVA table are indicated by F while the probability that differences in man-hours, within work type, are due to chance rather than effect or interaction are indicated by P.

ment of cuts and equipment by city crews.

Previously published reports (11, 14) suggest that species may influence the time needed for various types of tree maintenance. This was not observed with the Toledo data set.

Conclusion

The purpose of examining these man-hour work records was to establish standards for Toledo's work evaluation program. It is expected that other municipal forestry operations can benefit from Toledo's experience and use this study as a basis to develop their own work evaluation system. Caution, however, needs to be used when broadly applying the data presented here to other municipal forestry operations.

Job descriptions can, and do, vary from city to city. This element could alter crew size on any given type of tree maintenance thereby affecting the total man-hours required by each job. This is a factor that must be considered by the implementing agency.

The composition of a city's tree population varies with geographic region. Failure to establish

a species effect with the Toledo data set does not imply that one does not exist for a broader geographic grouping of species. The species studied in Toledo are common components of urban forests in the Midwest and northeastern United States. The conclusions reached in this report regarding species are only valid for the species group studied.

Consideration also needs to be given to the model itself. Our model accounts for variation brought on by differences in diameter class, season, species and overhead electric wires. In all work types, factors other than those in the model account for a significant portion of the variation in man-hours. Work is on-going to see what role crew and day of the week play in affecting the time needed to complete tree maintenance.

It has been suggested that the trimming standards may be affected by a history of prior trimming at a given site. At present, our database contains only information on initial trim work. As this database grows and begins to accumulate return visits, the relationship between cyclic pruning and existing standards can be more accurately evaluated.

It is hoped that this study has provoked thought and that it will stimulate discussion, positive or negative, on the subject of municipal tree care operations.

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Résumé. Une base de données composée de 6272 dossiers de travail en régie municipale, réalisés sur une période de 31 mois, était analysée pour établir des normes de productivité selon les diverses activités d'entretien des arbres. Le nombre d'heures-homme requis pour l'abattage, l'élagage et l'essouchage y est présenté. Les interactions entre le nombre d'heures-homme requis et, le diamètre, la saison de l'année, les réseaux électriques, l'espèce, furent examinées. Le diamètre influence tous les types de travaux; la saison, l'abattage et l'essouchage; et les réseaux électriques aériens, les opérations d'élagage. L'espèce de l'arbre exerce aucune influence sur les divers de travaux de cette étude.

Zusammenfassung. Einen Datenbestand über 6272 kommunale Arbeitsaufzeichnungen aus einem Zeitraum von 31 Monaten wurden analysiert, um die Leistungsnormen verschiedener Arbeitsgänge der Baumpflege festzustellen. Die arbeitsstunden, die für Baumentnahme, Astung, und Stubbenentfernung benötigt wurden, werden vorgestellt. Wechselwirkungen zwischen den benötigten Arbeitsstunden, Durchmesser des Baumes, Jahreszeit, elektrische Oberleitungen und Baumarten wurden untersucht. Der Durchmesser beeinflusste alle Arbeitsarten. Die Jahreszeit war ohne Einfluß für die Baumentnahme und die Stubbenentfernung. Elektrische Oberleitungen beeinflussten die Astungsvorgänge. Die Baumart beeinflusste keine der beobachteten Arbeitsweisen.

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