KEY TO SILVICULTURAL PRESCRIPTIONS

FOR

AREAS OF NATURAL AND SCIENTIFIC INTEREST

Compiled by J.R. Irwin

ABSTRACT

This report was the result of committee attempting to address forestry impacts to environmental and protection concerns in environmentally sensitive forested areas in southern Ontario, specifically, ANSI's, or Areas of Natural and Scientific Interest. The particular subcommittee that put together this key was tasked with presenting the normal silvicultural approach to managing specific stands, in order that this could be reviewed by other subcommittees for the potential impacts.

The document is set up as a key, a decision making tool which can be used in the field or the office to sort through a number of stand characteristics to lead to a recommended silvicultural approach to stand management. It has application beyond environmental areas and can be applied to many common stand types.

Specific stand values such as minor vegetation components or wildlife habitat features are not addressed in the key, nor are operational considerations. Rather, the key represents the first steps in a normal silvicultural decision-making process. The next step would be to consult a complete silvicultural guide for the species in the stand, and assess the potential impact of recommended treatments on the other sensitive stand features and values. Operational concerns or constraints are not dealt with.

Key words: Prescription, Silviculture, Key, ANSI

PREFACE

In 1987 and 1988, an Ontario Ministry of Natural Resources committee was organized to look at impacts of forestry operations on environmental features of Areas of Natural and Scientific Interest. Environmental features included the forest stand itself as well as the site, the flora and the fauna. Subcommittees looked at various components of the potential impact. The subcommittee which looked at silvicultural practices was composed of Harvey Anderson, a ministry research scientist, and two field foresters, Norm Tennant from Owen Sound District and John Irwin from Cambridge District. They developed this key which was to be reviewed by other professionals, from other disciplines, to assess potential impact to sensitive features from what was to be considered "normal silvicultural recommendations".

Although the key which resulted from this subcommittee work was not published, in 1990 Harvey Anderson produced A Silvicultural Guide for the Tolerant Hardwood Working Group in Ontario and referenced this key with John Irwin as the author (1988). Since there is a need for this information, not only for decision-making within environmental areas, but in many other situations on private and public land, the key is being printed as a generic key for "common stand types". Prior to printing the first draft version, it was reviewed by several forestry professionals including Eric Boysen, Dan Dey, Peter Williams and Ken Elliott, to ensure that information was current.

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NOTE: The key was published in 1995 by the Waterloo Stewardship Network and the Ontario Ministry of Natural Resources. For various reasons it was published as a draft document. Only one comment has since been received, and it has been incorporated into this edition of the key. One further note with respect to the section on White Cedar: although the paper by Schafer, 1996, was referenced, much of the material noted in the key is over and above what was included in this referenced paper.

Comments within the draft key regarding wildlife and other sensitive features of forest stands, and concerning timing of operations forestry equipment, and reduction of impacts due to forest operations, were added by the reviewers at the time of publication of the draft. The original key document was not intended to address these issues at all, as other subcommittees were dealing with other fields relating to impacts to, and preservation of, sensitive features of ANSI's. Besides wildlife concerns and operational constraints, there are many other issues that must be addressed in management planning for forested areas, and many ways to accommodate them in silvicultural prescriptions and operational guidelines. They cannot all be dealt with adequately in a key such as presented here, and to address even one feature like wildlife, in this superficial manner, is pointless, since it does not do the subject justice. I have therefore taken these sections out, as they cannot be dealt with appropriately and completely, and they therefore have no business here.

Some of the sections of the key, which were moved around in the draft, resulting in changes and inconsistencies with respect to the original intent of the key, were put back in their correct position. Likewise, inaccuracies that were created during the review by the publishing committee, have been corrected.

Credit given incorrectly to the wrong references and authors has been corrected. Incorrect key pathways, created by the addition of new information, have also been corrected.

J.R. Irwin

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As one works through the steps of the key, the recommendations address tree and stand components but do not directly address protection and management of environmental features or wildlife habitat. However, when objectives for a stand are known, whether they be forestry - related or for other values, the key leads to a number of silvicultural options which represent what is feasible in terms of management or maintenance of a stand on a particular site. A recommendation may describe the appropriate silvicultural system including thinning, harvesting and regeneration. It also addresses some natural changes that may take place without human intervention. In some instances, considerations for modified forestry or non-management are introduced. Management of non-tree ecosystems, such as prairies or shoreline dune systems, are not considered, although some of the recommendations could be applied to oak savannas.

Once this key has been applied, and a conclusion reached, it is advisable to consult a complete silvicultural guide for the species being managed. In some cases, silvicultural guides are incomplete or inadequate, and additional resources such as those in the appendix are suggested.

In Ontario, the Trees Act permits municipalities to pass bylaws regulating the destruction of trees by harvesting or other means. One of the exemptions to bylaws passed under this act is cutting trees under "good forestry practices". Enforcement officers who may be unsure whether removal of trees is actually good forestry practices may find the key useful in determining normal recommended stand treatment for given circumstances.

ACKNOWLEDGEMENTS

Much of the information in the key has been derived from work done by Harvey Anderson and Mac Mclean in Algonquin Park related to tolerant hardwoods, yellow birch, and hemlock. The author wishes to thank these two individuals for their untiring silvicultural work and their inspiration to field foresters. Additional information has been added from U.S. documents, and some has been added from the author's experiences. Sections pertaining to "fully regulated stands" of tolerant hardwoods are adapted from Arbogast, 1957, a marking guide that has been in use for many years in Cambridge District. Sections pertaining to oak, hickory and red maple, have been adapted in part from Sander, 1977. Appreciation is also extended to Norm Tennant for his work on the subcommittee.

Introduction

The following key is intended to provide a guide to the selection of silvicultural options for a range of natural stand types found in southern Ontario. It does not deal with plantations, as these have been dealt with in many other publications. This key is based on a decision - making process which progresses from what may be considered general observations to choices which may require some measurements or other stand measurements.

The types of observations and decisions are:

- the stand composition or dominant species as it exists
- whether the stand composition and structure is to be maintained or altered and whether the composition is undergoing transition
- whether significant minor species components, which require special consideration, are present, and whether their presence is declining or increasing
- stand stocking
- stand maturity
- presence, composition and condition of the understory
- suitability of the stand type to the site (site index)

If the stand is composed of a variety of species or stand conditions, the key may be used for each individual species or situation to suggest a range of options for the stand. In addition to stand type or composition, entry to the key is based on tolerance to shade. The key may provide a guide for species which are not specifically named in the key, providing their shade tolerance and other silvical characteristics are known.

The key points users towards treatment approaches for a stand based on accepted forestry principals and management objectives representing what is feasible in terms of silvicultural treatments. In some cases alternatives and recommendations for no management activity are suggested. If a recommendation from the key is not acceptable in consideration of the management objectives for the particular stand, other alternatives must be sought by researching additional references, or consulting with experienced foresters. One must decide whether it is feasible to maintain the stand values with or without the application of silvicultural treatments.

The objective of this key is to present silvicultural options for managing forest stands. It should be used as a starting point to develop workable strategies – it is not intended to provide

prescriptions without other supporting work or documentation.

A shade tolerance table is included as an Appendix A.

Appendix B is a glossary which expands on some of the terminology as well as some silvicultural systems (e.g. all-aged vs. shelterwood).

Appendix C is a list of references.

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ENTER KEY HERE:

Stand composed of shade tolerant hardwoods 1
(Sugar maple, Beech, Ironwood)

Stand composed of shade tolerant conifers - Hemlock 22
- White cedar 41

Stand composed of semi-(shade) tolerants 2
(Red maple, Basswood, White Oak, Yellow Birch, White Elm, White Pine)

Stand composed of (shade) intolerants 3
(White Ash, Walnut, Black Cherry, Tulip, Red Oak, Hickory, Butternut, Aspen, Silver Maple, Black Ash)

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SHADE TOLERANT HARDWOODS

(Adapted from Anderson 1990)

1a) Stand composition to be maintained 4

1b) Stand composition to be altered 21

4a) Stand composed of primarily hardwood species 5

4b) Stands where hemlock is to be favoured 22

5a) Stand understocked throughout entire structure
- Do nothing now and access in 5 years
- An understocked stand is one below the residual stocking levels outlined

in 14 and 20

5b) Stand fully stocked or overstocked 6

6a) Stand immature 8

6b) Stand mature 17

8a) Seedling and sapling stands (up to 9cm. (3.5 in.) dbh) 9

8b) Pole stands (9.1 cm. (3.6 in.) to 23.5 cm. (9.5 in.) dbh) 10

9a) without overstory
- do nothing until stand reaches pole size
- or do a crop tree or crown thinning by using the rule of thumb: tree spacing is tree dbh in feet X 20, or dbh in inches X 2 expressed in feet.

9b) with overstory of less than 9 m^2/ha (40 sq. ft. /A), 25 cm. (10 in.) dbh and greater 11

9c) with overstory of more than 9 m^2/ha. (40sq. ft./A.), 25 cm. (10 in.) dbh and greater 12

11a) Overstory with potential for future development 13

11b) Overstory with no potential for future development
-Remove overstory if necessary to promote development of understory

13a) If seedlings
- do nothing

13b) If saplings
- apply light improvement cut to overstory

12a) Overstory with potential for future timber development
-apply improvement cut to overstory

12b) Overstory with no potential for future timber development
- depending on uniformity in quality and arrangement of the overstory, an improvement cut to the overstory would be an option to improve overstory quality or favour the understory.
-reduce overstory to 9 m^2/ha.(40 sq. ft./A.), 25cm. (10 in.) and greater and further as necessary to promote development of understory

10a) with no potential for future timber development
- regenerate to appropriate species 14

10b) with potential for future timber development 15

15a) Without overstory
- apply crop tree release and thinning 14

15b) With overstory 16

16a) Overstory with potential for future timber development
- apply crop tree release and thinning to polewood with improvement cutting in overstory 14

16b) Overstory with no potential for future timber development
- remove overstory, apply crop tree release and thinning to polewood 14

14) Reduce stand to 20 sq. m. /ha. (85 sq. ft./A.) of basal area in poles and sawtimber together.
- Remove cull and defective overstory trees.
- Cut only poor growing stock in overstory.
- After defective overstory trees have been removed, reduce stand to desired stocking by cutting in pole - sized portion of stand.
- If no sawtimber is present, reduce poles to 17 to 20 sq. m./ha. (75 - 85 sq. ft./A.)

17a) With no potential for future timber development.....18

17b) With potential for future timber development.....19

18a) No satisfactory regeneration
- regenerate using the uniform shelterwood system reducing the overstory to favour the establishment of the understory, but do not reduce to less than 11 m^2/ha. (50 sq. ft./A.) 25 cm. (10 in.) and greater

18b) Satisfactory regeneration present
- reduce the overstory to 9 m^2/ha. (40 sq. ft./A.) 25 cm. (10 in.) and greater and further as necessary to promote development of understory

19a) Fully Regulated Stands - all elements of structure stocked in excess of recommendations: 20

19b) Stands overstocked with sawtimber but understocked with poles and saplings.
-Reduce dominant sawtimber portion of stand to 16 sq. m. /ha. (70 sq. ft./A.) basal area.
- Remove poles that will not produce high-quality timber in the future.

20. – Apply the all-aged system. The following is a guide suggested by Arbogast, 1957.

FULLY REGULATED STAND

SUMMARY OF DESIRABLE STOCKING RECOMMENDATIONS

(AFTER CUTTING, BASED ON A CUTTING INTERVAL OF 10 YEARS)

TREE SIZE	DBH RANGE (cm.)	RECOMMENDED STOCKING (sq. m. /ha.)
Sawtimber	25 cm. + (10 in.)	15 - 17 (65-75 sq. ft./A.)
Poles	9.1 - 24.9 (5 - 9 in.)	2.3 - 4.6 (10-20 sq. ft./A.)
Saplings	5 - 9 (2 - 4 in.)	1.2 - 2.3 (5-10 sq. ft./A.)

- Harvest mature timber. Reduce stocking of timber (25 cm.(10 in.) and greater to 16 sq. m. /ha. (70 sq. ft./A.) of basal area, poles to 3.5 sq. m. /ha.(16 sq. ft./A.) and saplings to 2.3 sq. m. /ha (8 sq. ft./A.). Remove the poorest trees but leave adequate stocking in all diameter classes well distributed throughout the residual stand.

20) The above recommendations, (No. 20 alternate) are based on the desired residual stocking level for a stand after cutting. The reasons for selecting this level are to favour the regeneration of desirable species - Maple, Ash, Cherry - while retaining sufficient stocking to produce trees of good form. It is assumed that the cutting interval is 10 years and is also assumed that the stand structure is based on a "q" value of 1.3. This value defines the proportion of smaller trees to larger trees, and hence the amount of timber in the various size classes of the stand and hence the stand structure of an all - aged stand.

Should it be desired to vary the stand for a particular reason, i.e. to control the amount of light reaching the forest floor, to adjust the amount of large timber retained in the stand, or to increase the maximum size to which timber is to be grown, assuming the site is capable of sustaining the growing stock, there is some flexibility to adjust the stand parameters. For instance, more and larger trees can be retained, but in order to maintain the vigour of the stand and ensure adequate ingrowth of regeneration, the "q" factor, the residual basal area after cutting, and the cutting interval may also have to be adjusted accordingly.

21) In most cases where tolerant hardwoods comprise the majority of the stand, the stand will be

maintained in these species. If other species are to be favoured such as intermediates or intolerants, the key choices and recommendations for these alternate stand types should be followed or incorporated into the prescriptions for the tolerants.

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SHADE TOLERANT CONIFER - HEMLOCK

(Adapted from Anderson 1990)

22) Sapling stands (up to 9 cm. (3.5 in. dbh) 23

22) Pole stands (9.1 cm. (3.6 in.) to 23.5 cm. (9.5 in.) dbh
- as above in 10

22) Sawlog stands 25

23a) Without overstory or with overstory of less than 9m.^{2} /ha.(40 sq. ft./A.), 25 cm. (10 in.) or greater dbh
- do nothing until average understory dominant reaches pole size

23b) With overstory of 9 m.^{2}/ha. (40 sq. ft.) or more, 25 cm. (10in.) or greater dbh 24

24a) Overstory with potential for future development
- if understory is more that 16 m.^{2}/ha. (70 sq. ft./A.) 25 cm. (10 in.) or greater dbh , reduce to 16 (70) through improvement cutting.
- If between 9 (40) and 16 m.^{2}/ha. (70 sq. ft./A), apply light improvement only where necessary

24b) Overstory with no potential for future development
- if overstory is more that 16 m.^{2}/ha. (70 sq. ft./A.), 25 cm. (10 in.) or greater dbh, reduce to 16 (70).
- If 16 m.^{2}/ha. (70 sq. ft./A.) or less, do nothing

25a) With no potential for future development 26

25b) With potential for future development
- make initial cut leaving 23 to 25 m.^{2}/ha. (100 to 110 sq. ft./A.) basal area of sawtimber sized trees.
- make planned salvage cut 3 to 5 years after initial cut. At time of salvage, reduce s awtimber to 18 m.^{2}/ha. (80 sq. ft./A.) Subsequent cuts similar to above 24

- the selection system has the effect of gradually increasing the proportion of the more tolerant hardwoods. To maintain the same proportion of hemlock, the uniform shelterwood

method is preferred. The first cut will discriminate against hardwoods and leave 70% - 80% of the crown cover and high levels of hemlock basal area (16 $m.^2$/ha.) (70 sq. ft./A.). Scarification before the cut is desirable to prepare the seedbeds and destroy advance hardwood regeneration. Good seedbeds are mixed mineral soil and humus. To assist natural seeding, hand seeding will improve the stocking. A second cut occurs in ten years to reduce the crown cover to 50% and again discriminate against hardwoods. A third cut occurs when reproduction is well established ($\pm$10 years and $\pm$2 metres tall (4 - 6 ft.)). This cut removes the remainder of the overstory.

26a) With no satisfactory regeneration present

- regenerate using the uniform shelterwood system leaving a minimum of 16 m^2/ha. (70 sq. ft./A.) basal area 25 cm. (10 in.) or greater dbh

26)b With satisfactory regeneration present

- If overstory is more than 16 $m.^2$/ha. (70 sq. ft./A.) 25 cm. (10 in.) dbh or greater, reduce to 16 (70).
- If 16 $m.^2$/ha. (70sq. ft. /A.) or less, do nothing.

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INTERMEDIATE - TOLERANT HARDWOODS

(Adapted from Anderson 1990 and Sander 1977)

2a) Stand understocked throughout entire structure
- Do Nothing

2b) Stand fully stocked or overstocked 27

27a) Stand immature 28

27b) Stand mature 37

28a) Seedling and sapling stands (up to 9cm. (3.5 in.) dbh) 29

28b) Pole stands (9.1 cm. (3.6 in.) to 23.5 cm. (9.5 in.) dbh) 33

29a) without overstory
- do nothing until stand reaches pole size

29b) with overstory of less than 9 m^2/ha (40 sq. ft. /A), 25 cm. (10 in.) dbh and greater 30

29c) with overstory of more than 9 m^2/ha. (40sq. ft./A.), 25 cm. (10 in.) dbh and greater 32

30a) Overstory with potential for future development 31

30b) Overstory with no potential for future development
-Remove overstory if necessary to promote development of un derstory

31a) If seedlings
- do nothing and reassess in 5 years

31b) If saplings
- apply light improvement cut to overstory

32a) Overstory with potential for future development
-apply improvement cut to overstory

32b) Overstory with no potential for future development
-reduce overstory to 9 m^2/ha.(40 sq. ft./A.), 25cm. (10 in.) and greater and further as necessary to promote development of understory

33a) with no potential for future development
- regenerate to appropriate species 36

33b) with potential for future development 34

34a) Without overstory
- apply crop tree release and thinning 36

34b) With overstory 35

35a) Overstory with potential for future development
- apply crop tree release and thinning to polewood with improvement cutting in overstory 36

35b) Overstory with no potential for future development
- remove overstory, apply crop tree release and thinning to polewood 36

36) Reduce stand to 20 sq. m. /ha. (85 sq. ft./A.) of basal area in poles and sawtimber together. Remove cull and defective overstory trees. Cut only poor growing stock in overstory. After defective overstory trees have been removed, reduce stand to desired stocking by cutting in pole - sized portion of stand. If no sawtimber is present, reduce poles to 17 to 20 sq. m./ha. (75 - 85 sq. ft./A.). To favour semi - tolerant tree regeneration, openings up to .1 hectare (1/3 acre) in size (group selection) may be created in the stand. The likelihood of satisfactory regeneration occurring in these openings decreases with increasing site index.

37a) With no potential for future development 38

37b) With potential for future development 39

38a) No satisfactory regeneration

- regenerate using the uniform shelterwood system (2) leaving a minimum of 11 m^2/ha. (50 sq. ft./A.) 25 cm. (10 in.) and greater

38b) Unsatisfactory regeneration of intolerants present

- depending on the site index or the suitability of the site for the semi - tolerant species it may be difficult in this situation to maintain the semi - tolerant species. As site index increases it is increasingly difficult to regenerate the desired species due to the increased competition from the established tolerants. If this situation exists, it may be necessary to follow some of the treatments described under the sections on maintaining intolerant species.

38c) Satisfactory regeneration present

- reduce the overstory to 9 m^2/ha. (40 sq. ft./A.) 25 cm. (10 in.) and greater and further as necessary to promote development of understory

39a) Fully Regulated Stands - all elements of structure stocked in excess of recommendations: 40

39b) Stands overstocked with sawtimber but understocked with smaller timber

-Reduce dominant sawtimber portion of stand to 16 sq. m. /ha. (70 sq. ft./A.) basal area.

- Remove poles that will not produce high-quality timber in the future. Openings may be created in the overstory up to .1 hectare (1/3 acre) in size (group selection). The likelihood of satisfactory regeneration occurring in these openings decreases with increasing site index.

40) If a shift to tolerant species is acceptable, or site index is too high which will preclude regeneration to semi-tolerants, apply the following guidelines as with tolerant hardwoods. If maintaining semi-tolerants is desirable consider treating the stand as with shade intolerant species

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FULLY REGULATED STAND

SUMMARY OF DESIRABLE STOCKING RECOMMENDATIONS

(AFTER CUTTING, BASED ON A CUTTING INTERVAL OF 10 YEARS)

TREE SIZE	DBH RANGE (cm.)	RECOMMENDED STOCKING (sq. m. /ha.)
Sawtimber	25 cm. + (10 in.)	15 - 17 (65-75 sq. ft./A.)
Poles	9.1 - 24.9 (5 - 9 in.)	2.3 - 4.6 (10-20 sq. ft./A.)
Saplings	5 - 9 (2 - 4 in.)	1.2 - 2.3 (5-10 sq. ft./A.)

- Harvest mature timber. Reduce stocking of timber (25 cm.(10 in.) + to 16 sq. m. /ha. (70 sq. ft./A.) of basal area, poles to 3.5 sq. m. /ha.(16 sq. ft./A.) and saplings to 2.3 sq. m. /ha (8 sq. ft./A.). Remove the poorest trees but leave adequate stocking in all diameter classes well distributed throughout the residual stand. To favour semi - tolerant regeneration, openings up to .1 hectare (1/3 acre) may be created in the overstory (group selection).

40) The above recommendations, (No. 40 alternate from Arbogasd, 1957) are based on the desired residual stocking level for a stand after cutting. The reasons for selecting this level are to favour the regeneration of desirable species - Red Maple, Basswood, Ash, Cherry etc. - while retaining sufficient stocking to produce trees of good form. It is assumed that the cutting interval is 10 years and is also assumed that the stand structure is based on a "q" value of 1.3. This value defines the proportion of smaller trees to larger trees, and hence the amount of timber in the various size classes of the stand and therefore the structure of an all - aged stand. Should it be desired to vary the stand for a particular reason, i.e. to control the amount of light reaching the forest floor, to adjust the amount of large timber retained in the stand, or to increase the maximum size to which timber is to be grown, assuming the site is capable of sustaining the growing stock, there is some flexibility to adjust the stand parameters. For instance, more and larger trees can be retained, but in order to maintain the vigour of the stand and ensure adequate ingrowth of regeneration, the "q" factor, the residual basal area after cutting, and the cutting interval may also have to be adjusted accordingly.

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SHADE TOLERANT CONIFER - WHITE CEDAR

(Expanded from Schaffer 1996, Adapted from Smith and Borczon 1981 and Johnston 1977)

41a) Seedling origin stands

- stands originating from seed are usually even-aged. Some thinning can be carried out in young stands, but as the stand matures, the stand should be harvested under a system that produces an even-aged new stand. This includes the uniform shelterwood, strip or patch shelterwood, or (small) clearcuts. Regeneration can be by seeding (in seed years – may take 15 to 20 years) or by planting.

41 (i) Stand not mature

41 (i)a Competition from other species not an issue
- thin stand to 30 sq. m./ha. (130 sq. ft./Ac.)
- subsequent thinnings can be done at intervals, to maintain the stand above 21 sq.m./ha. (90 sq.ft./A.)

41 (i)b Competition from other species likely
- maintain basal area above 34 sq. m./ha. (150 sq.ft./A.)

41(ii) Stand mature
- Shelterwood – the first or preparatory cut reduces basal area to 14 sq. m./ha. (60 sq. ft./A.) and should discriminate against competing species.
- for a patch cutting system, the second cut creates cleared areas of 0.08 ha. (0.2 A.) or 800 sq. m. (10,000 ft.) sq. ft., usually removing 1/3 of the stand in a harvest.
- for a strip cutting system, strips up to 20 m. (66 ft.) wide are cut through the stand, usually removing 1/3 of the stand in a harvest.
- Once the first patch or strip is satisfactorily regenerated by seeding or planting, the second patch or strip is removed. When this is regenerated, the third patch or strip is cut, which must usually be replanted by hand or machine.

41b) Stands originating from layering or vegetative means

- these stands are often multi-aged or multi-sized occurring most often on organic or muck sites. Trees originate from layers as branches of trees root in the soil. Because of shallow rooting due to high water tables, trees often windthrow and those branches on the downed trees which contact the soil take root and regenerate the stand. These stands are difficult to manipulate as heavy disturbance can raise water tables. Also because layer origin stands are typically poor seed producers harvesting, if no provision for regeneration is made, can result in poor regeneration of cedar and conversion of the stand to other species. For these reasons

effective management of these stands is difficult and perhaps should not be attempted.

NOTE: These cedar stands may contain minor components of yellow birch, tamarack, soft maple and black ash.

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SHADE INTOLERANT HARDWOODS

3) Stand primarily Aspen 42

3) Stand primarily Soft (Silver) Maple 43

NOTE: Silver maple working groups are normally found on imperfectly or poorly drained mineral soil or organic sites. Although predominantly soft maple, they may contain minor components of yellow birch, white cedar, tamarack and black ash. On such wet sites, evapotransporation may suppress water tables, and harvesting may cause water tables to rise, causing stand dieback, and impeding subsequent stand replacement.

3) Stand primarily Black Ash (often with tamarack)

NOTE: This cover type often occurs in the areas of the most diverse vegetation as well as on imperfectly to poorly drained sites. Since the stands are of low merchantability and present unique regeneration and operational problems, it may be advantageous not to manage them.

3) Stand primarily Oaks and Hickories, Walnuts and Red Maple 49

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INTOLERANT HARDWOODS - ASPEN

42) No understory present

-Aspen stands are normally managed under an even - aged system involving a complete removal of all or parts of the stand to create stands or interspersions of small stands of unique age classes. Regeneration is obtained by root suckers. Sapling stands must be left dense to maintain form, polewood stands and sawlog stands can be thinned to produce intermediate products, but the better stems must be retained to provide for regeneration of the best clones.

42) Regeneration present of other species

- As with most intolerant species, if an understory is present of other more shade tolerant

species, particularly on the better sites (higher site indices) it is often difficult or impossible to regenerate the intolerant overstory. In most cases, it is more practical to allow the stand to convert to the understory species by gradual removal of the overstory. Overstory removal is carried out with the primary consideration directed at the understory development, as with a uniform shelterwood.

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INTOLERANT HARDWOODS - SILVER MAPLE

43a) Stands that are understocked 44

43b) Stands that are fully stocked or overstocked 45

44a) Sapling Stands
-do nothing until stand reaches pole size

44b) Pole Stands
- understocked pole stands will generally be of poor form as excessive light will cause side branching and stem forking. These stands can be left to mature as low quality sawlogs or regenerated to a new stand using a regeneration system such as a shelterwood that creates an even-aged stand of high stocking which will create a new stand of better form. Regeneration can be by seeding, planting and coppice or a combination of these systems

44c) Sawlog Stands
- understocked stands are generally of poor form with excessive branching and stem forking. If the wood can be marketed, the stands can be regenerated as with polewood stands above.

45a) Seedling or Sapling Stands 46

45b) Pole Stands 47

45c) Sawlog Stands
- Harvest using a shelterwood system or a group selection system creating even-aged regeneration dense enough to maintain good form. Regeneration should be by seeding, planting and coppice (stump sprouts)

46a) With overstory
-remove overstory by harvesting or girdling

46b) Without overstory
-do nothing until stand reaches pole size

47a) With no potential for future development
-regenerate to appropriate species using a uniform or strip shelterwood system or a group selection creating small openings in the stand

47b) With potential for future development 48

48a) With overstory
-remove overstory

48b) Without overstory

- improvement cutting can be carried out maintaining a residual basal area of 21 - 23 m^2 /ha.(90 - 100 sq. ft./A.). Relatively high stocking values must be retained to produce good form.

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INTOLERANT HARDWOODS - OAK, HICKORY, RED MAPLE

Adapted from Sander 1977

49a) Stand immature (Seedling, sapling or polewood) 50

49b) Stand mature (Sawlog) 50

50a) Understory or regeneration absent 51

50b) Understory other tree species (tolerants) 55

50c) Understory Intolerant hardwoods 51

50d) Understory woody shrubs 57

51a) Site not limited for intolerant hardwoods 52

51b) Site limited for intolerant hardwoods 53

52a) Stand basal area two thirds of more in intolerant hardwoods
- manage for intolerant hardwoods or mixed intolerant - tolerant hardwoods.....54

52b) Stand basal area one third or less in intolerant hardwoods
- manage for other desirable hardwoods 54

53a) Site too productive (high site index)
- it may be possible under these circumstances to perpetuate intolerant species in the

absence of competition from tolerant hardwoods or woody shrubs either by utilizing an even - aged silvicultural system such as a uniform shelterwood or a quasi all - aged system such as a group shelterwood or group selection. The danger on these sites is that due to their high productivity, competition from other species, once they are established may preclude the maintenance of the intolerants.

53b) Site too poor (low site index)

- The poor sites are almost exclusively occupied by oaks. Stands are often of poor quality and dominated by the less desirable oaks such as bur oak. The best management for stands on the poorest sites may be no management.

- On poor sites that may have originally been pine, such sites may be easily converted back to pine or pine - oak - hickory mixtures following normal recommendations for the establishment of this species.

54a) On average sites for intolerant hardwoods where regeneration is absent or composed of intolerant hardwoods it should be possible to manage the intolerant hardwoods using an even - aged silvicultural system such as a uniform shelterwood or a quasi all - aged system such as a group shelterwood or a group selection. In situations where intolerant hardwoods compose part of the overstory, it may be expected that competition may result from these species and a mixed stand will result. If this occurs, it may be necessary to utilize regeneration techniques such as hand planting or hand seeding following site preparation by herbicide use or prescribed fire, and applying subsequent tending by hand release to ensure re-establishment of the intolerants.

55a) Site not limited for intolerants
- Manage for intolerants or mixed tolerant - intolerants as in 54a above.

55b) Site limited for intolerants 56

56a) Site too productive (high site index)

- It may be difficult on these sites, particularly since the competition from tolerants is already well established, to maintain the stand composition of intolerants. To do so will require the application of site preparation treatments, artificial regeneration and subsequent tending using prescribed fire, herbicides and/or hand release (as in 54 above). Consider under these circumstances allowing the stand to progress to other hardwood species.

56b) Site too poor (low site index)

- The poor sites can be almost exclusively occupied by oaks or oak - hickory. Stands are often of poor quality and dominated by the less desirable oaks such as bur oak. If other hardwoods are present as an understory, they can usually be removed much more easily than on the better sites. The best management for stands on the poorest sites may be no management.

- On poor sites that may have originally been pine, such sites may be easily converted back to pine or pine - oak - hickory mixtures following normal recommendations for the establishment of this species.

57a) On sites where woody shrubs such as witch hazel, serviceberry, blue beech, dogwood spp., prickly ash etc. form an understory, whether the sites are productive or poor, the understory may preclude regeneration of the intolerant hardwoods. In such cases, any thinning or harvesting may serve only to increase these lesser species. In order to maintain the stand as an intolerant hardwood cover type, prior to any cutting, it is usually necessary to remove the understory using prescribed fire or herbicides, to regenerate the stand through either natural or artificial means and to apply subsequent tending to ensure that the oaks develop into adequate regeneration.

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APPENDIX A
SHADE TOLERANCE OF TREE SPECIES

Very Tolerant

CONIFER

Eastern Hemlock *Tsuga canadensis*

BROAD-LEAVED

American Beech *Fagus grandifolia*
Blue Beech *Carpinus Caroliniana*
Sugar Maple *Acer saccharum*
Big Shellbark Hickory *Carya laciniosa*
Flowering Dogwood *Cornus florida*

Tolerant

CONIFER

+Balsam Fir *Abies Balsamea*
Red Spruce Picea rubens
*Eastern White Cedar *Thuja occidentalis*

BROAD-LEAVED

*Basswood *Tilia americana*
*Black Maple *Acer nigrum*
Manitoba Maple *Acer negundo*
*Red Maple *Acer rubrum*
Slippery Elm *Ulmus rubra*
Black Gum *Nyssa sylvatica*
Hop-hornbeam *Ostrya virginiana*
Red/Green Ash *Fraxinus pennsylvanica*
Red Mulberry *Morus rubra*

Intermediate

CONIFER

+Black Spruce *Picea mariana*
Norway Spruce *Picea abies*
Eastern White Pine *Pinus strobus*
+White Spruce *Picea glauca*

BROAD-LEAVED

Black Oak *Quecus velutina*
Sweet Chestnut *Castanea dentata*
Pignut Hickory *Carya glabra*
Rock Elm *Ulmus thomasii*
+Silver Maple *Acer saccharinum*
White Elm *Ulmus americana*
Yellow Birch *Betula alleghaniensis*
Bur Oak *Quercus macrocarpa*
Hackberry *Celtis occidentalis*
Red Oak Quercus rubra
Shagbark Hickory *Carya ovata*
Swamp White Oak *Quercus bicolor*
White Oak *Quercus alba*

Intolerant

CONIFER

Eastern Red Cedar *Juniperus virginiana*
Red Pine *Pinus resinosa*
Pitch Pine *Pinus rigida*
Scots Pine *Pinus sylvestris*

BROAD-LEAVED

Black Ash *Fraxinus nigra*
Black Walnut *Juglans nigra*
Butternut *Juglans cinerea*
Honey-locust *Gleditsia triacanthos*
Mockernut Hickory *Carya tomentosa*
Sassafras *Sassafras albidium*
Tulip-tree *Liriodendron tulipifera*
White Birch *Betula papyrifera*
Black Cherry *Purnus serotina*
+Bitternut Hickory *Carya cordiformis*
Chinquapin Oak *Quercus muehlenbergii*
Kentucky Coffeetree *Gymnocladus dioicus*
Pecan *Carya illinoensis*
+Sycamore *Platanus occidentalis*
+White Ash *Fraxinus americana*

Very Intolerant

CONIFER

+Jack Pine *Pinus banksiana*
Tamarack *Larix laricina*

BROAD-LEAVED

Balsam Poplar *Populus balsamifera*
Eastern Cottonwood *Populus deltoides*
Pin Cherry *Prunus pensylvanica*
Trembling Aspen *Populus tremuloides*
Black Locust *Robinia pseudoacacia*
Largetooth Aspen *Populus grandidentata*
Speckled Alder *Alnus rugosa*
Willows *Salix spp*.

* Tolerance considered to be as listed here, but decreasing in shade tolerance with maturity.
+ Sometimes considered slightly more tolerant than recorded here.

*+ Disagreement or differing opinions of tolerance, in the literature, may be due to differences in tolerance with maturity, site conditions, or genotype.

APPENDIX B

GLOSSARY

All-aged

- a condition where many ages of trees occur in a stand. An all-aged management system is designed to produce a stand where all ages, or sizes, are present in a stand at one time, usually to a predetermined *stand structure* model which defines the age or size spread and numbers of stems required in the stand by size class. The form of this model determines what the stand will look like, how it will grow, and which species and trees will thrive. This management system is more suited to *shade tolerant* species such as sugar maple than to *shade intolerant* ones such as oak.

Basal Area

- the cross sectional area of a stem at breast height (*dbh*) (4.5 feet for Imperial people and 1.3 metres for metric people), also expressed as the basal area per acre or hectare representing the sum of all trees on the unit of area.

- the purpose of this unit of measure is to indicate how much *growing stock*, or volume of trees is present on the area. It is used as part of a *stand structure* model to determine when thinning is necessary in order to thin crowded trees, and how much of a thinning in order not to decimate a stand. Hence the determination of a "optimum basal area" which will allow trees to grow at their maximum potential.

- residual basal area or *residual stocking* refers to the amount of the stand remaining after a thinning or harvest.

Coppice

- a shoot (sprout) or the resulting tree originating from a stump of a tree.

Crop Tree

- any tree forming or selected to form, a component of the final crop, specifically, one selected to be carried through to maturity.

DBH or Diameter, Breast Height

- the diameter of a stem of a tree measured at 4.5 feet for Imperial people and 1.3 metres for metric people. This is the point on the stem or bole at which *basal area* of a tree, or of trees per acre or per hectare, is calculated.

Even-aged

- condition of a stand in which relatively small age differences exist between individual trees. Normally, plantations occur this way. Even-aged management systems are those whereby *stands* are grown this way until harvest, and are regenerated or re-planted as a similar even-aged stand. This management system is most useful for *shade intolerant* species. Even though, in a shelterwood harvest, the stand is removed and regenerated in several stages, it is still considered an even-aged silvicultural system.

Habitat

- is the soil, water, air, rocks, rain, heat, and other plants and animals which combine to provide the food, water and space needed for wild life to survive. It is continuously changing in response to fire, flood, weather, new species, population fluctuations, disease, *succession* and human disturbance.

Improvement Cutting

- is a cut made to improve the quality of the stand rather than to realize or maximize revenue in the short term

Maturity

- Stand maturity can be determined by several means: current annual v.s. mean annual increment, growth value index, or the carrying capacity of the site. Therefore, tree or stand maturity can be a physiological maturity or an economic maturity based on growth rates and value appreciation. These factors, alone or together, can determine maturity for a tree or stand and will vary for different sites, based on site index.

Poor Growing Stock

- refers to trees of poor form and quality, economic value, or general use, which may be present and are not required or desired in a developing, or in subsequent stands. They may be retained for a specific purpose such as food or shelter for wildlife.

Potential future timber harvest potential

- refers to trees and stands of suitable quality, form, species and vigour to persist as trees of good future potential growing stock, and may include future economic potential.

Satisfactory Regeneration

- saplings of a species and form that are well established enough to survive, are able to compete for growing space and show potential to contribute to a future stand. Satisfactory regeneration also includes a numerical requirement that the regeneration has the potential to produce a future fully stocked stand.

Advanced Regeneration

- is regeneration present prior to a harvest cut, usually present as an understory, and with the species and numerical quality potential to contribute to the next stand.

Selection cutting

- is the annual or periodic removal of trees (particularly the mature), individually or in small groups from an uneven-aged forest in order to realize the yield and establish a new crop. The improvement of the forest is a primary consideration.

A selection system

-is an uneven-aged silvicultural system in which trees are removed individually, here and there, from a large area each year - ideally over a whole forest or working circle, but more practically, from an individual forest or stand at regular periodic intervals - using factors of vigour and risk when selecting, and using basal area and/or stand structure as a

guide; regeneration mainly natural and crop ideally all-aged.

Shade Tolerance

- a tree's ability to grow under a degree of shade produced by it's neighbours in a stand, or produced by competition such as weeds and grass. Shade tolerant species are sugar maple, beech or hemlock. Shade intolerant species are poplar, oak and red pine. Some species are in between such as white spruce and white pine. Shade tolerance may vary in some species between when the tree is a sapling and when it approaches maturity.

Silvics

is the life history and general characteristics of forest trees and stands, with particular reference to environmental factors.

Silviculture is the art of producing and tending a forest; the application of the knowledge of silvics in the treatment of a forest; the theory and practice of controlling forest establishment,composition, and growth.

Silvicultural system

- a method of silvicultural procedure worked out in accordance with the accepted sets of silvicultural principles by which tree crops constituting forests are tended, harvested, and replaced by new crops of distinctive form.

Site index

-is a measure of the capability of the site to grow a tree of a given species and is determined by measuring the height of a tree at a standard age, usually 50 years. It is expressed as feet or metres. For example a site index 65 for oak means that a tree growing on the site should be expected to achieve 65 feet in height after 50 years. The significance of the measure in selecting silvicultural options is that it also indicates, with shade intolerant species, the degree of competition that should be expected from other vegetation and from more shade tolerant species. Similarly, as soil types change from sand to silts, loams and clays, competition factors correspondingly increase. At either end of the spectrum, i.e. sands or gravels which may be dry, heavy clays and imperfectly or poorly drained soils of any textural class, site index is normally reduced. These factors become apparent when using the key, since as site index increases, the success of maintaining species such as intolerants is less and as site index is reduced the productivity of the site and the advantages of management for forestry purposes is less.

A Stand

-is a community, particularly of trees possessing sufficient uniformity as regards composition, constitution, age, spatial arrangement, or condition, to be distinguishable from adjacent communities, so forming a silvicultural or management entity.

Stocking is a loose term for the amount of anything on a given area, particularly in relation to what is considered the optimum. In a forest it refers to an indication of the number of trees or the proportion of the area actually occupied by trees as compared to the desirable.

Snag

- is a tree which is completely of partially dead, which is still standing. It is useful in a stand for wildlife, providing feeding, nesting and den sites. Usually a range of snag sizes and heights are desirable.

Structure

- of a forest or stand refers to the distribution and representation of age and/or size - particularly diameter - classes. In all - aged forests, the factor often used to define the structure is the "q" value. This value is the ratio of the number of trees in a given size class to the number of trees in the next larger size class. It can be used to identify stand parameters for wildlife features, such as describing preferred habitat for species such as red-shouldered hawk.

Uneven-aged

- refers to a forest, crop or stand composed of intermingling trees that differ markedly in age.

Uniform shelterwood

- a harvest cut (even-aged silvicultural system) constitutes the removal of the entire stand in two cuttings. Natural reproduction is established under the protection of the older stand and is released when the new crop is ready to fully occupy the growing space. The first cut concentrates on removing the most defective and less vigorous trees and leaves the best quality as the residual to furnish seed, protect the seedlings that will develop and continue to grow at an improved rate. This first cutting removes approximately 60% of the stand volume. The second cutting takes place after the regeneration is established and before it shows the effects of suppression. A shelterwood can also be a system whereby trees are removed in patches: Group Shelterwood or strips; Strip Shelterwood. Once regeneration is established in the first areas cut, further areas are harvested until the stand is completely replaced with a new even aged stand.

Wild Life

- all wild mammals, birds, reptiles, amphibians, fishes, invertebrates, plants, fungi, algae, bacteria, and other wild organisms.

APPENDIX C

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