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Influence of mechanical damage on the condition of trees

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Abstract: *Influence of mechanical damage on the condition of trees.* The aim of this work is to determine critical values (levels) at which mechanically damaged trees die in shorter or longer time. It is also the authors' intention to determine the extent and type of damage which makes the tree lose a given part of its value. In order to do so, a number of methods most commonly used (in Poland and abroad) to determine the influence of mechanical damage on trees were compared. The damage might be inflicted on different parts of the tree: root system, trunk or head. The marking of tree condition differs depending on the place where the damage was inflicted. The reaction of a tree to damage may be immediate or postponed even for many years, which depends on many factors, mainly tree species, time of damage and the tree's development phase.

Key words: trees, mechanical injures, tree vitality, stress factors, tree health condition, critical value.

INTRODUCTION

An often cause of tree destruction in municipalities is mechanical damage to the trunk (e.g. by cars parked nearby), roots (during excavations) and the head (cutting the thick trunks). An important cause of the mechanical damage, apart from traffic, are construction works and excavations carried in the vicinity (Coder, 2000; Kosmala, 2001). Construction works and the way they are carried out are an important, though often neglected, factor contributing to weakening the tree's condition and its premature death. Not only do those factors have negative influence on the tree, they may also completely destroy the underground environment of the room system (Szczepanowska, 2001). The damages and deteriorated condition caused by construction works depend also on the extent of damage, length of exposure and time of works. Another factor is the fact whether protective measures had been employed during the course of works and nurture techniques employed after completion of works.

As a result of mechanical damage the tree is hurt. Where necrosis occurs the trunk ceases to grow and exposed wood is a way for fungi spores and harmful insects to infiltrate. The final result is deformation of the trunk and often widespread decay, which significantly deteriorates the tree's vitality (Stebnicka, 1951). Damage locations are the main way through which pathogenic elements pene-trate the tree (Kryczyński, 2005). In case of conifers resin blisters may form which reduce the tree's flexibility up to 15% (Krzysik, 1975). According to many authors, the presence of cancers and damages (wounds) covering more than 1/3 of the trunk's circumference signifies

serious damage to the tree (Kane and Ryan, 2002). It is commonly accepted that a damage covering more than 50% of the trunk's circumference constitutes serious threat of damage or danger of the trunk or a branch being broken. As such, they require immediate intervention (Johnson, 1981; Coder, 1996; USDA Forest Service, 1996).

The results of damages are immediately noticeable but usually the can be perceived only after several years and depend on many factors such as the extent and duration of damage, regenerative capabilities and development stage of the tree. The tree's reaction may also take place after several decades when the tree dies due to its vital powers being exhausted (Coder, 2000). Postponed reactions are most common and thus they are most difficult to be identified as the cause of the tree's death. The borderline between total destruction of a tree and a damage which can be still handled by the tree's organism is not very clear and therefore it is necessary to define auxiliary criteria to evaluate the extent of damage and critical levels at which the tree dies.

RESEARCH METHOD

This work includes an analysis of factors which are crucial in evaluation of mechanical damages to trees. The type and frequency of occurrence of the features relevant to the employed methods was analysed. An attempt was made to determine what extent of damage to particular tree parts influences its overall condition and where is the critical level (borderline) which, when reached, cause the tree to die shortly or within several years. Having compared critical levels, that is the borderline percentage values of lost tissue, at which the tree is completely damaged and thus dies, a median of critical levels was defined for each of the tree parts subject to research: ratio of damage to the head, ratio of horizontal loss of bark and cambium and ratio of lost root mass. Apart from critical levels, percentage range of tree tissue damage was defined and corresponding decline of the tree overall condition. The results were used to make a chart depicting gradual decline in the tree's overall condition depending on the extent of damage.

Twelve methods of evaluation were subject to analysis including five Polish methods and seven foreign methods. The analysed methods have been for many years a part of the tree evaluation procedure, including the Koch method, the method used Vereinigung Schweizerischer Stadtgärtnereien und Gartenbauämter (VSSG) as well as methods used in the USA: Best Management Practices (BMPs), Construction Damage Assessment (CDA), and Damage Evaluation used by the International Society of Arboriculture (ISA). In case of the methods mentioned above, mechanical damages which occurs as an singular event are evaluated as an auxiliary factor helpful in the process of tree evaluation. The systems of damage assessment suggested in Bernatzky (1978), Supłat (1992), Borecki and others were also analysed (1992), Pacyniak and Smólski (1992), Duda (1994), Dmyterko et al. (2005).

RESULTS AND DISCUSSION

The research has shown that the author consider mechanical damage to the root system to be the most serious, the next is damage to the trunk (Tab. 1). Damage

to the head is considered to be of lesser importance CDA, BMPs, VSSG, ISA.

The head is evaluated as a whole or an acceptable ratio/number of dry branches, number of damages, thick branches under the head, etc. are analysed. Koch's method (1997) introduced the division between head parts subject to evaluation. Damage to the area of little twigs is considered to be of lesser importance, damage to thick branch zone is not taken into consideration in case of well-regenerating tree species while the zone of thick branches and trunk base is evaluated in every case since it is crucial to the tree's overall condition. In case of damage to the trunk, especially its base or the bases of main branches is often thoroughly inves-

TABLE 1. Comparison of mechanical tree damage with their frequency of occurrence in the analysed methods

Analyzed feature	Frequency of incidence
ability to remove a damage to the tree through the pruning shortening of potential tree age factors overlapping water availability barriers to the shape of the root system wood damage evaluation damage evaluation of low part of trunk damage evaluation of root collar	>10%
damage evaluation of whole tree duration of a damage storage of construction materials soil compaction raising the soil level removing the out soil trunk deformation core branches damages under the crown eveluation	>25%
tree response time on the damage bark and phloem damage evaluation of crown damage extent	>35%
long-term damage observation (5–6 years)	>50%
hierarchy of damages branches damage evaluation	>60%
evaluation of roots area damage extent evaluation of trunk damage extent	>70%
	10 20 30 40 50 60 70 80
Considered features/defects	Percentage number of methods, where the feature was considered.

tigated and the significance of damage to bark and cambium is emphasised. In most cases the ratio of damage area is considered (root system, wound area as compared to trunk circumference or the size of dead part of the head).

Other methods of evaluation (depending on the number of dead branches, acceptable number of wounds and damages as well as events ordered into categories according to their significance) do not seem to be precise enough, since there is little information or possibility to evaluate the extent of the event and the parts of the tree it influenced.

It is worth considering that certain methods (CDA i VSSG, Damage Evaluation and Koch's method) require that the damaged tree be monitored. In two of them there is a 5÷6 year's follow up observation period during which symptoms of the tree's death may be identified. It is due to the fact that mechanically damaged trees may become so called "problem trees" because there is not always a possibility to improve their habitat conditions, manage the damage results or diminishing their effects. Koch's method emphasises the fact that, according to the latest state of knowledge, the extent of measures undertaken immediately after the damage occurrence should be limited. Firstly, the tree must be given a chance to make its own reactions to the damage and only later appropriate measures must be employed (Breloer, 2001).

It seems justified to claim (Koch, 1979) that the evaluation of mechanical damage influence based solely on the ratio of tree tissue loss since different tree species exhibit different regenerative capabilities and their different development stages (a tree up to years after planting, a young tree, an adult tree and an ageing tree). Those factor must be taken into consideration every time the damage is evaluated. Damage evaluation focused exclusively on damage and the percentage of damaged tree part may be employed only in special situations and only if the loss ratio must be reliably evidenced. It may concern only light and simple tree damage.

Below, a characteristics of features included in mechanical damage evaluation may be found together with their frequency of occurrence in the analysed methods.

As it was mentioned before, the tree parts most frequently included in damage evaluation are the trunk and root system (70% of analysed methods). However, the significance of damages is not the same – in the CDA method in case of 30% damage to the root system it is recommended to remove the damaged tree. When the damage covers 50% of the trunk circumference it is considered to cause the tree's death. The authors consider damage to branches to be of lesser importance. This is probably due to the fact that trees have the ability to regenerate branches to different extents.

In order to determine the critical levels, the decrease in tree's overall condition resulting from mechanical damage was analysed as well as their extent compared to the size of the tree top, trunk and roots (Tab. 2).

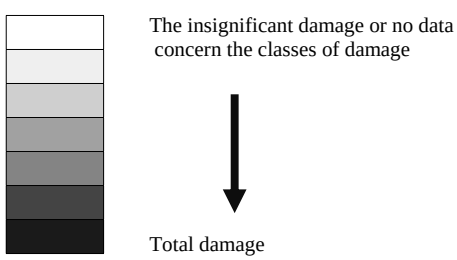
Authors (Mattheck, Breloer, 1994; Reinartz and Schlag, 1997; Coder and others, 2000) distinguish between three basic types of tree damage: (a) damage to the roots (b) damage to the trunk and (c) damage to branches and wigs. In risk evaluation methods there are two main damage types:

TABLE 2. Comparison of critical levels of the main factors of the analysed tree condition evaluation methods

Compared feature: damage/loss of leaves (or crown, alternatively)										
	Evaluation in percentage									
	0–10	1–20	20–30	30–40	40–50	5–60	6–70	70–80	80–90	90–100
Supłat, 1991		> 15			< 50				> 85	
Borecki i in., 1992	> 10			> 25			> 60			
Pacyniak, 1992	< 10	> 10		> 30		> 50		> 70		
Anonim, 1993		< 20		> 25	> 35	> 45				
Duda, 1994	< 10	> 10		> 25		> 50			> 75	
VSSG, 1991					< 50	> 50				
Koch, 1997		< 20				> 50				
ISA, 2007		< 25			< 50	> 50				
Bernatzky, 1978						> 50				
Dmyterko i in., 2005	< 10	> 10		> 25			> 60			
Compared feature: trunk damage										
Pacyniak, 1992	> 10			> 30		> 50			> 75	
Anonim, 1993*		> 10	> 20	> 30	> 40	> 50	> 60		> 75	
VSSG, 1991	< 10					>5 0				
ISA, 2007		< 2 5			< 50	> 50				
CDA, 1995			< 30	> 30						
Bernaztky, 1978		> 20		< 40		>50				
Duda, 1994	> 10			> 25		> 50			> 75	
Compared feature: roots damage										
VSSG, 1991	< 10				> 40					
Koch, 1997	< 10				> 40					
ISA, 2007		< 25			< 50	> 50				
Anonim, 1993	< 10	> 10	> 20	> 30	> 40	> 50				

*Critical levels of trunk damage depend on the breadth of the wound but also on its depth and height.

Consecutive classes of tree vitality – from insignificant to total damage



- Partial failure – causing the object's (tree's) inability to perform certain, but not all, necessary functions.
- Critical failure – causing the tree's death or downfall, creating danger to people, causing significant material damage or other unacceptable results.

Below there is a chart presenting the results of analysis of deteriorating tree condition depending on the extent of damage to the treetop, trunk or roots (Fig. 1). The chart also includes percentage of lost tissues which causes the tree's total destruction as soon as the damage occurs or its death within certain time.

CONCLUSION

Mechanical damage causes decrease in tree value. As a result of damage to their permanent parts, and resulting damage to the whole tree organism, the tree is weakened or even dies.

Mechanical damage may be related to branches, trunks and such parts are most often considered in the analysed methods. The extent of losses is initially proportional to the damage ratio. In case of larger damages, the losses and tree devastation are more extensive than the proportion of the loss ratio. Such disproportions are confirmed by the analysis of biological and structural results of mechanical damage in the overall tree condition.

Analysis of the method of damage influence on the condition of trees has shown that, although the influence differs between individual cases, common characteristics may be identified and common conclusions concerning the importance of damage may be made. As the research has shown, in case of mechanical damage to the treetop, the critical level is 55% of branches and wigs, in case of bark and trunk cambium the critical level is more than 50% of the trunk circumference, while in case of damage to the root system, a damage or removal of more than 45% of the system is considered critical.

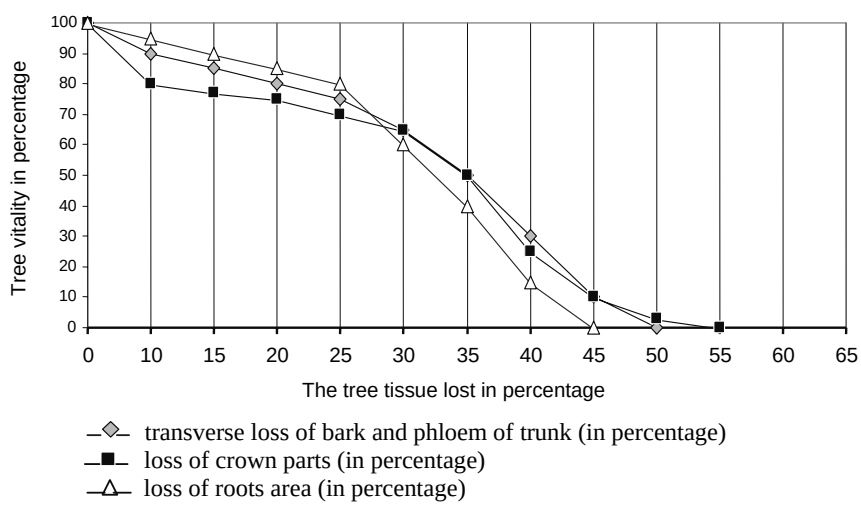


FIGURE 1. Decline of the tree value caused by damages of roots, bark, phloem and crown, applied in VSSG method (1991) and Koch's method (1997), modified

In case of mechanical damage, except for the evaluation of the percentage cambium loss, it is important to consider regenerative capabilities of a given tree species and its development stage. Since the results of damage may be postponed, it is necessary to introduce monitoring and its duration should be determined based on the evaluation of all factors mentioned above.

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Streszczenie: *Wpływ uszkodzeń mechanicznych na kondycję drzew.* Uszkodzenia mechaniczne wiążą się bezpośrednio z kondycją drzewa, jego walorami estetycznymi i często są przyczyną zagrożenia. Przyczynami uszkodzeń mechanicznych drzew są roboty budowlane, drogowe i sieciowe, wypadki komunikacyjne, akty wandalizmu oraz klęski żywiołowe. Szkody mechaniczne mogą być również spowodowane przez nieprawidłową pielęgnację, zwłaszcza przez wadliwe cięcie konarów oraz ogławianie, także w rezultacie kolizji budowlanych. W związku z tym, że trudne jest stwierdzenie, jak duże uszkodzenie powoduje śmierć drzewa w krótkiej lub oddalonej perspektywie czasu, w niniejszej pracy podjęto próbę określenia kryteriów pomocniczych w ocenie wagi uszkodzeń mechanicznych, takich jak wartość krytyczna utraty tkanek drzewa, której przekroczenie powoduje w efekcie jego śmierć oraz zdefiniowanie innych istotnych czynników wpływających na osłabienie kondycji drzewa i w rezultacie jego obumarcie. Wyniki badań sugerują, że największe znaczenie dla zachowania wartości drzewa ma obecność zdrowego, nieuszkodzonego systemu korzeniowego. W dalszej kolejności autorzy przypisują istotną rolę stanu pnia. Nieco mniejsze znaczenie w ocenie kondycji drzewa przypisuje się uszkodzeniom korony, ponieważ organ ten ma największy współczynnik regeneracji.

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