Unit 19: Understand the Principles of Tree Science

Unit code: M/601/0407

QCF Level 3: BTEC National

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit aims to provide learners with an understanding of tree science and how these can be put into practice. This unit is primarily aimed at learners within a centre-based setting looking to progress into the sector or to further education and training.

Unit introduction

Studying tree science will develop learners' understanding of tree growth and development in a range of environmental conditions. Within the unit the integration and application of tree science into arboricultural practice is emphasised to enhance the decision-making skills required in tree management. A holistic and contextualised approach to tree care will be encouraged and learners will study complex tree management scenarios.

Learning outcomes

On completion of this unit a learner should:

1 Understand how trees respond to changes in environmental conditions

2 Understand ill health and decay processes in trees

3 Understand wound response in trees

4 Understand tree biomechanics and structural assessment.

Unit content

1 Understand how trees respond to changes in environmental conditions

Tree growth and development: fundamental requirements for tree growth; primary and secondary growth

Tree morphology: above and below ground tree structure; principle root morphology types; excurrent and decurrent crown morphology, multilayered and monolayered canopies

Tree response to environmental stress: drought, flooding, cold tolerance; phenological response; adaptive rooting strategies; adaptive leaf strategies; carbohydrate accumulation; avoidance versus adaptation

Management of tree growth by modification of environment: irrigation, soil nutrition management (soil pH adjustment, fertilisation and mycorrhizal inoculation), soil and rhizosphere amelioration (mulching, radial mulching, vertical mulching, root invigoration, soil decompaction using compressed air (eg pneumatic air tools, terravent))

2 Understand ill health and decay processes in trees

Causes of ill health in trees: mammalian damage; insect damage; fungal colonisation and development; bacterial infection

Wood structure and decay processes: white rot; brown rot; soft rot; lignin and cellulose degradation

Physiological impact of ill health in trees: a range of abiotic and biotic causes of ill health; diminished photosynthetic capability, resource competition, root damage, active pathogenesis

Decay detection: visual tree inspection (VTA); decay detection equipment; the systematic evaluation of data to assess the potential of tree failure

Management of decay in trees: removal; pruning; tree health promotion; habitat promotion and conservation arboriculture; tree support systems

3 Understand wound response in trees

Anatomical features of wood: tracheids; resin ducts; vessel elements; fibres; axial parenchyma; radial parenchyma; vascular cambium; earlywood and latewood; ring and diffuse porous wood; growth layers; growth rings; transverse, radial and tangential sections

Tree response to wounding and decay: physiological impact of flush cuts, stub cuts, internodal cuts, reduction cuts and natural target pruning on tree response to mechanical wounding; wound occlusion; tree response to fungal colonisation with a focus on the Compartmentalisation Of Decay In Trees (CODIT) model

Current pruning practices: natural target pruning; reduction cuts; pruning of co-dominant stems; British Standard 3998 Recommendations for Tree Work

Arboricultural operations and their impact on tree growth, development and performance: impact of pruning operations; soil and rhizosphere amelioration and integrated support systems (bracing, propping and guying)

4 Understand tree biomechanics and structural assessment

Biomechanical theory: the principle of minimum lever arms; the axiom of uniform stress

Tree assessment for failure potential: basic visual tree analysis (VTA); integration of decay detection instrument data to tree management decisions

Implications of mechanical failure of trees: mechanical injury; basic tree risk assessment based on potential targets

Supporting weak tree structures: bracing, propping and guying

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe how trees adapt their growth and development to their environmental conditions	**M1** explain how tree decline can be related to specific environmental conditions	**D1** describe tree healthcare operations which moderate tree decline and promote tree vitality
P2 explain how selected environmental conditions can be altered to influence tree growth		
P3 explain how environmental conditions can increase susceptibility of trees to decay and mechanical failure [IE]		
P4 describe potential causes of ill health in trees	**M2** analyse the physiological impact of identified abiotic or biotic causes of ill health	
P5 explain how decay processes influence structural strength of trees		
P6 explain how decay detection can be used to assess potential tree failure		
P7 outline potential actions to manage decay in trees [CT]		

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P8 identify anatomical features in wood	**M3** explain how arboricultural operations impact on tree growth and development	**D2** describe the habitats which can be associated with structural defects and wounds in trees.
P9 explain growth and defence processes in trees in response to wounding and decay		
P10 explain how current pruning conventions relate to wound response in trees		
P11 explain current biomechanical theories explaining mechanical strength and integrity of trees	**M4** make specific tree management recommendations which will reduce the risk of mechanical failure.	
P12 evaluate how trees are assessed for potential mechanical failure		
P13 outline the implications of mechanical failure for tree management [RL]		
P14 describe how weak tree structures can be appropriately supported.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Delivery of this unit will involve practical and written assessments, visits to suitable collections and will link to work experience placements.

Tutors are encouraged to use a wide range of delivery methods, including lectures, discussions, seminar presentations, site visits, supervised fieldwork, internet and/or library-based research. Learners should also have access to a virtual learning environment (VLE) which will promote independent learning, provide a vehicle for learner differentiation, a store for lecture notes, self-assessment activities and links to online resources. Delivery should stimulate, motivate, educate and enthuse learners.

Visiting expert speakers, either internal or external, should form part of delivery, for example, an arboricultural consultant, local authority tree officer, arboricultural contractor or academic specialist.

Health and safety issues relating to the study and inspection of trees (which may be structurally unsound) throughout the year must be stressed and reinforced regularly. Risk assessments must be undertaken before any site visits or practical activities using any items of equipment. Adequate personal protective equipment (PPE) must be provided if this is industry best practice.

Due to the seasonal nature of tree growth processes and development, learners should be given the opportunity to study trees throughout the year.

Tutors are encouraged to consider integrating the delivery, private study and assessment for this unit with other relevant units and assessment instruments learners are taking as part of their programme of study.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan gives **an indication of the volume of learning it would take the average learner** to achieve the learning outcomes. It is **indicative and is one way of achieving the credit value**.

Learning time should address all learning (including assessment) relevant to the learning outcomes, regardless of where, when and how the learning has taken place.

Topic and suggested assignments/activities and/assessment
Tree growth and development. Core lectures in combination with the observation of trees at different stages of maturity.
Assignment 1: Tree Growth, Wood Anatomy and Causes of Ill Health in Trees (P1, P4, P8)
Observation of trees growing in various environmental conditions and ecological niches. This should include trees in urban environments.
Experiments designed to illuminate tree growth responses to a range of different environmental conditions (eg drought, temperature extremes, waterlogging, shade). Seedling development under alternative environmental conditions monitored throughout the unit.
Field study or site visits to develop understanding of the environmental conditions which accelerate tree decline.
Wood workshop. Core lecture followed by a workshop which uses wood samples, prepared wood microscope slides and microscopes.
Core lecture on principles of ill health in trees supported by field exploration.

Topic and suggested assignments/activities and/assessment
Core lecture on tree response to abiotic conditions and damaging biotic agents. Assuming season allows, specific examples should be investigated in the field.
Core lecture on tree biomechanics supported by site visits to trees displaying reduced lever arms, reaction wood and wound occlusion.
Assignment 2: Management Recommendations for Mature Trees (P2, P3, P5, P6, P7, P9, P10, P11, P12, P13, P14, M1, M2, M3, M4, D1, D2)
A series of workshops and seminars on tree healthcare operations which may include good pruning practice, bracing and supporting trees, mulching, soil decompaction, radial mulching and root invigoration.
Workshop developing practical skills in decay detection and evaluation.
Core lecture and field investigation into the features of post mature trees and the niche habitats they provide.
Independent learning structured using the assessment criteria.
Unit review.

Assessment

To achieve P1, learners must identify three different specific environmental conditions and describe a range of ways in which some trees can modify their development to aid survival or make them more competitive. The environmental conditions may be local, associated with an ecological niche or determined by regional climate. Evidence could be in the form of a factsheet or leaflet produced by the learner and oral responses to tutor questions, recorded on a suitable pro forma by the tutor.

For P2, learners must explain how selected environmental conditions can be modified to influence growth. For example, water deficit by irrigation, nutrient depletion –by fertilisation or soil amendment and modification. Evidence could be in the form of a written report.

To achieve P3, learners must explain how abiotic stress can increase the susceptibility of trees to decay and mechanical failure. Evidence could be in the form of a written report.

To achieve P4, learners must identify and give a brief description of potential causes of ill health in trees. These may include biotic causes, for example mammals, birds, insects, fungi, bacteria and viruses, or abiotic causes, for example soil compaction, soil contamination, pH extremes, water deficits and temperature extremes. Evidence could be in the form of a factsheet or leaflet produced by the learner and oral responses to tutor questions, recorded on a suitable pro forma by the tutor.

For P5, learners must identify the main structural components of wood (cellulose and lignin) and distinguish between the decay processes of brown and white rots. Evidence could be in the form of a written report.

To achieve P6, learners must explain contemporary methods of decay detection and how they can be used to assess potential tree failure. Evidence could be in the form of a written report.

For P7, learners must outline potential management options for a tree exhibiting signs of decay. This may include pruning, installation of a support system, tree health promotion, habitat promotion, removal of targets or tree removal. Evidence could be in the form of a written report.

To achieve P8, learners must identify the principal anatomical features in wood. These are vessel elements, fibres, axial and radial parenchyma, growth rings, growth layers, heartwood and sapwood. Learners should also identify associated tissues such as the vascular cambium, the cork cambium, phloem and bark. However, these are not essential in order to achieve P8. Evidence could be in the form of a factsheet or leaflet produced by the learner and oral responses to tutor questions, recorded on a suitable pro forma by the tutor.

For P9, learners must explain the process of wound-wood development, wound occlusion and internal reactions to wounding as outlined in the CODIT model. A broad explanation of the use of spines and thorns

in response to browsing mammals, and gums and resins in response to insect damage, is encouraged. Evidence could be in the form of a written report.

To achieve P10, learners must link the use of current pruning conventions (natural target pruning) to wound response. Evidence could be in the form of a written report.

To achieve P11, learners must explain the principal biomechanical theories relating to trees (the axiom of uniform stress and the minimum lever arm theory). Evidence could be in the form of a written report.

For P12, learners must use an industry standard approach to assess tree mechanical stability, including comments on both the value and the limitations of the standard approach. Evidence could be in the form of a written report.

To achieve P13, learners must outline the implications of partial tree failure, for example scaffold branch failure or partial root-plate failure, for tree management. The implications may include remedial pruning, tree support, habitat creation or total tree removal. Evidence could be in the form of a written report.

For P14, learners must describe how a practitioner can both identify and support weak tree structures such as included bark at a branch union, cracks or root instability. Support systems could include non-invasive bracing techniques, propping and guying. Reference to invasive techniques of bracing should be made in lectures/ field instruction but learners do not need to include them in their evidence, which could be in the form of a written report.

To achieve M1, learners must identify a specific environmental condition, for example drought, flooding or temperature extreme, and relate it to the process of tree decline. Learners should use language which demonstrates an understanding of the physiological mechanisms which cause overall tree decline. Evidence could be in the form of a written report.

For M2, learners must identify a biotic or abiotic cause of ill health and analyse the physiological impact of the causal agent. For example, the impact may be reduced photosynthesis, hydraulic xylem dysfunction, anoxia or reduced nutrient acquisition. Evidence could be in the form of a written report.

To achieve M3, learners must explain how a range (three or more) arboricultural operations will impact on the growth and development of a tree. This could be used to justify a particular pruning approach, linked to root management or a form of hazard management. Evidence could be in the form of a written report.

For M4, learners must make specific recommendations which will reduce the risk of biomechanical failure. These should involve arboricultural operations, for example pruning, bracing, guying or propping, rather than the removal of targets. Each recommendation must be appropriate for the size and location of the defect.

To achieve D1, learners must describe tree care operations which are targeted to moderate tree decline or promote tree health. Justification for each operation must be given with well-reasoned arguments. Above and below ground operations should be included. Evidence could be in the form of a written report.

To achieve D2, learners must describe habitats which can be associated with structural defects and wounds. Some of these features may also be associated with biomechanical weakness. Evidence could be in the form of a written report.

Where possible, assessment criteria should be based on real scenarios and case studies of trees which are significant locally or regionally.

Programme of suggested assignments

The following table shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P4, P8	Tree Growth, Wood Anatomy and Causes of Ill Health in Trees	You work as a education advisor for the Forestry Commission. Develop a factsheet to be used as part of an arborist's continuing professional development programme.	Factsheet Orally assessed based on knowledge acquired in a series of workshops. Tutors must develop an assessment proforma for recording evidence.
P2, P3, P5, P6, P7, P9, P10, P11, P12, P13, P14, M1, M2, M3, M4, D1, D2	Management Recommendations for Mature Tree(s)	A mature tree or trees of local importance will be systematically assessed. The tree(s) used should have complex management criteria which will require arboricultural operations to occur above and below ground.	Written report

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC land-based sector suite. This unit has particular links with:

Level 2	Level 3
Understanding Ecology of Trees, Woods and Forests	CU80 Plan and manage the control of pests, diseases and disorders

Essential resources

Delivery requires access to:

- mature trees in rural and urban locations
- prepared macroscopic wood samples of wounds, heartwood and sapwood
- microscopes and prepared slides of angiosperm (ring and diffuse porous) and gymnosperm wood sections
- equipment and product samples used to carry out operations discussed in the unit
- a broad range of arboricultural literature and computers.

Employer engagement and vocational contexts

Contractors with a proven track record of delivering a range of high quality arboricultural operations should be invited to share their experiences with learners. In addition, site visits to local trees which have complex management criteria are encouraged.

Indicative reading for learners

Textbooks

Bowes B G (editor) – *Trees and Forests: A Colour Guide: Biology, Pathology, Propagation, Silviculture, Surgery, Biomes, Ecology, Conservation* (Manson Publishing, 2010) ISBN 9781840760859

Gilman E – *An Illustrated Guide to Pruning, 2nd edition* (Delmar Thomson Learning, 2002) ISBN 9780766822719 – also available as an ebook on www.ebrary.com

Harris R W, Clark J R and Matheny N P – *Arboriculture: Integrated Management of Landscape Trees, Shrubs and Vines, 4th edition* (Prentice Hall, 2003) ISBN 9780130888822

Kozlowski T T, Kramer P J and Pallardy S G – *Physiological Ecology of Woody Plants* (Academic Press, 1992) ISBN 9780124241602

Kozlowski T T and Pallardy S G – *Growth Control in Woody Plants* (Academic Press, 1997) ISBN 9780124242104

Lonsdale D – *Principles of Tree Hazard Assessment and Management* (Stationery Office Books, 1999) ISBN 978-0117533554

Mattheck C and Breloer H – *The Body Language of Trees: A Handbook for Failure Analysis* (Stationery Office Books, 1994) ISBN 9780117530676

Mauseth J D – *Botany: An Introduction to Plant Biology, 4th edition* (Jones and Bartlett Publishers, 2008) ISBN 9780763753450

Pallardy S G – *Physiology of Woody Plants, 3rd edition* (Academic Press, 2008) ISBN 9780120887651

Schweingruber F H, Borner A and Schulze E D – *Atlas of Woody Plant Stems: Evolution, Structure and Environmental Modifications* (Springer, 2006) ISBN 978-3540325239

Shigo A L – *Modern Arboriculture* (Shigo and Trees Associates, 1991) ISBN 9780943563091

Sinclair W A and Lyon H H – *Diseases of Trees and Shrubs, 2nd edition* (Cornell University Press, 2005) ISBN 9780801443718

Strouts R G and Winter T G – *Diagnosis of Ill Health in Trees: 2nd Edition.* (Stationery Office Books, 2000) ISBN 978-0117535459

Thomas P – *Trees: Their Natural History* (Cambridge University Press, 2000) ISBN 9780521459631 – also available as an ebook on www.ebrary.com

Wilson B F – *The Growing Tree, revised edition* (University of Massachusetts Press, 1984) ISBN 9780870234231

Journals and periodicals

Arboricultural Journal

Arboricultural Newsletter

Arboriculture and Urban Forestry

Arborist News

Essential Arb

Websites

www.aieorg.uk	Arboricultural Information Exchange
www.forestry.gov.uk	Forestry Commission
www.isa-arboriculture.org	International Society of Arboriculture
www.trees.org.uk	Arboriculture Association
www.woodanatomy.ch	Online Microscopic Wood Anatomy of Central European species

Delivery of personal, learning and thinking skills (PLTS)

The following table identifies the PLTS opportunities that have been included within the assessment criteria of this unit:

Skill	When learners are ...
Independent enquirers	exploring and diagnosing tree health-related problems and developing management solutions
Creative thinkers	discussing and debating potential tree management options and developing arboricultural operations to promote tree health
Reflective learners	evaluating their own experiences and those of others before reaching their own decision
Team workers	working with other professionals to implement tree healthcare
Self-managers	developing a strategy for tree management which involves initiative, commitment and organisation
Effective participators	presenting a well-reasoned, specific series of arguments in favour of a particular tree management approach.

Although PLTS opportunities are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Independent enquirers	evaluating information which will contribute to a tree hazard analysis decision
Creative thinkers	communicating with tutors and invited professionals through workshops and seminars
Reflective learners	receiving and responding to assessment feedback and through formative assessment in academic discussion.

Functional Skills – Level 2

Skill	When learners are ...
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	exploring and diagnosing tree health-related problems producing a report on tree health and tree management options
Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used	producing a report on tree health and tree management options
Manage information storage to enable efficient retrieval	producing a report on tree health and tree management options
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	exploring and diagnosing tree health-related problems
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	exploring and diagnosing tree health-related problems
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	producing a report on tree health and tree management options
Bring together information to suit content and purpose	producing a report on tree health and tree management options
Present information in ways that are fit for purpose and audience	producing a report on tree health and tree management options
Evaluate the selection and use of ICT tools and facilities used to present information	producing a report on tree health and tree management options
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	explaining potential causes of ill health in trees
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	exploring and diagnosing tree health-related problems
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	producing a report on tree health and tree management options.