

Key Concepts
In The Design of Forest Inventories

A Blueprint for Cooperation Amongst Licensees and the B.C. Provincial Government

A Discussion Paper

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Executive Summary

The purpose of this paper is to outline a framework within which the Forest Industry would be an active partner in the development and implementation of the forest inventory at a local level. The main points are as follows:

- Provincial needs from the forest inventory do not coincide with those of Industry at the local level of forest management.
- There is the potential to design and implement an inventory that could fulfill both requirements; the key design principles or concepts necessary to obtain this goal are the main topic of discussion herein.
- Industry has a direct interest in the inventory insofar as issues relating to wood supply affect the market values of their assets. Therefore the Industry should consider taking a more active role in Inventory management and reporting.
- Given the need for extensive coordination amongst Government, Industry and other potential partners, it is recommended that the inventory be managed at a local level within an independent management agency.
- The Inventory should be managed at a level that is consistent with area-based management. For the purposes of areas managed under Forest Licenses are to be accommodated under the concept of Defined Forest Area Management (DFAM), albeit other systems of organization may be possible.
- The costs of this proposal can be largely accommodated through a realignment of current funds. However, inventory management should also be included as an eligible expense item within the system of appraisal allowance.
- The development, maintenance and utilization of a forest inventory requires a well structured and disciplined process to be effective, and the whole organization (woods department) needs to understand how the system works, why it is important to the organization, and what their responsibilities are with respect to this process. This is a key competency required by forest managers and their organizations, that to date has been under-developed within the current system of forest management in British Columbia. It will take time to overcome this weakness.

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Introduction

The Provincial Government is considering the option of delegating responsibility for forest inventories under the notion of Defined Forest Area Management (DFAM). In a recent “Strategy Report” (May 2003), the “Vegetation Update Task Team” of the Ministry of Sustainable Resource Management, reviewed the alternative means of maintaining the Inventory from a Government Agency Perspective, in consultation with Industry. The primary options assessed were:

1. MSRM business model with 12 staff.
2. Government stewardship model (Industry / MSRM partnership using RESULTS).
3. Industry stewardship model.
4. No update.

RESULTS refers to the Results Based Code Silviculture and Landstatus Tracking System. This system is intended as a means of integrating inventory information with MLSIS¹ and ISIS² information (which in itself is a worthy objective).

Their recommendation is that in the short term, the first option be chosen, and that option 2 be adopted for the intermediate term. Option 2 is largely predicated upon MSRM providing the forms and the framework for the inventory and Industry filling in the blanks.

The B.C. Provincial Forest Inventory is of use to Licensees in its current form, but it is not open to enhancement as a representation of one of the core assets of the Forest industry or the public. That is, the current and future states of the inventory are the cornerstones used for maintaining wood supply security, maintaining access to markets by way of maintaining an acceptable degree of environmental protection and stewardship, and for reducing costs and increasing revenues through more efficient and effective use of the resource. From a public perspective there may be particular social, economic and environmental assets that are not currently well represented within the inventory.

The demands from the forest inventory needed to address forest management issues are different at the levels of timber supply analyses and forest operations, and as a result the demands of the Provincial Government are different from Industry. In particular, the

¹ Major Licensee Silviculture Information System.

² Integrated Silviculture Information System.

dominant use of the inventory in the past has been for the determination of the Annual Allowable Cut by the Chief Forester. This is out of step with public demands as well as those of shareholders and the market place, that want assurances that the forest is being well maintained after the forest management activities have been completed. At the heart of this discussion is the valuation of assets, including corporate assets, a large proportion of which can be assigned to the forest asset, even if it is not formally recognized as part of the stated corporate book value. The inventory is the primary source of information regarding such valuation and is an integral part of the accounting for whether or not companies are meeting their social and environmental obligations.

The forest resource is a shared resource; corporations are being assigned the task of directly organizing how the resource will be shared, subject to approval by Government Agencies, rather than having a third party such as the Ministry of Forests take on that role. This means that they must also have a hand in the designing the information about what kinds of resources are available for sharing, when, where and how much.

Therefore, there is a need to have forest industry involvement in the design, development and management of the inventory that goes beyond acting as a delivery boy to the Crown. Their involvement is of strategic importance for achieving more efficient and effective local forest management, including a reduction in the amount of detailed regulation required to direct forest management practices in favour of activities directed through more local management planning along with an increased reliance on Professional judgement.

The purpose of this paper is to elucidate a vision for the forest inventory that can better accommodate public, private and government agency needs to address the above mentioned concerns. At the heart of this proposal is the idea that every polygon can be represented by a stand and stock table, because the numbers of alive and dead trees by species and diameter is implicated in almost every forest management decision ever made, whether it is to harvest a particular tree or stand while leaving another, or it is to protect some wildlife species habitat. Indeed even our notion of what is good versus bad habitat is significantly determined by trees as the dominant structural feature. This concept is to be supported by a system of plots that are established throughout the inventory and in such a way as to be properly represent the entire population of sites and stands (polygons) in the inventory. Inventories are dynamic; the plots provide a more reliable means for projecting and tracking the changes.

The cost of developing and implementing an inventory as proposed above can be easily rationalized in terms of a reallocation of existing dollars, including those from the Natural Stand Permanent Sample Plot growth and yield program, and the variety of cruises, surveys and assessments that are carried out in the woods. To date our predominant concern has been for the condition of individual cut-blocks or substrata thereof. This has lead to a kind of myopic forest management, where it is difficult "... to see the forest 'fore the trees". There is an opportunity to address this situation by reducing the intensity with which we look at each and every stratum in favour of a more comprehensive

accounting of the forest as a whole. It seems that a strategic reallocation of funds in this direction is in the best interests of all parties concerned.

As always there is an issue of who should pay. The first response to this question is that if Industry is to take on a primary role in maintaining the Inventory, then there should be compensation by way of an appraisal allowance within the stumpage system. The application of this principle is completely analogous to that of Silviculture. The Crown maintains a *minimum* set of standards for a Provincial inventory; the costs of meeting these standards are the responsibility of Licensees. Such costs include the establishment and maintenance of a system of plots to properly represent the inventory. Costs that are currently born within the system of forest management (cruising, silviculture surveys, etc.) and that are realigned for the purpose of better inventory management should also remain as eligible appraisal allowances.

The proposed enhancements to the inventory outlined below are recommended for adoption by Government and Industry within the concept of a basic forest inventory with proper consideration for the additional benefits that will be accrued as a result. These benefits relate to an enhanced level of detail that is required to address many forest management issues and to improved reporting and evaluation of the current status of the inventory at the unit (DFAM, TFL) level of management. Such improvements would be underwritten by the gradual migration of all inventories, including the “old” Forest Cover, into a plot-based system of management (perhaps circumventing VRI Phase I activities), and by the continued effort toward upgrading the inventory by realigning the various sources of existing information for that purpose.

A reasonably high level of coordination of forest inventory activities will continue to be required amongst licensees and the Provincial Government to ensure that the basic needs are being met. This level of coordination could be substantially reduced under a system of area based (rather than volume based) management. Within the current context of forest policy development, coordination could be achieved at the same level as DFAM, preferably by a distinct management agency directed by willing, and contributing (\$) partners that include both Government and Industry and perhaps so too municipalities and other agencies with a vested interest in forest and land management.

The remainder of this paper provides a more detailed description of the fundamental constituents of an inventory that could service many more end uses when compared with the basic forest cover or VRI inventories.

Components of An Enhanced Forest Inventory

1. Inventories are designed to service the meeting of forest management goals and objectives.
2. Goals for forest management include the following:
 - a) To provide a range of species habitats and associated stand structure attributes sufficient to maintain or enhance biodiversity.
 - b) To mitigate or prevent the occurrences of large scale, catastrophic events through the use of knowledge of large scale natural processes such as fire, bark beetles, root rots, wind and stand dynamics to create landscapes that emulate natural disturbance patterns, and in so doing.
 - c) To ensure that the above forest environmental objectives have been met, and that in so doing secure long-term access to reasonably stable amounts of economically viable sources of drinking water, guiding and outfitting, hunting and trapping, recreation, grazing, and to secure access to resource markets demanding products and services from forests that are being managed in accordance with biological principles of conservation.
 - d) The balance of goods and services produced from a forest, both in the short and longer-term is largely a matter of discretion in response to social, economic and ecological needs or constraints. Such discretion may be guided by the principles of sustainability; this being to ensure that the sum total of resource values left for future generations is at least equal to those that were made available to the current generation.
3. The most important forest management activities affecting the attainment of above mentioned goals are the timing and intensity of: road construction, maintenance and deactivation and timber harvesting.
4. Much of the value of forest-based assets is associated with the security in supply of a certain quantity and quality of timber, and in the ability of managers to efficiently and effectively capitalize that resource. This means that the forest asset is of direct interest to owners of processing facilities with licenses to cut timber on public lands. To the extent that the forest-based asset is eroded, and to the extent that managers are unable to make more effective use of that resource, company asset value is diminished, even if such assets are not formally recognized within generally accepted accounting principles.
5. The purpose of the inventory is to provide the information for ensuring that the foregoing goals will be and are being met efficiently and effectively by supporting:

- a) The determination what stands should be harvested when, what stands should be left remaining, what trees should be cut and when, and what trees should be left behind in accordance with various time horizons (daily, monthly, annually, etc.).
- b) The determination of what sorts of other activities should be conducted, when, where and to what intensity (road construction, maintenance and deactivation; silviculture; range management practices, watershed restoration, etc.) to meet the aforementioned goals.
- c) The determination of whether or not the intended goals described above are being achieved after having carried out a wide variety of activities in the forest and as a result of the occurrences of natural disturbances.
- d) The determination of what to do next (items a and b) following from the results in c).

In this context the forest inventory is the foundation for successful *forest* (as opposed to *stand*) monitoring and management.

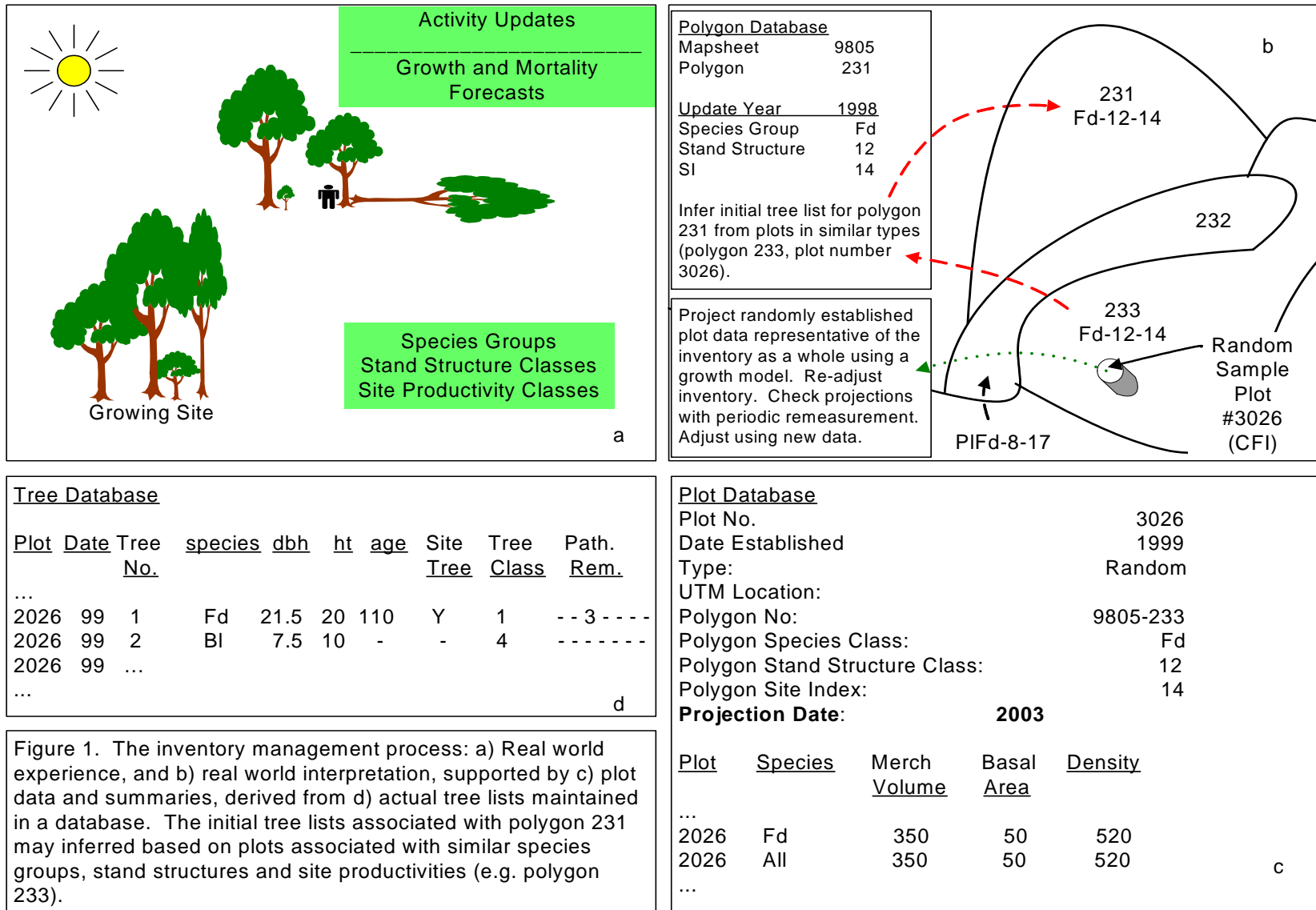
- 6. The basic unit of representation in an inventory is a polygon. A polygon represents a relatively uniform set of site and stand (vegetation) conditions relative to those adjacent to it. The benefits of having a high resolution inventory with a large number of polygons must be weighed against to the cost of collecting and maintaining the data at that scale of resolution, and the benefits that will be obtained relative to fulfilling the goals stated above.
- 7. By definition an inventory is an estimate of the current condition of a complete set of attributes that has been consistently recorded across all parts of the inventory. In other words, the properties associated with any polygon may be compared with those from any other polygon; if there are differences between them it is not because one attribute was assessed and recorded for one of the polygons but not the others.
- 8. The numbers of trees by species and diameter (referred to as a tree list³) and the productivity of the sites in which trees are grow are integral to defining a vegetation community and the site in which its is growing. These low level attributes provide fundamental descriptions of polygons in the forest inventory and are the predominant criteria for distinguishing one polygon from the next. They affect how natural disturbance patterns are manifested both historically and

³ A tree list provides an enumeration of the numbers of trees by species and diameter along with other attributes such as tree height, volume, tree class, pathological condition, etc. In contrast, a stand table provides a summary of the number of trees by species (and for all species in total) and diameter class (and for all diameter classes in total). A stock table provides a summery of the volume and basal area by species and diameter class.

in the future and so too, define the goods and services that are (expected to be) available.

9. For large forests wherein it is too expensive to sample every stand on a routine basis and where interventions at the polygon level as a result of harvesting and other forest management activities are relatively infrequent, there is a need for stand structure and species group classification in conjunction with limited ground sampling as a means of approximating the numbers of trees by species and diameter (Figure 1). The stand structure classification is intended for the purpose of making a best estimate of the total numbers of tree per hectare by diameter. The species group system of classification is ultimately intended to distinguish the different distributions of species by diameter (e.g. a pure species stand versus a mixed species stand with a shade intolerant species in the overstory and tolerant species in the understory). These two systems of classification must have enough categories to precisely characterize stands and their structures, but not so many as to frustrate easy recognition of one stand structure and species group from another. Differences between classes must, at minimum, be capable of being captured through casual field assessments and with the use of aerial photographs. Within these constraints, the stand structure classification should produce reasonably precise estimates of the numbers of trees by diameter. There must be enough groups to distinguish differences amongst stands that are currently lumped into one or two categories described as “irregular”, “multi-layered” or “complex” stands, these being categories that are too broad to produce an inventory for the purposes of underwriting forest management decisions as described above. Ideally, the combination of species and stand structure group leads to a relatively homogeneous growth type in which the expended growth and development of the stands within a group have more in common in with one another than they do with those stands in adjacent groups.
10. In the longer-term the assignment of species and stand structure groups to polygons and thereby, imputation of the numbers of trees in a given polygon (by species and diameter) from known points to unknown points may be automated using various sources of information including satellite imagery. This process may be extended to determining polygon boundaries and is similar in concept to developing a map of ecosystems (site series) by correlating various sources of inventory information with actual observations on the ground and then using that information to extrapolate from known to unknown points. This concept is an important area for research when considering the management of inventories across large landscapes.
11. Site productivity estimates involve a two-step process, wherein the boundaries between sites are best established on the basis of differences in ecosystem classification (e.g. one or more of site series, soil series, terrain, topographic position, etc.). Estimates of productivity are best determined in combination with differences in tree species using indices such as Site Index, and such a value should be estimated in the first place based on the species that currently occupy a

The Enhanced Inventory Management Process



- site. In the absence of a complete description of site classification as described above, differences in productivity should be included in delineating polygons along with stand structure class and species group.
12. The demands for a wide variety of indicators can be met by collecting the necessary data in association
 13. Forest inventories must be publicly defensible as a reasonable statement of the current state of vegetation resources. To assess the reliability of expected future forest conditions given different scenarios requires a reasonably reliable statement of the initial condition used to underwrite such forecasts. At minimum this means that the reliability of certain statistics, such as the numbers of trees of a given species and status (e.g. live or dead) greater than or equal to a given size (e.g. diameter or volume), be capable of estimation for a given area of land (at minimum for the forest estate as a whole) with inclusion of a confidence interval. To produce such a statement requires the proper use of sampling theory and an established set of plots to represent the condition of the inventory as a whole. Polygon level estimates of stand attributes (numbers of trees by species and diameter) must be adjusted so as to add up to the total values established for the population as a whole. Over time the forest characteristics are expected to change, regardless of whether there is forest management activity or not. Continuous Forest Inventory (CFI) includes establishing and then remeasuring some of the plots with the remainder being replaced with new temporary plots. Use of temporary and remeasured plots in combination provides the most reliable estimators of both growth and current standing volume⁴.
 14. The design of the system of plots should be such that: a) enough small and large trees are accounted for to underwrite growth and yield projections, b) they involve cluster sampling as means of assessing within polygon variation, and c) the system is affordable to maintain over a long period of time. This may involve fixed area plots, variable radius plots or a combination of the two. The former are the easiest to work with from an analytical point of view but must be of larger size to provide an adequate number of trees for monitoring over a longer period of time. The latter are more efficient in terms of the cost of establishment and remeasurement, but require more care when being analyzed⁵; the distance of each

⁴ Shiver, B. and B. Borders. 1996. Sampling techniques for forest resource inventory. John Wiley & Sons Inc., New York.

⁵ See the following references:

Flewelling, J.W. 1981. Compatible estimates of basal area and basal area growth from remeasured point samples. *For. Sci.* 27(1):191-203.

Flewelling, J.W. and C.E. Thomas. 1984. An improved estimator for merchantable basal area growth point samples. *For. Sci.* 30(3):813-821.

....

Gregoire, T.G. 1993. Estimation of forest growth from successive forest surveys. *Forest Ecology and Management*, 56:267-278.

tree from plot centre must be measured. In addition, it is recommended that a large (e.g. 1/10th hectare plot) be established for the purpose of measuring and recording only those trees that die from one period to the next⁶. This necessary to provide better estimates of mortality that tends to be highly variable. By measuring only dead trees, the costs of establishment remeasurement are reduced, where compared with similar sized, fixed area permanent sample plots. Vegetation (“ecosystem”) plots may also be established as part of the plot establishment and remeasurement program.

15. For any specific polygons or strata, sample based estimates of the numbers of trees by species and diameter may be used to establish the tree list rather than deriving it by way of ocular estimates of species and stand structure classification. Certain strata may be more important than others to the overall success of the forest management enterprise, and therefore require for more intensive sampling. Such strata may include those that have been intensively managed through thinning and fertilization for example, or those with attributes that are in short supply such as those with “old” forest characteristics.
16. After an inventory is established (initialized) it must be updated annually with consideration for changes due to forest management activities, large scale disturbances and so too, growth, mortality and perhaps ingress. The update mechanism requires at minimum that the numbers of trees by species and diameter class be re-initialized, either through means of casual observation and classification, or through the use of more intensive sampling. In addition, polygon-level tree lists should be projected using a growth model that has sufficient resolution to provide an indication of the expected changes in the numbers of trees by species and diameter class.
17. A combination of projected and measured continuous forest inventory plots can be used to adjust the polygon estimates so as to ensure that they are consistent with sample-based estimates for the estate as a whole. This requires a growth model. The continuous forest inventory plots can be used to calibrate the growth model, thereby ensuring localized growth projections. When the program is being established individual tree species, heights, diameters, live crowns, increments and ages can be used to initially calibrate the growth model, which can subsequently be improved through the process of remeasurement.
18. Treated stands may require additional plots established prior to treatment, and such plots should be established in both treated and untreated stands selected at

Iles, K. and T.W. Beers. 1983. Growth information from variable plot sampling. In Renewable resources inventory for monitoring changes and trends, edited by J. Bell. International Conference Proceedings. Oregon State University, Corvallis, OR, U.S.A.

Iles, K. 1981. Permanent “variable” plots for forest growth to have and to hold ...? Paper presented to the 1981 Annual Meeting of the Western Forest Mensurationists, Ketchum, Idaho. 412 Valley Place, Nanaimo, B.C.

⁶ Personal communication, Kim Iles, Nanaimo, BC.

random. The establishment of these kinds of plots, in addition to those for CFI, should be discretionary.

19. Many (criterion) indicators can be derived from plot-level details and extrapolated to the rest of the inventory using the procedures outlined above. Therefore, the CFI, and inventory update and forecasting processes provide the basis for long-term monitoring and adaptive management.
20. A system is required for undertaking routine updates of the inventory, for providing a proper reconciliation of the changes that are matter of public record, and auditing the results. In addition, it is recommended that an economic valuation of forest assets be part of the update to provide assurances as to the changes not just in physical characteristics, but also in value assigned to various (social, economic, and ecological) accounts.
21. The cost of producing and maintaining an inventory in the manner prescribed above can be partially offset, by: a) eliminating the need for a “Natural Stand” permanent sample plot program, and b) reducing the intensity of cruising through use of initial estimates of volume by species and diameter according to the concept of “comparative based cruising”; this concept is identical with the extrapolation of tree list data from known points to unknown points using species group and stand structure classification, as well as site productivity group classification. In addition, silviculture surveys can be reduced in intensity by applying them to strata instead of individual cut-blocks or subdivisions thereof (i.e. “standards units” or “treatment units”). Such a shift in allocation of funds can be rationalized on the basis of the importance of the inventory to the conduct of successful forest management. Finally, if the inventory is a public resource, then the cost of collecting and managing the data should be deducted from the total stumpage paid by licensees to the landowner.
22. The hardware necessary to store the inventory may be distributed amongst a variety of owners, and must be supported with a system of proper backups. In order for this to happen however their must be a way of linking the databases; this may be accommodated by developing standard naming conventions for identifying “forestry objects” such as trees, stands, roads, lakes, rivers, etc⁷ and for declaring their attributes. This enables easy transfer of data from one format to another, without having to translate one format to another as if in every instance, they are a special case. Such flexibility is needed, because beyond a core set of data, there are large amounts of data collected that must be connected to an inventory, but from a broad perspective are special cases. There are instances where several parties are involved in collecting such data; it is therefore necessary that they be able to share the data amongst themselves. Of course considerable coordination is needed to maintain a consistent forestry objects language as the primary source of interpretation from one database to another. It is conceivable

⁷ Personal communication, Mishtu Banerjee, Harmeny Systems Ltd.

that with such a system, an individual could develop their own database and then import the data they needed from other databases without having to further enquire as to the structure of the data.

Conclusion

Our view of the forest is largely driven by our experiences within it. In most of British Columbia the landscapes we work within are in excess of 100,000 hectares. This means that it takes many years before any one of use can become truly familiar with the landscape, and even then it can be difficult to communicate to others without having data to provide some clarity. With each person passing, so too their experiences. The inventory embodies past, present and future that can be handed from one generation to the next in a way that personal experiences cannot. Therefore in addition to forests, forest inventories are, and embody, a core asset that is to be managed.

Inventories require a steady commitment in both their development and commitment, otherwise they tend to age like fruit left on the kitchen counter for too long. They must be maintained according to a strict and routine discipline of data collection, entry and analyses. Finally, for an inventory to be truly effective, everybody in the woods departments of organizations must understand what the inventory is, how it is maintained up-to-date and what their responsibilities are in that process. There is indeed a management culture that must be built up around the inventory and its management with a thorough understanding of why it is important to the organization. When starting with a culture that has not been extensively engaged in these activities, there is a lot of work to be done to get everybody involved in the process with enough understanding to do an efficient and effective job of inventory management and analyses. Therefore, the reason for becoming engaged in developing and maintaining an inventory is because it is seen as a core asset; it is more than a mere luxury that we can afford to do without.