# A Procedural Guide For Ecological Landscape Analysis

*An Ecosystem Based Approach to Landscape Level Planning in Nova Scotia*


Approved Guide for the Nova Scotia Department of Natural Resources
Integrated Resource Management (IRM) Planning Process

REPORT FOR 2008-2

Prepared by
Bruce Stewart and Peter Neily

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NOVA SCOTIA
Natural Resources

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Authors:

Bruce Stewart, BScF, RPF
Peter Neily, BScF, RPF

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Contacts:

Bruce Stewart
Nova Scotia Department of Natural Resources
Forestry Division
Ecosystem Management Group
PO Box 68, Truro, NS  B2N 5B8
902 893-5684
bjstewar@gov.ns.ca

Peter Neily
Nova Scotia Department of Natural Resources
Forestry Division
Ecosystem Management Group
PO Box 68, Truro, NS  B2N 5B8
902 893-5692
pdneily@gov.ns.ca

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# Introduction

This procedural guide presents a methodology for conducting an ecological landscape analysis - a critical component of IRM planning. The guide closely follows the methods outlined by Diaz and Apostle (1992), which have been tested and refined through several pilot projects and training courses on crown and private lands in Nova Scotia (Mulgrave Plateau Long Range Management Framework (2004), Chignecto Ridges Ecosystem Planning Course (2004), Sutherlands Brook Forest Ecosystem Design Plan (1995), River Philip IRM Demonstration Forest (1994). This guide presents the analysis phase of landscape planning (Figure 1) which will provide a comprehensive description and mapping of ecosystem conditions and functions across the full ecological landscape, including all ownerships. Results of the analysis will provide the basis for incorporating an ecological approach into the landscape design and planning phase. The planning phase is a separate process that on Crown land will occur within the IRM planning framework. Results of the landscape analysis can be made available to other ownerships undertaking ecological landscape planning. The analysis process will benefit from consultation to the following reference:

Diaz, N. & D. Apostle. 1992. *Forest Landscape Analysis and Design: A process for developing and implementing land management objectives for landscape patterns.* USDA Forest Service PNW-R6 ECOL-TP-043-92.

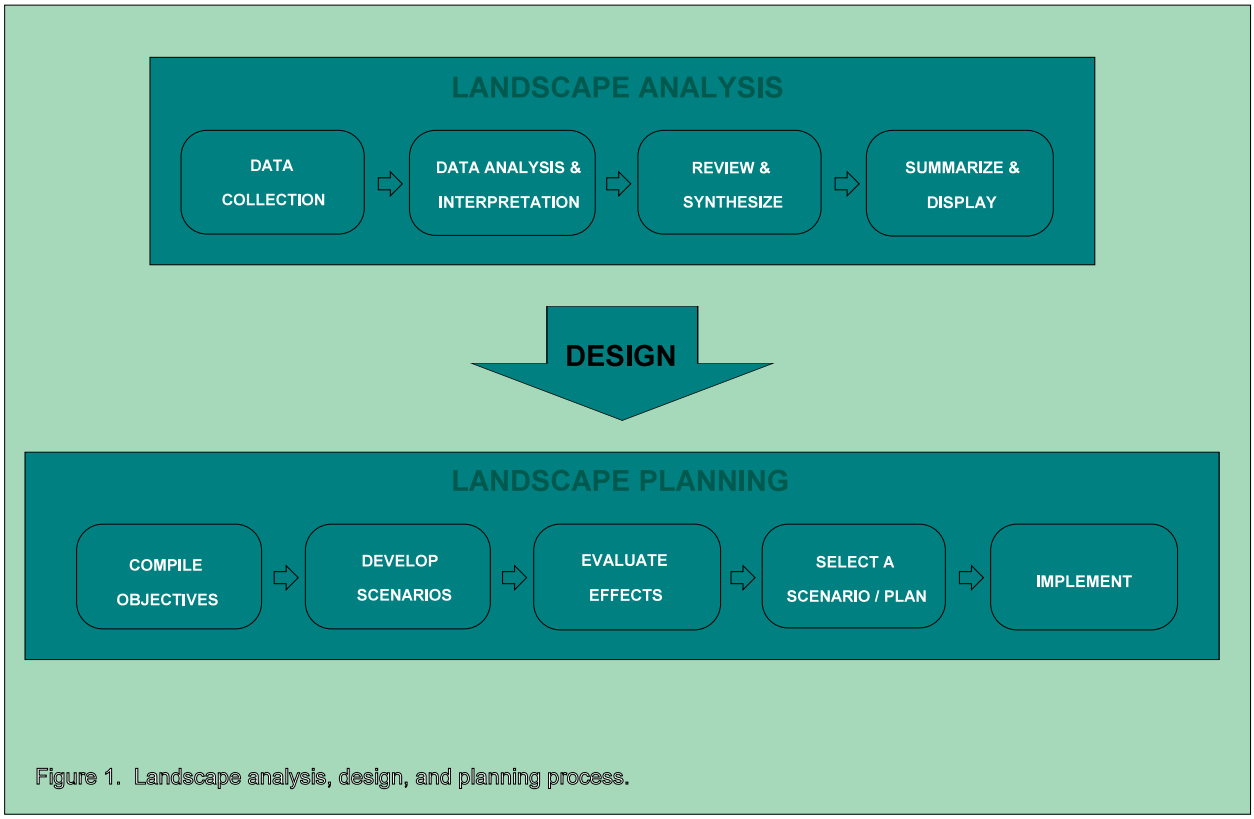


Figure 1. Landscape analysis, design, and planning process.

Landscape analysis will provide a foundation for ecosystem based planning, the essence of which is captured by the following definition:

Ecosystem management approach: "*a conservation planning approach that considers the composition, structure, functions, and processes of ecological communities occurring within a landscape. It uses a reference to the characteristics of ecological communities that occurred in an area historically, and strives to provide representation of these ecological communities while integrating human economic and social demands.*"

> Editors. 2004. North American grouse management plan. North American Grouse Partnership, Williamsport, MD.

# Landscape Characterization

The **Ecodistrict** level of the *Ecological Land Classification of Nova Scotia* defines landscape ecosystems at the appropriate scale for Integrated Resource Management planning within the Province. The first step in developing an understanding of the landscape ecosystem is to compile a resource inventory. All relevant data pertaining to composition, structure, function, and land use within the ecodistrict is collected and organized, including information on the surrounding ecodistricts. While some of this information may be in tabular or written form, most will be produced as GIS based theme mapping presented at a consistent scale suitable for spatial analysis. The following checklist identifies a standard data set that should be prepared. Other relevant information can be included as available. To assist with the analysis phase, the data should be organized under two themes; 1) inherent, enduring, and historical conditions, and 2) currently existing conditions. In preparing these data layers it is essential to critically review the information for accuracy.

## Enduring Feature Theme Layers

**A. Nova Scotia Ecological Land Classification**

(A regional review of the ELC unit under consideration will ensure the most current local knowledge is incorporated in the classification. Submit requests for review and change to the Forestry Division's Ecosystem Management Group)

- G Ecoregion with surrounding Ecodistricts & Sections
- G Ecodistrict with Ecosections
- G Ecodistrict with Potential Climax Forests
- G Ecodistrict with Natural Disturbance Regimes
- G Uncommon and Under-represented Ecosections

**B. Physiography, geology, soils.**

- G Topography & Elevation map based on digital elevation model/hill shading
- G Contour lines acetate overlay
- G Bedrock and surficial geology
- G Soils theme mapping *(use FEC based soil typing if available)*
- G Watersheds *(use most current DEL mapping available)*

**C. Historical Conditions**

- G Fernow Inventory 1912

## Existing Condition Theme Layers

**A. Current Forest Cover**

- G Covertype (from forest model)
- G Development classes (from forest model)
- G Seral stages (from forest model)
- G Community vegetation types (forest classification from DNR model, wetland, non-forest)

- Volume classes
- Satellite imagery
- Land Capability Classes (from forest model)

**B. Human Land Use Profile**

- Land use (urban, farm, mines, timber management, parks, wilderness, population density centers)
- Road Index Map (including transportation elements identified by index class - trails, secondary roads, primary roads, utility corridors)
- Ecological Emphasis Classes
- Ownership
- IRM land use and values mapping
- Reserve areas/special places (parks, wilderness reserves, significant wildlife habitats, old growth)
- Water supply areas

**C. Conservation Themes**

- Wildlife Significant habitats mapping
- Species of social/economic significance
- Special cases such as endangered species and indicator species
- DEL significant values mapping
- Restricted and Limited Land Use layer
- Old Forest

# Spatial Analysis and Interpretation

## Describe the Landscape as an Ecological System

The goal of landscape analysis is to develop an understanding of the landscape as an ecological system by exploring the relationship between structure and function. The purpose is to provide a basis for ecologically informed landscape planning and design. Analysis focuses primarily on current landscape conditions, highlighting the existing features and functions. The process begins by evaluating inherent and historical conditions using ELC in order to gain a perspective of the ecological system in a natural state. Comparison of existing and historical conditions will help identify the naturally intact systems and highlight major landscape change. Results of analysis include spatial mapping of the major findings, supported by summary tables and text.

### Landform Analysis

Analysis of topographic patterns, particularly the arrangement of ridges and valleys, helps define the operational environment of the landscape. Topography has a strong influence on natural vegetation patterns and flows of animals, wind, and water. Landform analysis helps planners "read" the landforms and get a feel for patterns that promote connectivity and influence ecological structure and function. The resulting landform analysis map allows landscape designers to recognize aesthetically and functionally appropriate vegetation patterns. It will be most applicable at the stage of designing and laying out forest operations.

*Step 1 - Landform Mapping*

Using an overlay of topographic, shaded relief, and watershed mapping, identify major and minor valleys and ridgelines according to standard landform analysis procedures (Diaz & Apostle, 1992; pg 4.55). Focus on identifying major patterns at a coarse scale. Digitize the resulting landform analysis theme map.

### Structure and Function Analysis

To determine landscape structure and associated functions follow the procedure (Steps 2-6) developed by Diaz and Apostle (1992). Analysis will use the landscape characterization themes to synthesize several new map layers illustrating dominant landscape structures and functions. Document the process using acetate overlays and notes to track findings and discussions.

*Step 2 - Landscape Structure*

Using the ecosections as the base mapping, classify, map, and describe the current structure of the landscape in terms of the primary elements (patches, corridors, matrix). Describe major structural differences from the inherent natural structure. Finish up with a brainstorming of collective knowledge on each element using flip chart technique.

*Step 3 - Landscape Flows*

Identify and map landscape flows of interest or concern. (ie. those things that move across

or interact with the landscape, and that are of particular interest for management and for which a knowledge base exists). Select a suite of species that will help illustrate the functions and operating scales of the landscape elements described in step 2. The significant habitats database may contain pertinent information.

*Step 4 - Relation between Landscape Elements and Flows*

Describe the interactions and relation of landscape flows to the elements and major landscape structures using the worksheet in Appendix 1. This will provide a fundamental understanding of landscape function.

*Step 5 - Disturbances and Succession*

Using the ecosection based natural disturbance interpretations and the forest ecosystem classification (request interim from Ecosystem Management Group, DNR Truro) describe the dominant natural disturbances and associated successional processes and vegetation communities. These should provide an understanding of habitat development and assist planners with composition objectives and silvicultural prescriptions.

*Step 6 - Linkages*

Describe and map the major functional linkages between the ecodistrict and adjacent ecodistricts, and examine ecoregional issues.

## Landscape Connectivity

Connectivity refers to the movement of organisms and processes (eg. disturbances) and the features that affect this movement. Movement is one of the most basic ecological functions, and should be well described and understood. The ability to move without excessive risk is of critical importance for maintaining biodiversity at all levels (genetic, individual, species, population, metapopulation, community, and ecosystem). The landscape analysis procedure has identified the major structural elements affecting movement within the landscape:

i) Linear Corridors - Flow along popular routes is dictated by enduring physical features such as river valleys and ridge lines. Linear flow often requires continuous connection (eg. rivers), whereby breaks in the connection serve as obstacles. It is a characteristic of continuous linear features that they often serve as connective corridors for some species and barriers for others.

ii) Island Ecosystems - Species movement among patches of suitable habitat is dictated by the arrangement and size of patches, as well as the nature of the intervening habitat. Islands of suitable habitat conditions must occur at acceptable intervals of time and space. Some island habitats have critical functions and must be continuously sustained (eg. wetlands for migrating bird staging and feeding areas), while others may be dynamic, shifting about the landscape as ecosystems evolve. Edge and interior habitat conditions may be important features of island ecosystems.

iii) Matrix Ecosystems - percolation of species through the dominant community type characterizes the ecosystem matrix. Matrix implies large areas of broadly similar habitat type in which movement is not constrained to particular routes. The percolation function is dependant upon the “large patch” condition, which may be vulnerable to fragmentation. Interior habitat is often an important feature of matrix ecosystems.

Landscape connectivity is complex, functioning in a variety of ways for many different species. The connective structures in the landscape are dynamic, take many forms, and operate at a wide range of spatial and temporal scales. The primary strategy is to conserve natural connective function by sustaining and restoring natural patterns, particularly within the most important connective features. The focus of planning should be to recognize the most important connective systems, and remove or mitigate unnatural barriers to their function.

*Step 7 - Connectivity Analysis*

Using the results of the *Structure and Function Analysis* (steps 2-6) characterize the landscape connectivity and fragmentation by completing the Landscape Connectivity Worksheet (Appendix 2). Identify and describe the nature of connectivity (existing and formerly existing) among structural elements within the Ecodistrict and also the major links between neighboring Ecodistricts. Describe the particular “connectivity” character of the Ecodistrict in terms of the system (linear, island, matrix), and relative importance of connectivity between the major components such as upland ridges, river and stream riparian zones and wetlands. Identify island ecosystems and important areas of isolation. Finally identify the most important connectivity issues for management, particularly where barriers exist or are anticipated.

*Step 8- Fragmentation Analysis*

Summarize selected patch metrics for each of the major landscape elements, using existing vegetation communities as defined by the forest modeling process. Interpret the major findings and trends based on expected conditions for each element type. (Fragmentation statistics methods are being developed by Forestry Division, Truro).

## Rare, Uncommon, and Threatened Species, Sites, and Habitats

Use the ecological land classification, significant habitats database, representivity analysis, and other landscape characterization theme mapping to identify uncommon species, sites, communities, habitats, and ecosections. This information will help planners identify the features within the ecodistrict that occur at a sub-landscape scale, and which may require special attention to conserve their uncommon characteristics. Lindenmayer and Franklin (2002) refer to the importance of identifying “midspatial-scale” features and “patch-level habitats”, including (1) aquatic ecosystems, such as streams, lakes, and ponds; (2) wildlife corridors; (3) specialized habitats, such as cliffs, caves, thermal habitats, meadows, and vernal pools; (4) biological hotspots or places of intense biological activity, such as calving sites, overwintering grounds, and spawning habitats; and (5) remnants of old forest. This exercise collates existing information and does not represent a complete inventory, thus planners must exercise caution as the occurrence of additional features can be expected.

*Step 9- Special Occurrences*

Map known and suspected locations, and complete the "Special Occurrences", and "Uncommon Ecosections" tables (Appendix 3). This should include:

Special Occurrences Table:

- Uncommon forest species for which genetic viability may be threatened (use the DNR Endangered Species Rating System - yellow and red listed).
- Species, sites, and habitats known in the ecodistrict from the Sighab database. Significant Habitats data consists primarily of recorded observations and does not represent a complete scientific inventory. Therefor IRM teams should add to this information using personal knowledge.
- Uncommon community conditions of note (eg. old age, tree size, species composition, etc.)

Uncommon Ecosections Table:

- Ecosections that form less than 2% of the Ecodistrict, or in which land use has removed more than 75 percent of the area from a forested state.
  - I. Verify the true existence of the ecosection.
  - ii. At both the ecodistrict and ecoregional levels record the extent of occurrence (ha, %), relative level of land use (EEC index), and abundance of the associated climax community type (ELC interpretation) using the following classes:

    Unique: < 1% of area, or less than 1000 ha
    Rare: 1 - 2 % of area
    Uncommon: 3 - 10 % of area
    Common: > 10 % of area

## Ecological Representation

Ecological Representation is a landscape ecology term describing the degree to which the range of natural ecosystem diversity is sustained in a naturally functioning, unmanaged, state. The concept was originally introduced as a strategic component of protected areas planning, where the aim was to secure the range of ecosystem diversity within reserve systems. The overall goal is biodiversity conservation through protection of natural habitat diversity. It is employed as a "coarse scale" ecosystem planning concept. Landscape analysis will evaluate and identify the reserve status of the ecosections and climax communities located within the Ecodistrict:

*Step 10 - Representivity*

Complete the Ecological Representation worksheet (Appendix 4) and Reserve Program Summary (Appendix 5) to evaluate the reserve status of all ecosections. Representation will consist of all lands classed as "Reserve" in the Ecological Emphasis Classification (see page 10). Begin with an evaluation of the ecosections to determine the accuracy of their classification, as well as their distribution within the larger ecoregional landscape. Two levels of reserve are recognized; legally protected reserves (IUCNI, II, III), and policy protected reserves.

## Road Index

Road, trail, and utility corridors are vital components of human land use. However transportation systems are expensive and have undesirable environmental effects such as water course siltation, exotic species invasion, habitat fragmentation, dispersal barriers, plant and animal mortalities, loss of productive land, and an overall increase in human presence. In order to reduce conflicts with natural systems and improve transportation safety it is necessary to incorporate landscape ecology into the planning of transportation networks. Techniques of road ecology include overlaying a spatial analysis of the transportation network with an ecological landscape analysis in order to identify potential points of conflict and compatibility. Selection of access routes should incorporate knowledge of landscape functions to improve compatibility with natural ecosystem flows and connectivity. Unroaded and lightly roaded areas are important features for biodiversity conservation that should be considered during planning. Efficient access systems should be strategically designed to minimize environmental impacts by incorporating factors such as harvest scheduling, road life expectancy, location, class requirements, decommissioning, and mitigation techniques.

The GIS based “Road Index” program calculates and maps the spatial influence of the transportation network. It provides consistent assessment and mapping of road distributions across EcoDistricts, and can help describe existing conditions, highlight management opportunities, and provide a valuable monitoring and indicator tool. It is a management tool designed to provide a spatial perspective to help planners integrate the transportation system into an ecological landscape analysis and design process. In addition to mapping, the index provides a numerical indicator of road influence that can be used to monitor temporal change and compare different landscapes.

*Step 11 - Road Index*

Begin with the most current Service Nova Scotia topographic series “road” and “utilities” layers to map the existing transportation network. Review and update this information using expert knowledge and satellite imagery to identify major changes. Analyse and map the spatial influence of the transportation network using the GIS based *"Road Index"* procedure outlined in Appendix 6. Identify major “nodes” of intersection between the transportation and ecological systems. Flip chart comments. Complete the road index worksheets in Appendix 7.

## Landscape Composition (Non-spatial)

Management of landscapes for biodiversity conservation involves maintaining the full variation of forest composition, through time, at levels appropriate for the inherent ecological structure. This “coarse scaled” approach strives to ensure that habitat for all native forms of wildlife (ie. biodiversity) is sustained at levels that are inherently natural at a landscape scale. Forested lands contribute to the maintenance and conservation of native biodiversity if a diversity of forest composition is sustained that reflects natural patterns of disturbance and succession. Human activities, such as forest harvesting, can have a significant influence on the structure and composition of the forested landscape. Forest harvesting can be applied to provide many of the structures associated with natural disturbances in the forest. There are three dominant disturbance regimes at work in a natural forest:

- Frequent Stand Initiating - disturbances usually occur more frequently than the average lifespan of the dominant species and are of sufficient intensity to kill most of the existing mature trees, thereby promoting the establishment of a new forest within a relatively short period of time.
- Infrequent Stand Initiating - the time between stand initiating disturbances is usually longer than the average longevity of dominant species, thereby supporting processes of canopy gap formation and understory development in mature forests.
- Gap Replacement - an absence of stand initiating disturbances supports the development of a dominant overstory that is sustained through dynamic processes of canopy gap formation, understory development and overstory recruitment. Gap formation ranges from individual tree mortality to periodic gap forming events that are rarely of a stand initiating intensity.

For more information on natural disturbances in Nova Scotia refer to the report *A Spatial Application of Natural Disturbance Regimes to the Ecological Land Classification for Nova Scotia* Neily et.al, 2008, Department of Natural Resources, Ecosystem Management Group, Truro.

Forest disturbances lead to forest renewal and the development of forest habitats following characteristic successional patterns. At a landscape scale, the variety of habitats thus produced can be coarsely described in terms of the composition of development classes, seral stages, and vegetation communities (Appendix 8 & 9). Management of landscapes to conserve biodiversity requires sustaining an ecologically adequate composition of this habitat diversity.

Development classes describe changes in structure and process as forests age. For landscape management purposes, four development classes are recognized;

- forest establishment
- young forest:
- mature forest
- multi-age/old growth forest

Seral stages describe the successional progress of forests from the typical domination of early seral “pioneer” species following disturbance towards late seral communities dominated by long-lived “climax” species. Thus seral stage is dependant upon the tree species composition of a forest, irrespective of age. For landscape management purposes, three seral stages are recognized;

- early
- mid
- late

Vegetation Community Types provide a further refinement of landscape composition. The Department of Natural Resources Forest Model provides a GIS based classification of 12 vegetation communities based on 3 covergroups. These have general correspondence to specific seral stages.

- softwood covergroup
    - red/black spruce dominant *(late seral)*
    - white spruce dominant *(early seral)*
    - balsam fir dominant *(early seral; late in ecodistricts 100, 210, 810, 820)*
    - spruce/fir dominant *(mid seral; late in ecodistricts 100, 210, 810, 820)*

- pine dominant *(mid to late seral)*
- mixed spruce/pine/hemlock *(late seral)*

- mixedwood covergroup
  - tolerant mixedwood *(late seral)*
  - intolerant mixedwood hardwood dominant *(early to mid seral)*
  - intolerant mixedwood softwood dominant *(early to mid seral)*

- hardwood covergroup
  - tolerant hardwood *(late seral)*
  - tolerant/intolerant hardwood *(mid seral)*
  - intolerant hardwood *(early to mid seral)*

The forest composition should contain a range of conditions that sustain the inherent forest communities and dominant natural disturbance regimes. The following table provides an interim indication of desirable composition levels for dominant ecosystems. Further guidance will be developed through the Code of Forest Practice (NSDNR, 2004):

| Natural Disturbance Regime | *Landscape Composition by Development Class / Seral Stage* | | | |
|---|---|---|---|---|
| | Establishment | Young Stem Exclusion | Mature (including multi-aged and old growth) | Multi-aged and Old Growth |
| Frequent Stand Initiating | 5 - 30% | 5 - 30% | >40% **early, mid, & late seral representation** | >8% |
| Infrequent Stand Initiating | 5 - 20% | 5 - 20% | >60% **most in mid and late seral stages** | >16% |
| Gap Replacement | 0 - 15% | 0 - 15% | >70% **most in late seral stage** | >24% |

*Step 12 - Development and Seral Stage Composition*

Complete the Forest Landscape Composition Worksheet (Appendix 10) to summarize the existing forest composition and provide a comparison to the potential climax forest composition interpreted in the ecological land classification

*Step 13 - Vegetation Community Classification*

Summarize the distribution of vegetation communities within each of the major landscape elements (Appendix 10 - Table 2) and the abundance of potential climax forest types (Appendix 10 - Table 3).

# Ecological Emphasis Classification (EEC)

A variety of land management practices occur across landscapes, ranging from undisturbed natural protected areas to highly modified urban environments. Conserving biodiversity requires a balance of land uses in which practices which sustain ecological integrity dominate. To assist managers in assessing land use intensities and develop appropriate practices, four levels of conservation are defined based on the degree to which the conservation of natural conditions is emphasized in the management practices and policies applied to the land (Appendix 11). All lands within an ecologically defined area (eg. ecodistrict landscape, or landscape elements) are assessed at the stand level of the GIS forestry database layer, and assigned to one of the four "ecological emphasis classes". The proportion of land in each of the classes can be used to calculate an "ecological emphasis index" as an indicator of overall land use intensity.

## Ecological Emphasis Classes

*Reserve Class*

Reserved lands which meet biodiversity conservation goals through preservation of natural conditions and processes. Resource management activities are not usually permitted except where required to perpetuate desired natural conditions. This class is assigned based on the types of laws and policies governing the management. (For example: Wilderness, Parks, Conservation Easement, Old Forest Policy)

*Extensive Management Class*

Lands in the managed landscape with ecologically based management activities that conserve biodiversity and sustain natural structure and functions. Forestry practices maintain native species composition and consider natural disturbance regimes, successional trends, and important elements of ecological structure. Natural regeneration is favoured to provide the next forest. Generally, these lands are in a natural condition, support a moderate level of resource production, and meet multiple resource objectives.

The determination of class is ultimately dependant upon site level evaluation of prescriptions, practices, and conditions (eg. using Forest Code of Practice guidelines employing Forest Ecosystem Classification). However, GIS inventories, coupled with local knowledge, can provide an initial estimate of the extent of these lands across landscapes. This will include most untreated land, as well as tending operations in which natural regeneration is being managed and a diversity of species and structure is expected to occur.

*Intensive Management Class*

Lands managed intensively to optimize resource production from sites maintained in a native state (eg. forested). Management may eliminate or reduce the duration of some development stages and successional processes, particularly mature old forest stages. Practices may produce unnatural conditions such as exotic species, old field spruce, monoculture plantations, or altered structure and composition. Forests are protected from fire, insects, and competing vegetation, and site productivity is maintained. Despite the potential for a reduction of biodiversity on these lands, intensive management areas contribute substantially to landscape function, structure, and composition. Management adheres to environmental regulations and policies such as the Habitat Sustainability Regulations, and Forest Code of Practice.

The determination of class is ultimately dependant upon site level evaluation of prescriptions, practices, and conditions (eg. using Forest Code of Practice guidelines). However, as with the Extensive Class, GIS inventories coupled with local knowledge can be used to provide an initial estimate of the extent of these lands across landscapes (eg. plantations with less than 30 percent natural

regeneration, exotic species, off-site native species, genetically modified organisms, stand conversion, and herbicide sites).

*Converted Class*

Areas converted to an unnatural state for human use, or in which inherent site productivity has been degraded (For example: agriculture, urban, power lines, roads, mines).

## Ecological Emphasis Index

The ecological emphasis index (EEI) provides an indication of the degree to which land management practices within an ecosystem are directed towards conserving natural ecosystems. The index has a potential range of 0 to 100 (completely converted to completely protected). Under step 14, all lands within the landscape ecosystem are evaluated at the stand level to determine their ecological emphasis class. The index is calculated by applying a contribution factor to each class and then summing the "effective" proportion of land in each category. There are many ways to get the same score, and the index provides a rough cut at indicating the level of ecological pressures. It can be applied to any unit, a connective corridor, ELC unit, ownership, landscape element, etc. This information should help when strategically planning activities, such as restoration priorities, conservation areas, intensive management areas, etc. Because there are many combinations available to get the same relative score, it should foster creative thinking regarding striking balances among land use practices. Ecological emphasis index contribution factors are as follows:

*Reserve Class* - 100%;
*Extensive Management Class* - 75%;
*Intensive Management Class* - 25 %;
*Converted Class*- 0 %.

*Step 14 - Ecological Emphasis Classification and Mapping*

Use the most current GIS inventory to classify and assign an ecological emphasis class to each stand in the forestry database layer. Map the resulting EEC distribution across the Ecodistrict. Use local expert knowledge to review and revise the GIS based classification to best match the appropriate emphasis class to the existing stand conditions. This will generate mapping of the "existing" Ecological Emphasis Classification as a final landscape analysis product.

*Step 15 - Ecological Emphasis Index Calculation*

Complete the Ecological Emphasis Index Worksheets (Appendix 12a & 1b) to summarize the distribution of ecological emphasis classes and index values among ecosections and landscape elements.

## Landscape Analysis Synthesis

The process of landscape analysis allows the resource and planning specialists involved to gain an intimate understanding of the ecodistrict. This new perspective will provide a critical basis for the future development of integrated plans and landscape designs that achieve multiple strategic objectives. The steps followed in the foregoing analysis involved a broad range of issues that must be synthesized to highlight the major findings and identify important gaps and issues. A summary report should allow managers from diverse land ownerships to obtain a collective perspective of overall landscape function, and thereby achieve some harmony and compatibility between their differing planning objectives.

1. Complete ecological analysis by producing a mapping synthesis that highlights major structures, identifies important features, and notes gaps and issues.
2. Produce an arcview project file containing the digital theme layers developed through the process.
3. Produce a report summarizing major findings and describing results from each step.

# Literature

Bruce, James and Bruce Stewart. 2005. *Development of a "road index" for landscape level assessment of linear transportation features using density, distance, and class measures*. Unpublished report.

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# Appendix 1: Flow - Element Interactions Worksheet

| Matrix Elements | Deer | Moose | Water | Humans | Fish | Furbearers | Birds Goshawk | Reptile & Amphibians | Bats | Rodents |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

| Corridor Elements | Deer | Moose | Water | Humans | Fish | Furbearers | Birds Goshawk | Reptile & Amphibians | Bats | Rodents |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

| Patch Elements | Deer | Moose | Water | Humans | Fish | Furbearers | Birds Goshawk | Reptile & Amphibians | Bats | Rodents |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
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| | | | | | | | | | | |

Note: Select a suite of flows to best illustrate the functions and operating scales of the landscape elements (not necessarily the examples used in these tables).
Briefly note the nature of interactions, and highlight the boxes with the most important relationships.

# Appendix 2: Landscape Connectivity Worksheet

| Feature | Structure Type *(corridor, matrix, island)* | Importance in EcoDistrict *(high, moderate, low)* | Significant Cases *(species, EcoSections, Specific Rivers,...)* | Scale and Pattern of Operation *(local, landscape...)* | Associated Natural Disturbance Regime | Characteristic Community | Characteristic Neighbour(s) | Barriers - Impediments to Functionality | Significant Issues | Management Strategy |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
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| | | | | | | | | | | |

**Connective Management Strategies**:

| Structure Type | Attributes | Conditions of Concern | Management Strategies |
|---|---|---|---|
| **Linear Corridors** | continuous connection | barriers, interruptions, excessive edge | 1. Mitigate unnatural barriers<br>2. Map and Manage along natural boundaries<br>3. Conserve “interior” conditions where appropriate through strategic management of neighbouring ecosystems<br>4. Sustain continuity, through management of overstory and interior structure appropriate to Natural Disturbance Regime<br>5. Follow habitat reg’s for buffer management. Establish wider buffers with natural boundaries along major waterways |
| **Patch Ecosystems** | patch size, nearest neighbour, edge/interior, intervening habitat condition | undesirable connections, internal composition, excessive separations, threats to key patch | 1. Identify and map key patch representatives (high quality, or critical link/distance)<br>2. Maintain natural isolations, as well as necessary “nearest neighbour” distances<br>3. Identify potential metapopulation habitat dynamics (if applicable) |
| **Matrix** | percolation, large patch, interior habitat | fragmentation, excessive edge | 1. Promote contiguous forest structure using strategies such as patch aggregation and overstory sustaining selection cutting.<br>2. Promote large patch structure and interior conditions<br>3. Mitigate large scale, long term, fragmentation of the matrix that could impede percolation.<br>4. Manage age and structure appropriate to NDR. For gap and infrequently disturbed ecosections maintain ≥ 60 % mature cover. |

# Appendix 3: Special Occurrences Worksheet

Table 1: Rare, uncommon & threatened species, sites & habitats"

| Feature | Type | Information Source | Legal Designation | Class |
|---|---|---|---|---|
| | *Species, Habitat, Ecosystem, or Community Type* | *eg. Sig.Hab. Database, ELC* | *COSEWIC, Endangered Species Act, other Acts...* | *Red or Yellow listed, Climax Abundance (unique, rare, uncommon, common) etc.* |
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Table 2: Comparison of Ecological Emphasis Index by ecosection within the ecodistrict and ecoregion. Ecosections that form less than two percent of ecodistrict area or are more than 75 percent converted are highlighted. The table provides a sense of how unique an uncommon ecosection and its associated climax communities are within the ecodistrict and across the ecoregion. The EEC Index value conveys an indication of relative land use pressure on the ecosection.:

| Ecosection | Climax Type | EcoDistrict Occurrence | | | | | | EcoRegion Occurrence | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area of Ecosection | | Area of Climax Type (1,2,3)[1] | | EEC Index ecosection | Percent Converted | Area of Ecosection | | Area of Climax Type (1,2,3)[1] | | EEC Index ecosection | Percent Converted |
| | | Ha | %of Distr. | Ha | %of Distr. | | | Ha | % of Region | Ha | %of Region | | |
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[1]Area of climax type (1,2,3) is the total area of that climax type across all ecosections within the ecodistrict or ecoregion.

# Appendix 4: Ecological Representivity Worksheet

| Ecosystem | | | Crown Responsibility | Legal Reserve ( IUCN I, II, III) | | Policy Reserves (including unproclaimed legal reserve proposals) | | Ecological Emphasis Classification "Reserve Class" | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EcoSection | Climax Type | A rea (ha) | Percent of Area on Crown (%) | Crown Area (ha) | Private Area (ha) | Crown Area (ha) | Private Area (ha) | Crown | | Private | | Total Reserve | |
| | | | | | | | | ha | % (EcoS) | ha | % (EcoS) | ha | % (EcoS) |
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| Total | | | | | | | | | | | | | |

# Appendix 5: EcoDistrict Reserve Program Summary

| Legal Reserves ( IUCN I, II, III) | | | Policy Reserves (including unproclaimed legal proposals) | | |
|---|---|---|---|---|---|
| Act -Designation | Area by Ownership | | Policy - Program | Area by Ownership | |
| | Crown (ha) | Private (ha) | | Crown (ha) | Private (ha) |
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# Appendix 6: Description of Road Index

Road, trail, and utility corridors provide the background structure for transporting people and goods and are integral components of human land use. However transportation systems are expensive and have a wide range of negative environmental impacts including, water course siltation, habitat fragmentation, dispersal obstruction, plant and animal mortality, exotic species invasion, loss of productive land, and an overall increase in human presence (Forman & Deblinger 2000, Reed et. al. 1996, Lindenmayer & Franklin 2002). In order to reduce conflicts with natural systems and improve transportation safety there is clearly a need to incorporate landscape ecology into the planning of transportation networks (Forman 2004, Forman & Hersperger 1996, Spellerberg 1998). The emerging science of road ecology advocates integrating spatial analysis of the transportation system with ecological landscape analysis as a fundamental step in transportation system planning (Forman 1999, Lindenmayer & Franklin 2002, Diaz & Appostol 1992).

Efficient access systems can be strategically designed to minimize environmental impacts by incorporating factors such as harvest scheduling, life expectancy, location, road class requirements, decommissioning, and mitigation measures (Lindenmayer & Franklin 2002, Forman, 2004). Selection of transportation routes should incorporate knowledge of landscape functions to improve compatibility with natural ecosystem flows and connectivity (Forman & Hersperger, 1996). Furthermore unroaded and lightly roaded areas are important for biodiversity conservation and should be considered during planning (USDA Forest Service 1999).

The GIS based "Road Index" procedure calculates and maps the spatial influence of the transportation network. It is a management tool designed to help planners gauge the relative influence of man-made linear features within landscapes. It was designed to help integrate the transportation system into an ecological landscape analysis process. In addition to mapping, the index provides a numerical indicator of road influence that can be used to monitor temporal changes and compare different landscapes.

**Main Concepts:**

The influence of the transportation network on the ecological landscape varies with 3 main factors: 1) the type of transportation feature (e.g. highway, powerline, trail, etc.); 2) the density of linear features in a given area, and 3) the distance of an area from transportation features (Forman 2004, Lindenmayer & Franklin 2002, Forman & Deblinger 2000). The Road Index is a weighting of these 3 factors reflecting their relative influence on ecosystem function.

Road density has a well documented influence on many factors, including wildlife movements, fragmentation, human access, hydrology, and fire patterns (Forman and Hersperger, 1996). Forman & Deblinger (2000) report great variance in road effect zones, with average cumulative effects extending 300 metres from road edges, and some impacts penetrating up to a kilometre. Consequently, Index values are determined by assessing the transportation network within a 1 kilometre radius. The Index algorithm is applied to a grid of 1 hectare squares representing the landscape in question. The calculation provides a measure of the density of the transportation network and the specific distance to the transportation features. The resulting index values are scaled to provide a potential range of 0 to 100. For the purpose of map interpretation these values have been grouped into benchmark ranges that reflect characteristic patterns of land use in Nova Scotia.

In Nova Scotia, as in most populated jurisdictions, transportation networks are continuously changing as new roads and utilities are constructed and unused roads and trails deteriorate. As such, any analysis of the current state of these features must be based on reasonably up to date data. In this province, the Geomatics Centre, administered by Service Nova Scotia and Municipal Relations, is responsible for mapping transportation

features which they include in their 1:10000 Topographic series mapping. On a provincial level, this work is updated on a ten year repeat cycle and includes changes to existing features and the delineation of new features. Before undertaking road analysis, the Geomatics Centre should be contacted to ensure that the most current data is used to calculate the Road Index values. This data should be further updated using Landsat satellite imagery to add significant new roads and utilities that are over 500 metres in length on lands currently with a remote or forest resource index value. Department of Natural Resources Forestry Branch maintains a table relating the Topographic series attribute coding used by the Geomatics Centre to the feature categories used in the Road Index calculations, along with Arcview programs allowing the data to be formatted correctly. An inventory of recent Landsat satellite images is also available.

**Calculation Details (Appendix I - Road Index Grid aml):**

1. The initial step in arriving at an index score is the calculation of a "density" measure and a "distance" measure for each feature type.
   - The Density measure is derived from the ratio of linear meters per meters$^2$ within a 1 km radius of a given 1 hectare pixel.
   - The Distance measure is a function of the distance from a given 1 hectare pixel to the nearest linear feature to a maximum distance of 1 km.
   - The density and distance measures are each scaled from zero to ten in order to give them equal weighting.
   - The measures are then summed and the result is divided by two to produce a "feature score" ranging from 0 - 10.

2. The feature types are then weighted to reflect an intuitively rational, but arbitrarily derived, opinion on the relative impact of the feature type on an ecosystem (Table 1).

3. The final Road Index score is derived by summing each of the separate feature type scores to provide an overall Road Index value with a potential range of 0 to 100:

   Road Index = (Trail score + (Utility score * 3) + (All feature score * 5) +
   (Gravel road score * 6) + (Paved road score * 10) + (Highway score * 15)) / 4

Table 1. Weights and descriptions of the feature types.

| Weight Factor | Feature Type | Description of Ecological Consequence |
|---|---|---|
| **1** | Tracks, Trails, Abandoned Railroads & Roads | Narrow often with closed canopy, minor barrier, variable disruption, low mortality, minor invasive advantage, habitat change largely restricted to ROW |
| **3** | Utility Corridors, Pipelines, High Voltage Transmission | Sometimes a very wide behavioral barrier, variable disruption, low mortalities, some invasive advantage. Habitat change largely restricted to ROW |
| **5** | All Features | The "all features" category is used to account for the overall density of all man made linear features regardless of type. This includes; trails, abandoned railroads, active railways, all utilities features and all mapped roads. |
| **6** | Gravel Access Roads, Active Railways | Wide physical and behavioral barrier, frequent disruption, some mortality, invasive advantage frequently noted, some permanent land use change mostly related to forestry and resource extraction. |
| **10** | Paved Collector Roads | Wide physical and behavioral barrier, frequent to continuous disruption, frequent mortality, highest invasive advantage, ease of access increases permanent land use change. |
| **15** | Divided Highways | Very wide physical and behavioral barrier, continuous disruption, high mortality, invasive advantage. Habitat change largely restricted to ROW |

Note: Mechanism of deleterious effects considered (Forman & Deblinger 2000, Lindenmayer & Franklin 2002):

- Noise and disruptive presence
- Physical or behavioral barrier
- Mortality, vehicular impacts, poisoning, hunting, gathering
- Competition, invasive species
- Habitat change due to increased land use

## Development of Road Index Benchmarks for Land Use Types

Interpretation of the Road Index score is facilitated by correlating index values to familiar patterns of land use. To this end, the relationship between broadly recurring patterns of land use within the province and their corresponding index scores was investigated. After studying the distribution of roads, trails and utility corridors, along with the most recent inventory information concerning urban and rural land use as well as satellite imagery, five basic repeating patterns of land use were identified: Urban, Suburban-Agricultural, Mixed Rural, Forest Resource, and Remote Landscape. These land use categories were mapped at a coarse scale and intersected spatially with the Road Index values (Figure 1). The summary statistics generated allowed the distribution of index scores for each land use category to be examined (Table 2). The figures indicate that the interpretation of land use pattern was reflected in the statistical distribution of index values. The means and standard deviations were then used to develop benchmark index ranges for typical land use patterns (Table 3) (Figure 2).

Table 2. Summary of road index values for typical land use patterns in Nova Scotia.

| Land Use Pattern | Road Index Value | | |
|---|---|---|---|
| | Maximum | Mean | Standard Deviation |
| Remote Landscape | 46 | 2.4 | 4.9 |
| Forest Resource | 72 | 9.6 | 7.3 |
| Mixed Rural | 73 | 18.6 | 6.6 |
| Agriculture Suburban | 80 | 28.1 | 11.8 |
| Urban | 82 | 51.6 | 11.6 |

Note: The Road Index has a potential range of values from 0 to 100.

In discussing road ecology, Forman (2004) describes five distinctive landscape types in North America: city-suburb, agricultural, forestry, arid-grassland, and natural landscape. Each has a characteristic pattern of road networks with distinctive ecological effects and planning considerations (Forman & Hersperger 1996). Except for the lack of an "arid-grassland" class, these patterns correspond closely with those observed in Nova Scotia and used to benchmark the road index ranges. The addition of a "mixed rural" class recognizes a fine scale integration of an urban-agriculture-forestry setting which exists in the rural areas of Nova Scotia.

Table 3. Road index benchmark value ranges and descriptions for land use classes.

| Road Index Benchmark Range | Land Use Class | Land Use Pattern |
|---|---|---|
| 0 - 6 | Remote Landscape | Unpopulated areas with very few roads, trails or other linear features. |
| 7 - 15 | Forest Resource | Areas without significant settlement where forest resource access roads are the primary linear feature . |
| 16 - 24 | Mixed Rural | Areas of mixed land use comprised of rural settlement, forest resource and some agriculture |
| 25 - 39 | Agriculture / Suburban | Areas dominated by suburban settlement and/or open agricultural field |
| 40 - 100 | Urban | Typical urban environment with high building densities and road access and few tracts of undeveloped land outside municipal parks. |

Note: The benchmark ranges represent the distribution of road index values typical for each land use class, and do not define spatial categories. For example, road index values typical of a "urban" area may occur in a "forest resource" environment, and values typical of the "remote access" class will be found in an "urban" setting. The ranges are meant to benchmark the Road Index values to known land use patterns, and not to serve as definitive classes.

### Application of Road Index tool in Ecological Landscape Analysis and Design Process

- Identify how proposed harvest plans will effect the distribution of road index values within an ecosection
- Set targets for road index values within ecosections
- Identify the percentage of an ecosection with a remote access character
- Identify ecosections within a planning unit significantly affected by anthropogenetic linear features.

- Target specific instances of an ecosection showing no road influence for special management (reserve or road exclusion or road type exclusion)
- Identify optimum roads that could be decommissioned to meet ecosystem management targets
- Identify corridor opportunities between ecologically related landscapes
- Plan road routes to meet road index targets
- Relate species abundance to road index values or factors

**Literature Cited**

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USDA Forest Service.1999. *Roads analysis: informing decisions about managing the national forest transportation system*. Misc.Rep FS-643. Washington, D.C.: U.S. Department of Agriculture, Forest Service. 222 p.

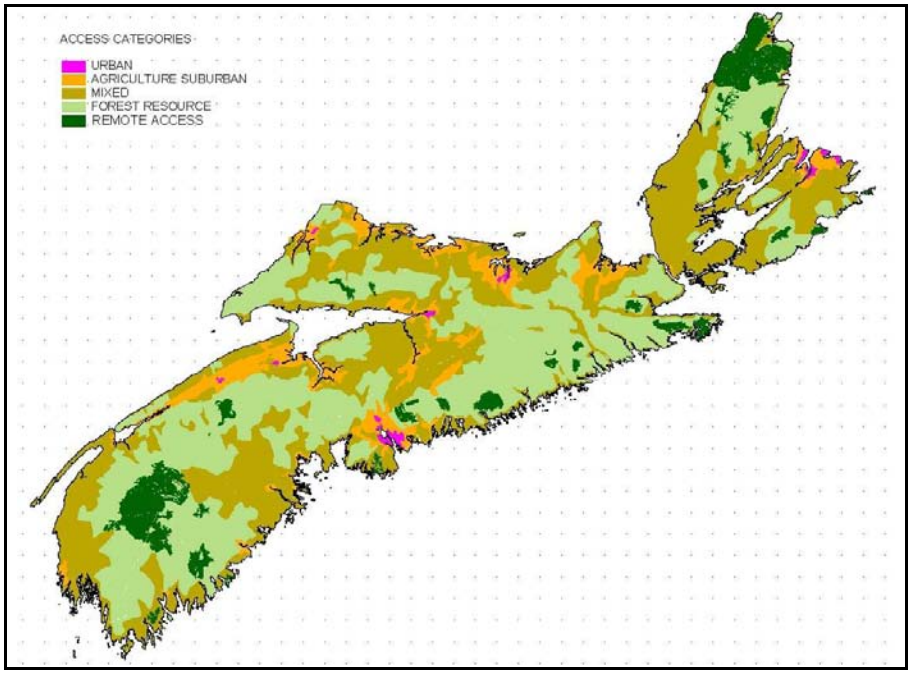


Figure 1. Visual mapping of land use categories at a coarse scale.

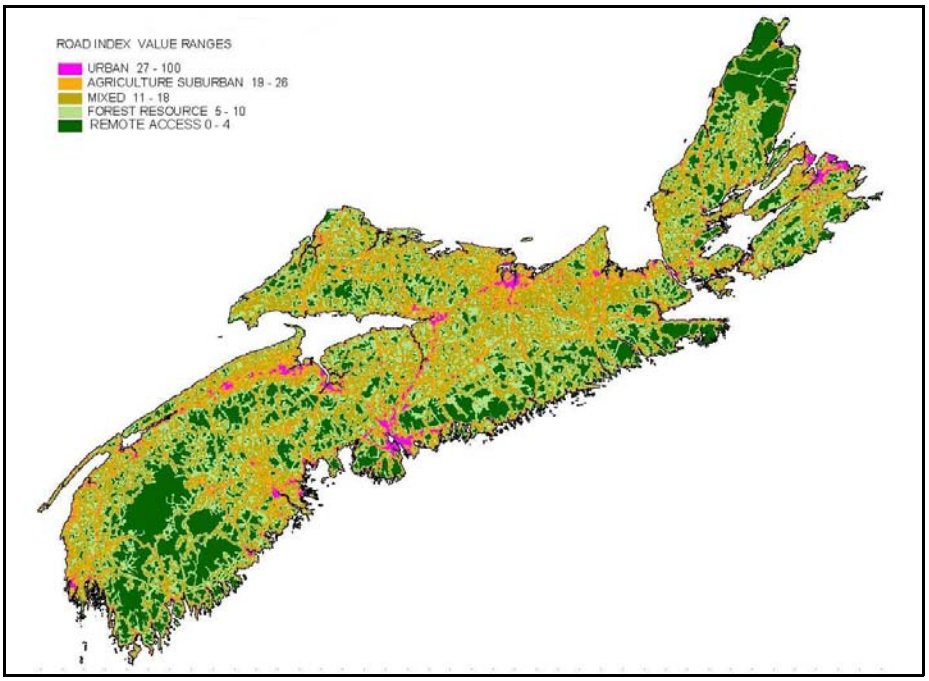


Figure 2. Map of Road Index land use classes using 1 hectare grid for Nova Scotia.

# Appendix 7: Road Index Worksheets

Table 1. Length of access systems and index weighting for the different road types..

| Road Type | Road Index Weighting | Length (km) |
|---|---|---|
| Trails (incl abandoned rail) | 1 | |
| Utility corridors (Pipelines, High Voltage Transmission) | 3 | |
| Gravel Roads, Active Railways, Airstrip | 6 | |
| Paved Road | 10 | |
| Divided Highways | 15 | |

Table 2. Distribution of road index classes.

| Road Index Value | | Area of Ecodistrict Affected | |
|---|---|---|---|
| **Indication** | **Range** | **Hectares** | **Percent** |
| Remote | 0 - 6 | | |
| Forest Resource | 7 - 15 | | |
| Mixed Resource & Rural Settlement | 16 -24 | | |
| Agriculture & Suburban | 25 - 39 | | |
| Urban | 40 - 100 | | |
| **All** | | | |

Table 3. Road index values for each landscape element type.

| Landscape Element | Area (ha) | Road Index |
|---|---|---|
| | | |
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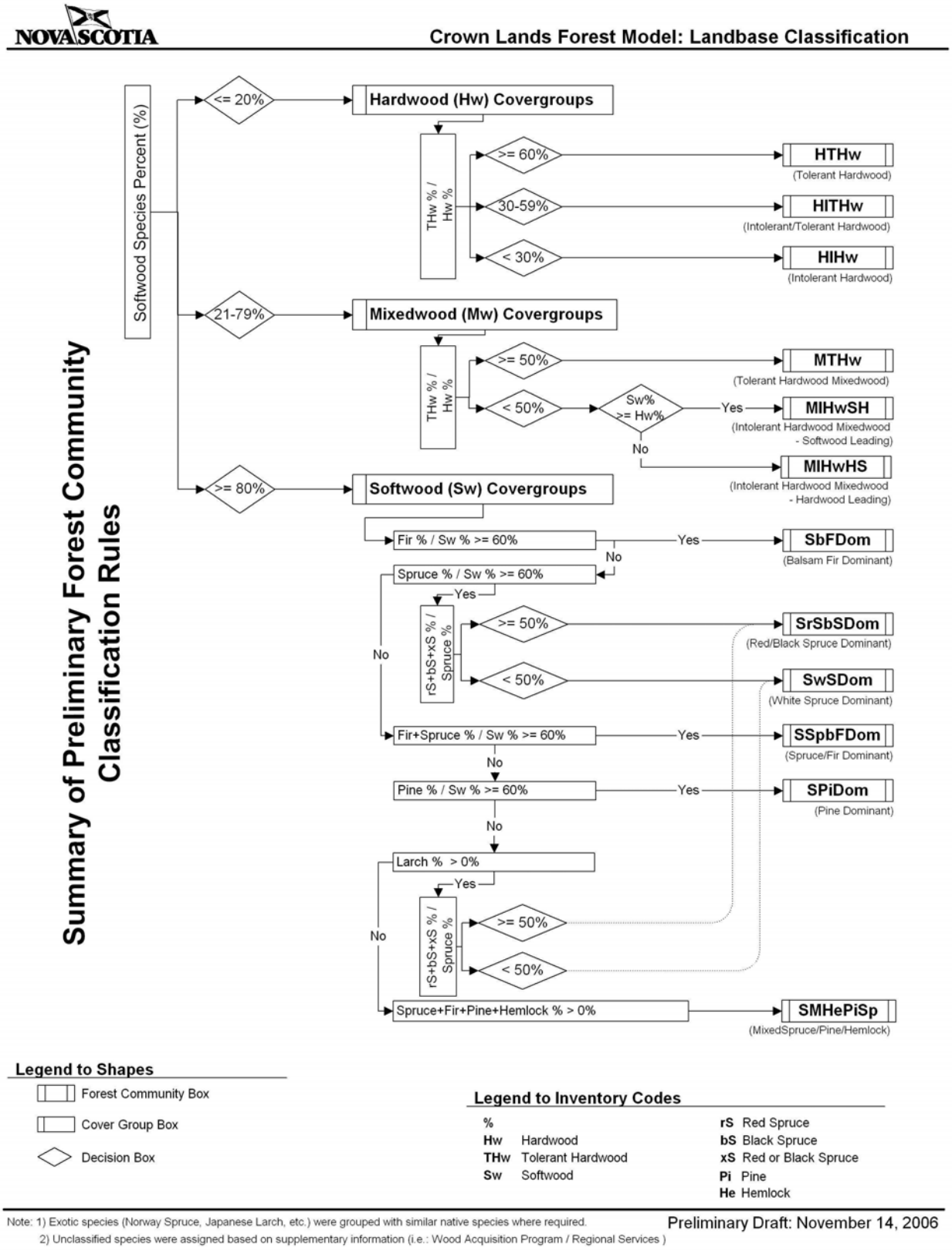
| | | |
| **Over All** | | |

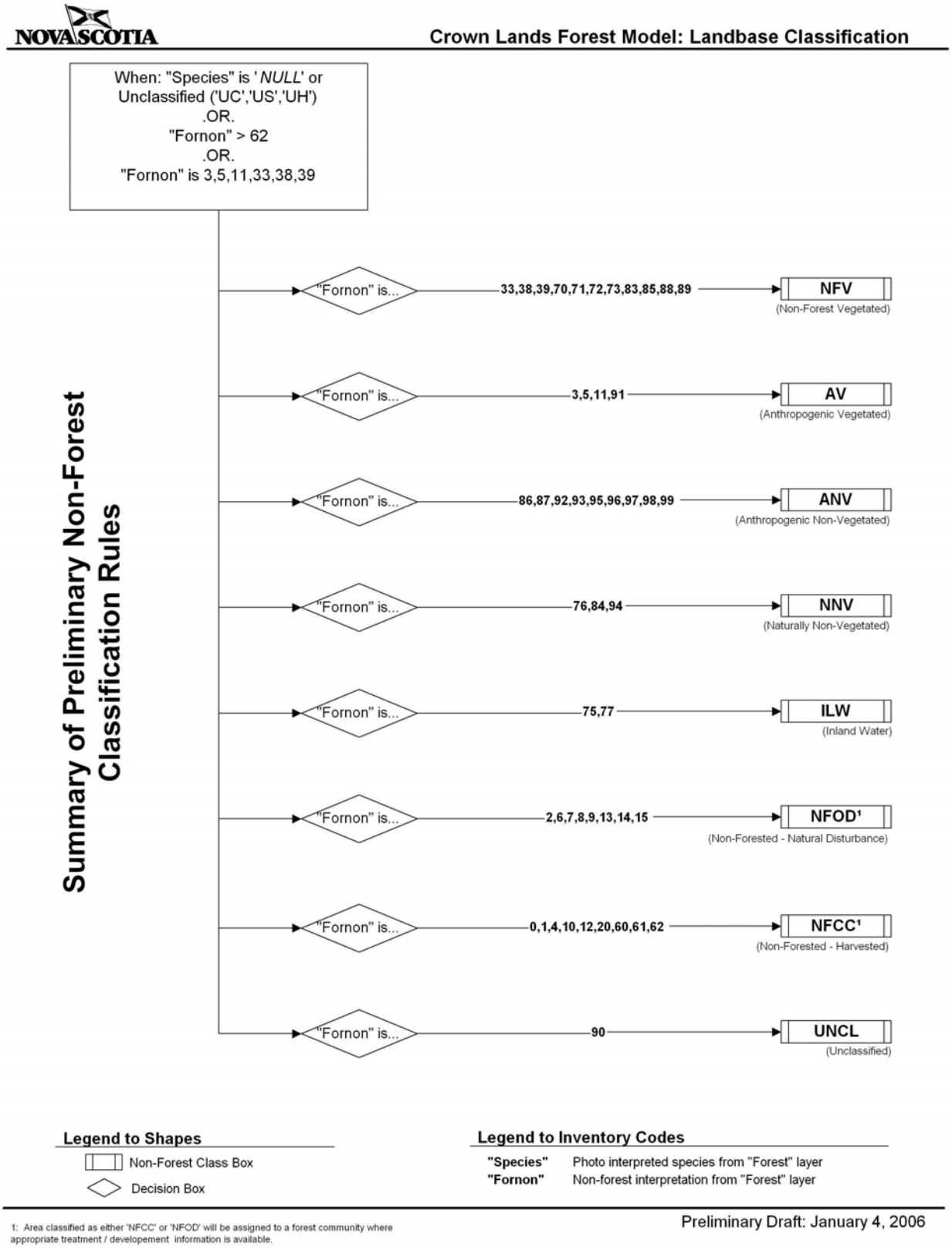
# Appendix 8: Development Class and Seral Stages

| Development Class | Seral Stage[1] |
|---|---|
| **1. Forest Establishment** (*Height 0 - 6 m)*<br>! establishment of new growth following a stand initiating disturbance<br>! high diversity of forbs, shrubs, and tree regeneration, many of which are short-live shade intolerant "pioneer" species<br>! peak seed production by forbs and shrubs<br>! Approximate age 0 - 25 years | **Early Seral Species** *(Score 10 - 23)*<br>- new growth dominated by pioneer tree species or unclassified regeneration |
| | **Mid Seral Species** *(Score 24 - 37)*<br>- regeneration composed of a mixture of pioneer, mid-climax, and climax species |
| | **Late Seral Species** *(Score 38 - 50)*<br>- regeneration dominated by climax species |
| **2. Young Forest** *(Height 7 - 11 m)*<br>! young forests with developing tree canopies characterized by vigorous self-thinning and crown differentiation<br>! early tree seed production, no understory development<br>! Approximate age 25 - 40 | **Early Seral Species** *(Score 10 - 23)*<br>- canopy dominated by pioneer tree species |
| | **Mid Seral Species** *(Score 24 - 37)*<br>- canopy composed of a mixture of pioneer, mid-climax, and climax species |
| | **Late Seral Species** *(Score 38 - 50)*<br>- canopy dominated by climax species |
| **3. Mature Forest** *(Height > 11 m)*<br>! Stands dominated by upper canopy with full differentiation into dominance classes<br>! self-thinning process reduced<br>! tree seed production prominent and regular<br>! individual tree mortality creates canopy gaps that are soon closed by neighbouring tree growth<br>! increased light initiates regeneration and early understory development<br>! Approximate age 40 - 125 years | **Early Seral Species** *(Score 10 - 23)*<br>- canopy dominated by pioneer species<br>- overmaturity initiates canopy breakup and understory development |
| | **Mid Seral Species** *(Score 24 - 37)*<br>- climax species in mixture with pioneers in the overstory<br>- often reflecting a transition to climax domination following a period of sub canopy development |
| | **Late Seral Species** *(Score 38 - 50)*<br>- canopy dominated by climax species<br>- overmaturity initiates gap dynamic processes leading to multi-age and old growth conditions |
| **4. Multi-aged and Old Growth Forest** *(Age 999 or Old Growth ID*)<br>! dominant overstory exhibiting a variety of crown sizes and canopy densities<br>! canopy gaps promote development of multi-layered understory and recruitment to overstory | **Early Seral Species** *(Score 10 - 23)*<br>- canopy likely to break up and be replaced by developing understory |
| | **Mid Seral Species** *(Score 24 - 37)*<br>-Pioneer dominated overstory with canopy recruitment from a climax species dominated understory. |
| | **Late Seral Species** *(Score 38 - 50)*<br>- climax species dominated overstory maintained through gap dynamic processes. |

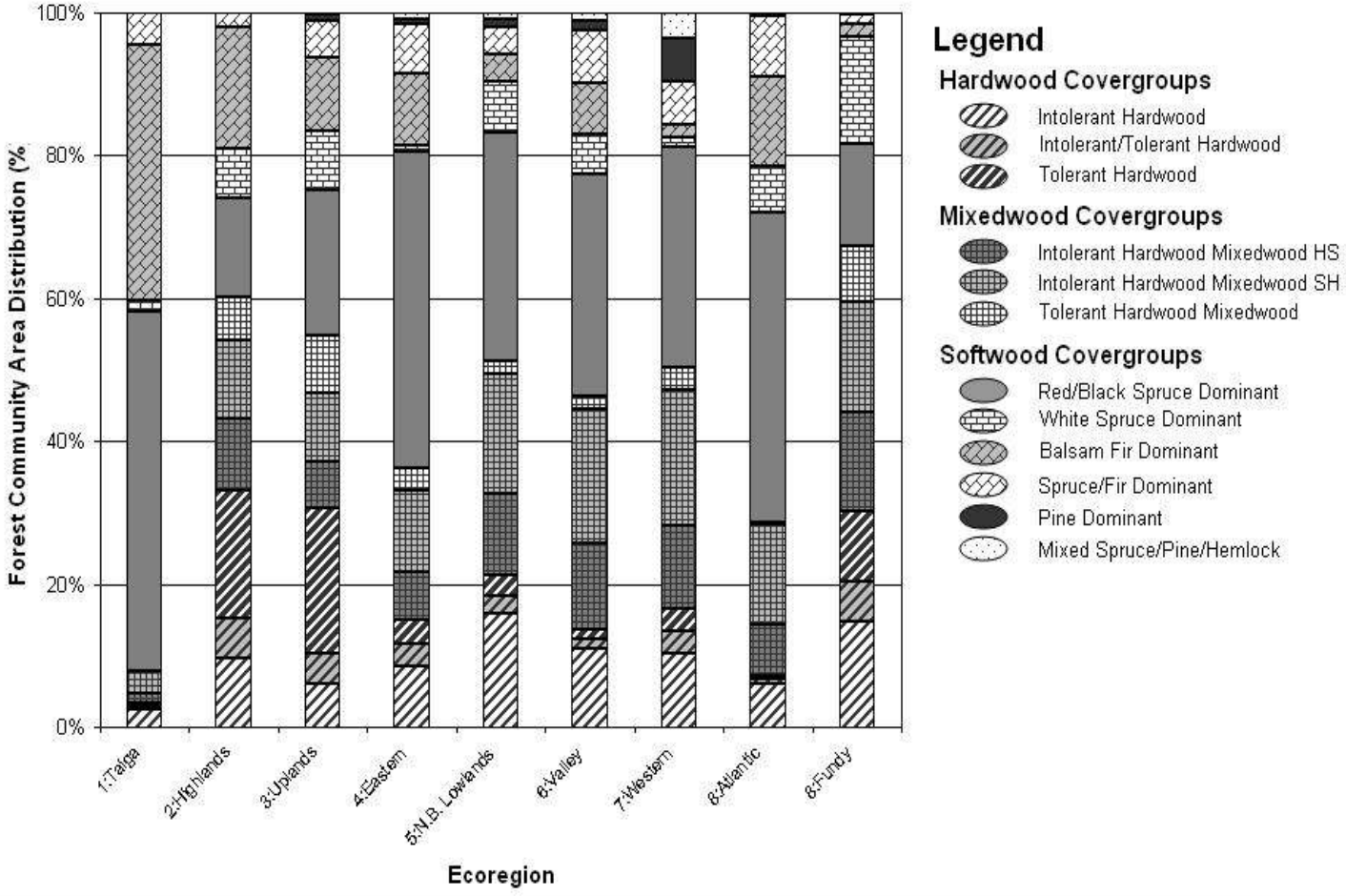
[1] Seral stage classification and scoring - DNR Wildlife Division, Habitat Management Section

# Appendix 9: Forest Community Classification




NOVA SCOTIA
Crown Lands Forest Model: Landbase Classification
When: "Species" is 'NULL' or Unclassified ('UC','US','UH')
.OR.
"Fornon" > 62
.OR.
"Fornon" is 3,5,11,33,38,39
Summary of Preliminary Non-Forest Classification Rules
"Fornon" is... 33,38,39,70,71,72,73,83,85,88,89 → NFV (Non-Forest Vegetated)
"Fornon" is... 3,5,11,91 → AV (Anthropogenic Vegetated)
"Fornon" is... 86,87,92,93,95,96,97,98,99 → ANV (Anthropogenic Non-Vegetated)
"Fornon" is... 76,84,94 → NNV (Naturally Non-Vegetated)
"Fornon" is... 75,77 → ILW (Inland Water)
"Fornon" is... 2,6,7,8,9,13,14,15 → NFOD¹ (Non-Forested - Natural Disturbance)
"Fornon" is... 0,1,4,10,12,20,60,61,62 → NFCC¹ (Non-Forested - Harvested)
"Fornon" is... 90 → UNCL (Unclassified)
Legend to Shapes
Non-Forest Class Box
Decision Box
Legend to Inventory Codes
"Species" Photo interpreted species from "Forest" layer
"Fornon" Non-forest interpretation from "Forest" layer
1: Area classified as either 'NFCC' or 'NFOD' will be assigned to a forest community where appropriate treatment / developement information is available.
Preliminary Draft: January 4, 2006

## Nova Scotia Forest Inventory Area Distributions by Proposed Forest Community Grouping and Ecoregion



# Appendix 10: Forest Landscape Composition Worksheets

**"All Land Inherently Capable of Supporting Forest"**

Table 1. Summary of development classes and seral stages by landscape element.



| Element | Eco-section (% land area) | CoverType | Climax Species (M=Mid; L=Late Seral) | Natural Distur-bance Regime | Total Land Area of Potential Forest (ha; %) | Seral Stage | Current Forest - GIS Inventory: Development Class (ha) Establi-shment (1) | Young Forest (2) | Mature Forest (3) | Multi-age (4) | Total Forested Area (ha) | Cover Type (ha; %) | Seral Stage Summary (ha; %) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Softwood | | | | Early | | | | | | | EARLY |
| | | | | | | Mid | | | | | | | |
| | | | | | | Late | | | | | | | |
| | | Mixedwood | | | | Early | | | | | | | MID |
| | | | | | | Mid | | | | | | | |
| | | | | | | Late | | | | | | | |
| | | Hardwood | | | | Early | | | | | | | LATE |
| | | | | | | Mid | | | | | | | |
| | | | | | | Late | | | | | | | |
| | | Unclassified | | | | Early | | | | | | | |
| ***Totals*** | | | | | | **# ha** | | | | | | | |
| | | | | | | **%** | | | | | | | |
| | | Softwood | | | | Early | | | | | | | EARLY |
| | | | | | | Mid | | | | | | | |
| | | | | | | Later | | | | | | | |
| | | Mixedwood | | | | Early | | | | | | | MID |
| | | | | | | Mid | | | | | | | |
| | | | | | | Late | | | | | | | |
| | | Hardwood | | | | Early | | | | | | | LATE |
| | | | | | | Mid | | | | | | | |
| | | | | | | Late | | | | | | | |
| | | Unclassified | | | | Early | | | | | | | |
| ***Totals*** | | | | | | **# ha** | | | | | | | |
| | | | | | | **%** | | | | | | | |

Table 2. Current composition of forest communities in Ecodistrict., grouped by landscape element.
Data from Crown Lands Forest Model - Landbase Classification

| Element | Ecosections | Dominant NDR | Dominant Climax Type | Cover Type | Forest Community (Crown Model) | Area (ha) | Percent of Element | Successional Stage | Successional Types |
|---|---|---|---|---|---|---|---|---|---|
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Table 3. Summary of “potential climax” forest abundance based on ELC interpretations.

| Climax Type | EcoDistrict | | EcoRegion | |
|---|---|---|---|---|
| | Hectares | Percent | Hectares | Percent |
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| **Total** | | 100 | | 100 |

# Appendix 11: Ecological Emphasis Classification

## *"Use in implementing Sustainable, Ecosystem Based Management"*

A variety of land management practices occur across landscapes, ranging from undisturbed natural reserve areas to highly modified urban environments. Conserving biodiversity requires a balance of land uses in which practices which sustain ecological integrity dominate. To assist managers in assessing land use intensities and develop appropriate practices, four levels of conservation are defined based on the degree to which the conservation of natural conditions is emphasized in the management practices and policies applied to the land. All lands within an ecologically defined area (eg. ecodistrict landscape, or ecosection elements) are assessed at the site level and assigned to one of the four "ecological emphasis classes - EEC". The proportion of land in each of the classes can be used to calculate an "ecological emphasis index" as an indicator of overall land use intensity.

In Practice:

The determination of ecological emphasis classes is ultimately dependant upon site level evaluation of prescriptions, practices, and conditions (eg. following Forest Code of Practice guidelines employing Forest Ecosystem Classification interpretation). Three planning phases are involved:

1. An initial classification of the "existing" conditions using GIS inventory will provide a preliminary estimate of the extent of past land use practices. This information will be updated by regional DNR staff as part of the IRM Landscape Analysis procedure to provide an initial mapping of EEC classes for planning, and establish a starting reference point for EEC index calculations.

2. The initial estimate of "existing" ecological emphasis classes will be followed up during the IRM Planning and Design stage with the classification and mapping of the "desired" distribution of ecological emphasis classes. This will be determined by the land manager (ie. Crown) as an integral part of strategic planning. The "desired" classification will guide subsequent operational planning by ensuring that site specific prescriptions are compatible with the specified EEC class designation.
   The two classes that pertain to resource management lands (intensive & extensive) will be linked to specific practices in the Forest Code of Practice. They will be ecosystem based and require use of the FEC and ELC ecosystem classifications and interpretations. In addition, DNR's strategic forest model will employ different growth forecasts for different EEC classes, enabling the impact of EEC decisions on important values to be forecast for scenario testing.

3. At the end of the planning period, the "existing" EEC classes will again be mapped to start the next planning period. A site will be deemed to have changed classification based on the implementation of actions compatible with the new EEC class. This will allow changes over the past planning period to be assessed, and the success of implementation of the "desired" plan to be evaluated.

| Ecological Emphasis Class | Description | Criteria | Preliminary Identification using GIS inventory |
|---|---|---|---|
| ***Initial Selection of Land for Classification****: The classification will include all upland conditions, both forested and non-forested, under all types of administration and land use practices. It will not include wetlands, beaches, or other non-terrestrial conditions.* | | | ***FORNON not = 74, 75, 77, 78*** *(exclude coastal habitats, lake wetlands, inland water, and ocean)* |
| **Reserve Class** | - Reserved lands which meet biodiversity conservation goals through preservation of natural conditions and processes. Resource management activities are not usually permitted except where required to perpetuate desired natural conditions. This class is assigned based on the types of laws and policies governing the management. (For example: Wilderness, Parks, Conservation Easement, Old Forest Policy) | - IUCN protected area categories I, II, III<br>- Old Forest Policy<br>- IRM C3 zoning<br>- IRM C2 K&L (?) | - **RLUL theme provides IUCN designations=I, II, III**. This theme must be intersected with Forestry layer to select identified stands.<br>- **Old Forest** theme provides old forest policy selections<br>- **IRM theme** provides IRM zone<br>- note: recent and "in progress" reserves may not be entered in GIS database by crown lands records |
| **Extensive Management Class** | - Lands managed for multiple values using ecosystem based techniques that conserve biodiversity, and natural ecosystem conditions and processes.<br>- Forestry practices employ ecosystem based prescriptions which consider natural disturbance regimes, successional trends, structure and composition. Natural regeneration is favoured to provide the next forest. Practices may include protection from fire and insects.<br>- Management complies with the Forest Code of Practice, and excludes the use of herbicides, exotic tree species, off-site native species, genetically modified organisms, and stand conversion. | - ELC & FEC based management prescriptions<br>- native species appropriate to site and successional stage<br>- silviculture supports natural disturbance and ecosystem processes<br>- structural elements conserved (eg. snags, nests, woody debris, pools & seeps)<br>- excludes exotic, off-site species, GMO's, site conversion. | **FORNON = 0 to 62** (excepting 3, 5, 11, 20) unless appropriate ecosystem based management used.<br>**FORNON = 70, 71, 72, 73, 76, 83, 84, 85, 88, 89, 94** (wetlands general, beaver flowage, open bog, treed bog, cliffs, dunes, coastal rocks, brush, rock barren, barren, alders, beach)<br>**SP1 or SP2 not = XL, AP, SP, DF, NS, SS, WS, EL, JS, WL** (exclude exotic or offsite species)<br>Silviculture in natural regeneration where species diversity is sustained. |
| **Intensive Management Class** | - Lands managed intensively to optimize resource production from sites maintained in a native state (eg. forested). Despite intensive practices these lands are an important component of landscape structure and composition.<br>- Management may eliminate or reduce the duration of some development processes, particularly mature old forest stages, and may result in non-natural succession. Practices may produce unnatural conditions such as exotic species, old field spruce, and monoculture plantations, or reduce structure and composition below ecologically desirable levels. Forests are protected from fire, insects, and competing vegetation.<br>- Management adheres to environmental regulations and policies such as the Habitat Sustainability Regulations, and Forest Code of Practice. | - Maintenance of native "site type" (eg. forest, barren, meadow)<br>- Maintenance of site productivity<br>- Practices may include:<br>  - Active protection from damaging agents such as fire, insects, competing vegetation.<br>  - Pesticide use, exotic species, site conversion, monoculture<br>  - Silviculture which simplifies ecosystem structure, composition, and function. | **SP1 or SP2 =XL, AP, SP, DF, NS, SS, WS, EL, JS, WL** (exotic or offsite species)<br><br>**FORNON=20** (plantations are initially assessed as"intensive class", unless they are > 30 percent stocked to natural regeneration, and are planted with native species that are ecologically appropriated to the site) |
| **Converted-Industrial** | Land converted to an unnatural state for human use, or areas where practices have significantly degraded site productivity. (Eg. agriculture, urban, roads, Christmas trees, seed orchards, forest soil compaction). | - "site type" conversion<br>- degraded productivity | **FORNON=3, 5, 11, 86, 87, 91, 92, 93, 95, 96, 97, 98, 99** (xmas trees, old field, seed orchard, agriculture, urban, misc non-forest, blueberries, landfill, gravel pit, pipeline, powerline, road, rail) |

# Appendix 12a: Ecological Emphasis Index[2] Worksheet - Ecosections

| Ecosection | Total Area (ha) | Ecological Emphasis Classes | | | | | Ecological Emphasis Index | |
|---|---|---|---|---|---|---|---|---|
| | | Reserve Area (ha) | Extensive Forest Management Area (ha) | Intensive Forest Management Area (ha) | Conversion to Non-Forest Area (ha) | Unclassified Land Use Area (ha) | Effective Area Range (ha) | EEC Index Range |
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| EcoDistrict Total | | | | | | | | |

[2] The index is intended as a benchmark indicator to track land use changes over time. The index is not a management target.

# Appendix 12b: Ecological Emphasis Index[3] Worksheet - Landscape Elements

| Landscape Element | Total Area (ha) | Ecological Emphasis Classes | | | | | Ecological Emphasis Index | |
|---|---|---|---|---|---|---|---|---|
| | | Reserve Area (ha) | Extensive Forest Management Area (ha) | Intensive Forest Management Area (ha) | Conversion to Non-Forest Area (ha) | Unclassified Land Use Area (ha) | Effective Area Range (ha) | EEC Index Range |
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| EcoDistrict Total | | | | | | | | |

[3]The index is intended as a benchmark indicator to track land use changes over time. The index is not a management target.

# Appendix 13: Glossary of Terms

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| **Age Class** | Any interval into which the age range of trees, forests, stands, or forest types is divided for classification. Forest inventories commonly group trees into 20-year age classes. |
| **Biodiversity** | The diversity of plants, animals and other living organisms, in all their forms and level of organization, including genes, species, ecosystems, and the evolutionary and functional process that link them. |
| **Climax Vegetation** | A forest or non-forest community that represents the final stage of natural succession for its environment. |
| **Coarse Filter Approach** | An approach to maintaining biodiversity that involves maintaining a diversity of structures within stands and a diversity of ecosystems across the landscape. The intent is to meet most of the habitat requirements of most of the native species. |
| **Coarse Woody Debris (Cwd)** | Sound and rotting logs and stumps greater than 20 centimeters in DBH that provides habitat for plants, animals, and insects and a source of nutrients for soil development. Also provides significant habitat structure for aquatic environments and species. |
| **Commercial Thinning** | Silviculture treatment that 'thins' out an overstocked stand by removing trees that are large enough to be sold as products such as poles or fence posts. It is carried out to improve the health and growth rate of the remaining crop trees. |
| **Composition\ Species Composition** | The proportion of each plant species in a community expressed as a percentage of the total number, basal area or volume of all species in that community. |
| **Converted** | Lands removed from a natural state, changed to other uses, ex; agriculture, urban, settlement. |
| **Crown Land** | means all or any part of land under the administration and control of the Minister of Natural Resources Forests Act, Section 3. May also include federal lands. |
| **Development Class** | The description of the structure of forests as they age and grow. (forest establishment, young forest, mature forest) |
| **Disturbance** | A discrete event, either natural or human-induced, that causes a change in the existing condition of an ecological system. |
| **Ecodistrict** | An ecological land unit characterized by distinctive assemblages of relief, geology, landform and vegetation. (Ecological land Classification for Nova Scotia Volume 1.) The third of five levels in the DNR Ecological Land Classification system. |

**Ecological Classification**

An approach to categorizing and delineating, at different levels of resolution, areas of land and water having similar characteristic combinations of the physical environment (such as climate, geomorphic processes, geology, soil and hydrologic function), biological communities (plants, animals, microorganisms and potential natural communities). The classification system adopted for use in IRM Planning is: Ecological land Classification for Nova Scotia Volume 1.

**Ecological Integrity**

The quality of a natural unmanaged or managed ecosystem in which the natural ecological processes are sustained, with genetic, species and ecosystem diversity assured for the future.

**Ecoregion**

Representations of broad provincial climatic patterns as expressed by the macro-features of vegetations. (Rowe 1972)
The second of five levels in the DNR Ecological Land Classification system.

**Ecosection**

An ecological land unit with a repeating pattern of landform/topography, soils and vegetation throughout an ecodistrict. (Ecological land Classification for Nova Scotia Volume 1.)
The fourth of five levels in the DNR Ecological Land Classification system.

**Ecosite**

Subdivisions of ecosections which describe the site conditions such as elevation, communities, species, successional development and productivity. (Ecological land Classification for Nova Scotia Volume 1.)
The fifth of five levels in the DNR Ecological Land Classification system.

**Ecosystem**

A functional unit consisting of all the living organisms (plants, animals, and microbes) in a given area, and all the non-living physical and chemical factors of their environment, linked together through nutrient cycling and energy flow. An ecosystem can be of any size-a log, pond, field, forest, or the earth's biosphere-but it always functions as a whole unit. Ecosystems are commonly described according to the major type of vegetation, for example, forest ecosystem, old-growth ecosystem, or range ecosystem.
Can also refer to units mapped in the DNR Ecological Land Classification system.

**Ecozone**

Broad mosaics formed by the interactions of macroclimate, human activity, soils, geographic and physiographic features.( Ecological Stratification Working Group, 1966) The Acadian Forest is the only ecozone within Nova Scotia. . (Ecological land Classification for Nova Scotia Volume 1.)
The first of five levels in the DNR Ecological Land Classification system.

**Edge Effect**

Habitat conditions (such as degree of humidity and exposure to light or wind) created at or near the more-or-less well-defined boundary between ecosystems, as, for example, between open areas and adjacent forest.

**Element**

An identifiable component, process or condition of an ecosystem. (Matrix, Patch, Corridor)

**Endangered Species** A wildlife species facing imminent extirpation or extinction. A species listed as endangered under the federal or Nova Scotia endangered species legislation. ( NS Endangered Species Act or SARA)

**Even-aged** A stand(s) of trees consisting of one or two age classes. Even-aged stands are often the result of stand initiating disturbance such as fire, or a harvesting method such as clearcutting or shelterwood.

**Extensive Land Use** Lands managed for multiple values using ecosystem based techniques that conserve biodiversity and natural ecosystem conditions and processes.

**Extinct Species** A species that no longer exists. A species declared extinct under federal or Nova Scotia endangered species legislation. (NS Endangered Species Act or SARA)

**Extirpated Species** A species that no longer exists in the wild in Nova Scotia but exists in the wild outside the province. A species declared extirpated under federal or Nova Scotia endangered species legislation. (Nova Scotia Species Act or SARA)

**Fine Filter Approach** An approach to maintaining biodiversity that is directed toward particular habitats or individual species that might fall through the coarse filter. These habitats may be critical in some way and the species threatened or endangered. (Source: BC Ministry of Environment)

**Forest Cover Type** A descriptive term used to group stands of similar characteristics and species composition (due to given ecological factors) by which they may be differentiated from other groups of stands.

**Forest Management** The practical application of scientific, economic and social principles to the administration and working of a forest for specified objectives. Particularly, that branch of forestry concerned with the overall administrative, economic, legal and social aspects and with the essentially scientific and technical aspects, especially silviculture, protection and forest regulation.

**Frequent Stand Initiating** Disturbances usually occur more frequently than the average lifespan of the dominant species and are of sufficient intensity to destroy most of the existing trees, promoting a new forest within relatively short periods of time.

**Gap Replacement** An absence of stand initiating disturbances supports the development of a dominant overstory that is sustained through dynamic processes of canopy gap formation, understory development and overstory recruitment. Gap formation ranges from individual tree mortality to periodic gap formation events that are rarely of a stand initiating intensity.

**Habitat** The place where an organism lives and/or the conditions of that environment including the soil, vegetation, water, and food.

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| **Impact Assessment** | A study of the potential future effects of resource development on other resources and on social, economic and/or environmental conditions. |
| **Infrequent Stand Initiating** | The time between stand initiating disturbances is usually longer than the average longevity of dominant species, thereby supporting processes of canopy gap formation and understory development in mature forests. |
| **Integrated Resource Management (IRM)** | A decision making process whereby all resources are identified, assessed and compared before land use or resource management decisions are made. The decisions themselves, whether to approve a plan or carry out an action on the ground, may be either multiple or single use in a given area. The application of integrated resource management results in a regional mosaic of land uses and resource priorities which reflect the optimal allocation and scheduling of resource uses. |
| **Intensive Land Use** | Lands managed intensively to optimize resource production from sites maintained in a forested state. |
| **Landform** | A landscape unit that denotes origin and shape, such as a floodplain, river terrace, or till plain. |
| **Landscape** | An expanse of natural or human made scenery, comprising landforms, land cover, habitats and natural and human-made features that, taken together, form a composite. May range in scale from a few hectares to large tracts of many square kilometers in extent. (Dunster) |
| **Long Range Management Framework** | A strategic, integrated resource plan at the subregional level. It is based on the principles of enhanced public involvement, consideration of all resource uses and values, consensus-based decision making, and resource sustainability. |
| **Matrix** | The most connected or continuous vegetation type within the landscape. |
| **Mature** | Trees or stands that have attained maximum physiological growth. |
| **Memorandum of Understanding (MOU)** | An agreement between ministers defining the roles and responsibilities of each ministry in relation to the other or others with respect to an issue over which the ministers have concurrent jurisdiction. |
| **Mixed Stand** | A stand composed of two or more tree species. |
| **Multiple Use** | A system of resource use where the resources in a given land unit serve more than one user. |
| **Natural Disturbance Regimes** | The patterns (frequency and extent) of fire, insects, wind, landslides and other natural processes in an area. |

**Patch** In landscape ecology, a particular unit with identifiable boundaries which differs from its surroundings in one or more ways. These can be a function of vegetative composition, structure, age or some combination of the three.

**Planting** Establishing a forest by setting out seedlings, transplants or cuttings in an area.

**Precommercial Thinning** A silvicultural treatment to reduce the number of trees in young stands, often carried out before the stems removed are large enough to be used or sold as a forest product. Prevents stagnation and improves growing conditions for the remaining crop trees so that at final harvest the end-product quality and value is increased.

**Recreation** Any physical or psychological revitalization through the voluntary pursuit of leisure time. Forest recreation includes the use and enjoyment of a forest or wildland setting, including heritage landmarks, developed facilities, and other biophysical features.

**Reserve** An area of forest land that, by law or policy, is usually not available for resource extraction. Areas of land and water set aside for ecosystem protection, outdoor and tourism values, preservation of rare species, gene pool, wildlife protection etc.(wilderness areas, parks, etc).

**Road Deactivation** Measures taken to stabilize roads and logging trails during periods of inactivity, including the control of drainage, the removal of sidecast where necessary, and the re-establishment of vegetation for permanent deactivation

**Seral Stage** Any stage of succession of an ecosystem from a disturbed, unvegetated state to a climax plant community. Seral stage describes the tree species composition of a forest within the context of successional development.

**Species** A group of closely related organisms which are capable of interbreeding, and which are reproductively isolated from other groups of organisms; the basic unit of biological classification.

**Species-at-risk** Legally recognized designation for species at federal and/or provincial levels that reflects varying levels of threats to wildlife populations. The four categories of risk are extirpated, endangered, threatened and species of special concern.

**Succession** The supplanting of one community of plants by another, the sequence of communities being termed a sere and each stage seral. (Source: BC Ministry of Environment)

**Threatened Species** A species that is likely to become endangered if the factors affecting its vulnerability are not reversed.
A species declared as Threatened under the federal or Nova Scotia species at risk legislation. (NS Endangered Species Act or SARA)

**Tolerance** The ability of an organism or biological process to subsist under a given set of environmental conditions. The range of these under which it can subsist, representing its limits of tolerance, is termed its ecological amplitude. For trees, the tolerance of most practical importance is their ability to grow satisfactorily in the shade of and in competition with other trees.

**Vulnerable Species** A species of special concern due to characteristics that make it particularly sensitive to human activities or natural activities or natural events. May also be referred to as "species of special concern" A species declared as Vulnerable under the federal or Nova Scotia endangered species legislation. (NS Endangered Species Act or SARA)

**Wilderness Area** A part of the provincial land base designated under the Wilderness Areas Protection Act (eg: Canso Barrens).