ASSESSING CONSTRUCTION DAMAGE:

TREE DAMAGE EXPOSURE VALUES AND RECOVERY TIMES

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One of the most important aspects of assessing construction damage to trees is the amount of time development activities occur on a site. Both the absolute time span and the timing of damage in comparison to tree growth patterns are critical to assessing damage and estimating recovery times. Use of a construction damage timing table is both a method of training new assessors and a means of quantifying potential extent of damage to trees.

Each tree, site, and development type interact in unique ways across time. In addition, construction activities occur in progressive waves and can be seasonal. Construction damage to tree and sites are highly variable. This assessment system can help teach development planners and construction professionals about the general timing of tree damaging actions. This assessment system must be modified to the specific circumstances of any site. It is important that tree-literate professionals familiar with construction activities are used in any assessment.

The first step in assessment is developing a time-line of events. The time-line starts when construction begins on a site. This corresponds to the first soil movement, soil compaction, machinery use, or tree injury events. In forested areas, pre-development tree harvesting begins the tree damage time-line and could be considered a separate, earlier event for assessment if enough time has past. The time-line ends when the last site or tree-altering event has been completed (**i.e.** final installation of landscape).

Tree damaging events associated with construction could commence during any of the four tree growth seasons. Determining the specific tree growth season when construction activities begin is important because trees are more susceptible to injury, and may demonstrate poorer reactions to change during some seasons of the year than at others seasons. An example time-line is given in Figure 1 from which assessment timing counts can be made.

Understanding and delineating tree growth seasons are essential for assessing potential damage on the site from construction activities. For assessment purposes, the life of a tree is separated into four seasons. In each season the tree responds to the environment and has some internal level of reactivity to site changes and injury. The individual tree growth seasons that will be used here are dormancy, the first portion of the growing season, the second portion of the growing season, and a senescence season. Year after year, the tree follows this pattern with one season preparing the way for

the next. Note that in some areas, dormancy is not brought about by winter, but by a dry season or simply a resting stage in development. Definitions of tree growth seasons for use in exposure timing are given below:

Figure 1: Example time-line for calculating potential damage exposure timing for trees on construction sites.

		Four Tree Growth Seasons		
YEAR #l	‘dormancy	first portion of growing season	second portion of growing season	senescence
YEAR #2 :	dormancy	first portion of growing season	second portion of growing season	senescence
YEAR #3:	dormancy	first portion of growing season	second portion of growing season	senescence
YEAR #4:	dormancy	first portion of growing season	second portion of growing season	senescence
YEAR #5:	(etc.)			

The “dormant season” in trees is the span of time from the loss of leaves / existence of resting buds / cool weather / precipitation limits on growth, until the buds and growing points undergo noticeable changes, which would include swelling in preparation for elongation growth. The dormant season is preceded by the senescence season.

The next season in tree growth is called the “first portion of the growing season.” This season represents the active shoot elongation period. Defining this season depends upon tree growth patterns and wood architecture. The first portion of the growing season in ring porous or gymnosperm trees is the time span from the first noticeable change in buds (swelling, bud-break, or major color change) until the leaf blades are fully expanded, the shoot has elongated, and the new resting or terminal vegetative bud(s) is formed. The first portion of the growing season for diffuse porous trees is the time span from the first noticeable changes in buds (swelling, bud-break, or major color change) until the final set of leaf blades for this growing season are fully expanded (the shoot may continue to elongate over the rest of the season.)

The "second portion of the growing season” can be considered an active growth period between shoot elongation events. This tree growth season is the time span from the end of the first portion of the growing season defined above, until the first leaf color change events (fading, color unveiling, and color generation) begin. The second portion of the growing season is a period of time dominated by diameter growth in the stem, branches, and roots.

The “senescence season” is a time span from the end of second portion of the growing season (as defined above) when leaf color change events (fading, color unveiling, and color generation) begin, until all above-ground growth has ended and the deciduous leaves are dead. The dormant season follows the senescence season.

This assessment process develops a “Tree Damage Exposure Value.” This Exposure Value is determined by establishing a time-line for beginning and ending construction activities on a site.

Components of the Tree Damage Exposure Value include the number of different tree growth seasons the construction activities have spanned, which season construction activities began within, which season construction activities ended within, and how many full years have been involved in the construction process.

The easiest way to appreciate this process is to mark on the time-line (in year one) when construction activities began. Construction could have began in any of the four tree growth seasons in year one. Next mark the season (in the correct year) when construction activities ended. This assessment system requires the number of tree growth seasons impacted from start to end to be counted and scored.

Each specific tree growth season signifies tree susceptibility to some varying degree from construction damage. The relative difference among tree growth seasons in tree susceptibility to construction damage has been defined as: dormant season = 1; first portion of the growing season = 12; second portion of the growing season = 9; and, senescence season = 3. These relative points by season add up to a full year being valued at 25 points and a-full growing season valued at 24 points.

In addition to the number of different tree growth seasons affected, the tree growth season when construction damage commenced and ended also play a role in assessing relative construction damage. Penalties are assigned for beginning or ending construction in a particular tree growth season.

The final assessment factor concerns the total number of years a site and tree are exposed to construction activities. Potential injury is not simply additive, but escalates with the passage of time and the site remaining open to construction activities.

Below is the assessment outline and scoring system for determining the Tree Damage Exposure Value on a construction site. Table 1 provides a calculated Tree Damage Exposure Value.

TREE DAMAGE EXPOSURE VALUE COMPONENTS

1) SEASON INFLUENCE (whole or part of season affected by construction)

- full year (GS 1 +GS2+SENC+DORM) = 25
- dormant season (DORM) = 1
- full growing season (GS 1 +GS2+SENC) =24
  - first portion growing season (GS 1) = 12
  - second portion growing season (GS2) = 9
  - senescence season (SENC) = 3

2) SEASONAL STARTING PENALTY (season when construction began)

- dormant season (DORM) = 0
- first portion growing season (GS 1) = 6
- second portion growing season (GS2) = 4
- senescence season (SENC) = 2

3) SEASONAL ENDING PENALTY (season when construction ended)

- dormant season (DORM) = 0
- first portion growing season (GS 1) = 6
- second portion growing season (GS2) = 0
- senescence season (SENC) = 0

4) MULTIPLE-YEAR PENALTY (unreactive / dormant period lay-overs)
-- multiply the summed results of preceding three steps by (1 .05years)
examples: 2 years = 1.05^2 = 1.10
3 years = 1.05^3 = 1.16
4 years = 1.05^4 = 1.22

5) YOU HAVE NOW COMPLETED THE FOLLOWING FORMULA:

TREE DAMAGE EXPOSURE VALUE =
(SEASON INFLUENCE NUMBER +
SEASONAL STARTING PENALTY NUMBER +
SEASONAL ENDING PENALTY NUMBER) X
MULTIPLE-YEAR PENALTY FACTOR.

RECOVERY TIMES

Construction activities usually move steadily, if not quickly, to a conclusion. The biology of the site is pushed along as resources availabilities, absolute amounts, and rates of change in resources are modified and/or disrupted. There is rarely adequate time for a tree to adjust appropriately to site changes and injury. Tree responses are not proactive but generate responses to information provided by its sensors and growth control system. Responses are designed for the present moment and immediate past. Unfortunately, both the sensor systems and response systems in a tree have significant time delays present before application begins. The tree, outside its genetic contingency table for seasonal effects and naturally selected processes, reacts on a moment by moment basis to past changes in resource availability. At times, this delay can represent one tree growth season in the past or last year's growing season.

Once the construction damage exposure timer has been used to determine relative tree damage from construction activities (Table l), the recovery time must be calculated. Recovery time begins when construction activities end on a site. Landscape disruption and installation are the final parts of construction on a site and can be extremely damaging, especially to any mature trees present. When the last machinery has left the site and the landscape and hardscape are completely installed, recovery time can begin.

Recovery timing uses the same time-line (Figure 1) as the construction damage exposure timer (Table 1). For each tree growth season affected by construction activities, a specific length of recovery should be observed. From the moment of injury, the recovery timing begins. Because of tree biology, recovery time periods are not additive, but run concurrently as each tree growth season is affected and grown past.

Recovery times for each tree growth season impacted by construction activities are:

A) Dormant season (DORM) = 1 year;
B) Senescence season (SENC) = 2 years;
C) Second portion of growing season (GS2) =
3 years plus time to the end of the growing season;
D) First portion of growing season (GSl) -- diffuse porous =
3 years plus time to the end of the growing season;
E) First portion of growing season (GS 1) -- ring porous / gymnosperms
4 years plus time to the end of the growing season.

The recovery period in trees begins when the active damage accumulation period ends. From that moment on, changes in site resources, tree injuries and the tree's reaction to internal and external changes determine the efficiency and success of recovery. Tree response generation can actually lead to major resource allocation problems. These "mistakes" by the tree arise from its never having been designed for these types of site disturbances and injury events. Tree response generation is targeted at immediate problems from some period in the immediate past compounded by limited structural and biological solutions to some problems. Immediate death, and relatively rapid decline and death are the biological consequences of site disruptions and tree injuries.

By the end of the next full growing season after site disruption and injury, trees with diffuse porous architectures -- or by the end of the second full growing season in trees with ring porous or gymnosperm architectures -- should be reacting to present site resource and tree injury levels. At the time when responses to direct disruption and injury is ending, active resource control processes and new crown / root renovations are beginning.

Continued decline is possible as the tree attempts to control space and other natural resources with what ever carbon (food) is available. Decline include accelerated shedding of tree parts, increased heartwood formation, indiscriminate and unorganized release of growth control, smaller annual growth rings, less starch storage, failure to capture vital resources of the quality and quantity needed, reduced living tissue volume, and loss of physical space.

The active resource control period in a tree concentrates around new capacity building, internal reallocation of resources to new areas, shedding of tree parts, reduced living tissue volume, generation of new food and resource acquisition structures, tighter growth control, and tuning growth to current conditions.

CONCLUSIONS

The final use of exposure timing and recovery timing information in assessing construction damage revolves around five items, only the first two are covered in this publication:

1) How long a tree is exposed to potentially damaging construction activities.
2) Recovery period required after construction activities have ended.
3) Summary of injury severity and site disruption by individual tree growth season.
4) Sensitivity and tolerance of the site to disturbance.
5) Limitations and availability of essential resources for tree growth as modified by construction activities.

Construction activities are important to society and individuals. All the resources and living things on a site (or that can colonize a site) are either helped, hurt, or not effected by site changes. Most things damaged or disrupted on a site are repairable with labor, time and economic inputs. Large and established trees can be permanently damaged, and as such, are not truly replaceable nor repairable. These once-damaged trees can generate further problems in the future as injuries become compounded by tree growth reactions and liability risks increase. We will have construction activities, but we need to protect a tree's structural quality and biological quality of life. Tree-literacy is critical to living with and among trees in our built-up environments.

Table 1: Tree Damage Exposure Values.

To determine a Tree Damage Exposure Value, begin at the top of the table and identify when construction activeties began on the site (by tree growth season). Next move downward in the appropriate starting column until you reach the row representing the end of construction activities on the site. The number presented is the "Tree Damage Exposure Value." Abbreviations: DORM = dormancy season; GS 1 = first portion of growing season; GS2 = second portion of growing season; SENC = senescence season.

	CONSTRUCTION BEGINS			
CONST. ENDS	YEAR 1 DORM	YEAR 1 GSl	YEAR 1 GS2	YEAR 1 SENC
YEAR 1 DORM	1	_-	---	-_
YEAR I GSl	18	24	__	-_-
YEAR 1 GS2	22	27	13	__
YEAR 1 SENC	25	30	16	5
YEAR 2 DORM	29	34	19	7
YEAR 2 GSl	48	54	39	26
YEAR 2 GS2	52	57	42	30
YEAR 2 SENC	55	61	45	33
YEAR 3 DORM	59	65	60	36
YEAR 3 GSl	80	86	70	57
YEAR 3 GS2	84	89	73	60
YEAR 3 SENC	87	93	77	64
YEAR 4 DORM	93	99	94	68
YEAR 4 GSl	115	121	104	90
YEAR 4 GS2	118	124	107	94
YEAR 4 SENC	122	128	111	98