Benefits of Forest Research, 1994 – 2014

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Summary of Key Findings

- ✧ Forest management research has been instrumental in enabling a dramatic shift in the forest management paradigm over the past decade.
- ✧ Concepts of ecosystem-based management, biodiversity, protection of rare and endangered species, and sustainability of multiple resource values have been defined and realized through research.
- ✧ Research and development of the Biogeoclimatic Ecosystem Classification has provided a platform for a host of applications that are fundamental to implementing sustainable forest management.
- ✧ New knowledge about forest productivity under natural and managed conditions has increased estimates of timber harvest potentials, partially or fully offsetting, or even exceeding, the downward pressures exerted by other forest management objectives.
- ✧ Genetics research has led to development of improved growth, disease resistance and form of major commercial tree species, provided tools to assess genetic worth of pedigreed seed, and established criteria for maintaining genetic diversity.
- ✧ Silvicultural systems research has enabled an evolution from primarily clear-cut logging and regeneration of even-aged stands, to alternative systems such as variable retention that result in complex stands of mixed species and ages.
- ✧ Modeling of forests has expanded from a timber focus to include multiple values, with greater spatial specificity, and with capabilities to accommodate the complex stands being generated by current forest management practices.
- ✧ Benefits of forest management research can be partially quantified in economic terms, primarily for the timber harvesting account. Direct annual provincial revenue from timber that would not have been available for harvest without the research program of the past decade is estimated to be about $370 million.
- ✧ If benefits could be quantified of other research initiatives that have fostered attainment of sustainable ecosystems, maintenance of biodiversity, protection of species at risk and identified wildlife, the financial worth in the opinions of project contributors would exceed that for timber.
- ✧ The total annual value of quantitative and qualitative benefits from a decade of forest management research probably exceeds $1 billion annually, and these benefits will continue in perpetuity.
- ✧ The value of benefits from forest management research exceeds the cost of the research program by a factor of 7 to 10 times, if only the quantitative timber revenues are considered, and by a least 20 times if the value of qualitative non-market benefits are considered.
- ✧ Forest management research pays huge dividends by any measure!

Introduction

The project was undertaken at the request of the Chair of the Forest Science Board to provide a description and assessment of the benefits of forest resource management research in advancing forest policies and practices toward attaining sustainable forest management. This project does not include advances in knowledge through research on forest products and forest engineering technology. The timeframe selected for review is the 2-decade period beginning in 1994 and extending into the future to 2014. The approach uses previous assessments and informed opinions to identify how research has contributed to improving or substantiating policies and practices over the first decade, and to speculate on anticipated gains over the following decade.

The current review attempts to identify the big forces of change that have emerged from research and then describes the extent of the related benefits. The three sets Timber Supply Reviews and AAC rationales show major shifts in estimates of timber supplies and enable some quantification of how new knowledge has contributed to improved decisions. That knowledge includes not only information about forest productivity, but also better information for managing forests for conservation and utilization of multiple values. The latter benefits are not easily quantified and are therefore expressed in a descriptive manner.

Identifying benefits of research is confounded by the element of risk in decision-making. Ideally, decisions made in the absence of complete knowledge will reflect a considered allocation of risks. Resulting total benefits will often be sub-optimal because of the need for a wider margin for error. That is not always the case, however. Decisions can be made with only a small margin for error if the consequences of the error are considered to be acceptable or manageable. That has typically been the case with forest management in British Columbia where time and space has allowed iterative adjustments to decisions as new knowledge became available. This enabled delivery of a set of benefits that might be unsustainable in the long-term, but with little consequence for the short-term. It did, however, build a set of expectations across all sectors that exceeded resource capacities, at least under the prevailing state of management and investment.

Over the past two decades, the risks associated with resource management decisions have come to the fore. Consequences of decisions about utilization rates or interactions among resource uses have become more pressing and urgent as development has spread across and filled the landscape. Some responses have been dramatic such as the expansion of the park system in the face of diminishing wilderness and the introduction of more stringent management practices under the Forest Practices Code. Others have been more subtle, including introduction of more sophisticated models to assist in setting sustainable timber harvest rates.

It is against this backdrop of change that advances in knowledge through research are portrayed. Even as the knowledge base has expanded, apparent resource supplies have diminished through policies and practices that promote sustainability. There can be a perceived causal relationship that the more we learn through research, the less we get from our resources! This project therefore attempts to portray the benefits of research in the context of where resource policies and management decisions might have trended in the absence of new knowledge.

It is possible to identify some specific benefits from individual projects, but more significant gains result from the synergism of multiple projects in building and reinforcing the knowledge base for decision-making. This paper takes a broad oversight of collective benefits of a decade of research in selected topic areas. Where possible, results from previous reviews of individual projects are incorporated in the overviews of topic areas.[1]

Because of the number of different funding mechanisms that have been in effect over the past decade, forest research is considered inclusively, regardless of funding source or forest science provider. For the second decade, expected benefits are described from investments through the Forest Investment Account – Forest Science Program (FIA-FSP) since inception in 2004/2005, with a particular emphasis on currently funded projects and anticipated projects over the next decade.

The Starting Point, 1994

This was the immediate pre-Forest Practices Code era. Pressures that led to establishment of the Code were already being felt and a number of changes were in transition. Also, the Forest Act had been amended to require greater consideration of integrated resource management issues in determining timber harvest rates. The Chief Forester had embarked on an intensive review of Allowable Annual Cuts starting in 1992 and consequently began to phase in reduced harvest rates over about half of the province. Concerns of continuing trends toward reductions in wilderness area triggered the first of several reviews of parks and wilderness options, and the eventual creation of a much-expanded system of parks.

All of the changes were made utilizing the scientific knowledge of the day, to the extent it was known to decision-makers. Resulting resource management policies and practices were based on some uncertain knowledge, and consequently will have produced sub-optimal benefits across resource sectors. As a general practice, dispersal of timber harvesting was viewed as an expedient means to achieve integrated resource management objectives, at least for the immediate future. Forest plans typically contained prescriptions to shrink cutblocks, disperse timber harvesting through alternating cut and leave patterns, further disperse timber harvesting by establishing continuous corridors of older forest, extend green-up periods, and defer timber harvesting in contentious areas of wildlife habitat and other resource values. These prescriptions were inefficient because of higher operating costs to the forest industry, downward pressure on timber supplies and relatively low or uncertain benefits for other sectors in relation to those costs. Longer-term uncertainty was increased because harvest rates were not reduced in relation to deferred

[1] Lyn Davis & Associates, Victoria. An Evaluation of the Impact of Research Program Investments Made by Forest Renewal BC -- Interim Report: High Level Review of 80 Projects October 31, 2001. Draft report.

BC Market Outreach Network. Forestry Innovation Investment Review of Investment Results – Research Program September 2004. Draft report.

areas, leaving unresolved problems to be dealt with when it became necessary to direct timber harvesting operations into these areas. The Forest Practices Code contained many similar prescriptions in its initial regulations and guidebooks.

The timber supply implications of forest practices of that era are described later in this report for the Timber Supply Areas that were selected as case studies. Information is derived from analysis reports prepared for successive Timber Supply Reviews.

Achievements in Forest Science 1994 through 2004

Events of the early 1990's stimulated a number of initiatives to address knowledge needs in forest management. Forest Renewal British Columbia began making investments in forest research in 1994/05, in a program that continued through 2001/02. That program was replaced by the Forest Investment Account (FIA) in 2002/03. Research investments under FIA were enabled first as part of the Forestry Innovation Investments (FII) mandate and subsequently as a separate FIA Forest Science Program (FIA-FSP) beginning in 2004/05. FIA-FSP investments, currently totaling over $10 million per year, are undertaken on the advice of a Forest Science Board that reports to the Deputy Minister of Forests and Range. Funding for forest science providers in various agencies comes in part from in-house budgets (for example, the Ministry of Forests and Range base budget) and in part from these externally administered sources.

As a result of these initiatives, research activities have progressed on a wide variety of topics that range from understanding ecological niches of forest dwelling insects to measuring timber growth gains through genetic selection. Research on integrating non-timber values and environmental protection with timber harvesting has been active over the decade. The Chief Forester's decision to limit timber supply impacts of the new Forest Practices Code to 6% added considerable impetus to find more effective and efficient solutions to sustaining ecosystems and integrating resource uses.

What Will the Future Hold – Benefits of Research circa 2014?

This part of the review focuses specifically on the expected benefits of forest science investments under the FIA-FSP. The scope of current research provides insights into how it will contribute to informing future policy and practice decisions. Although any projections of the future will contain uncertainties, there is good information about the nature of new knowledge that will be generated over the next several years. Research undertaken in 2004/05, and currently underway in 2005/06, will not yet have had an effect on policies and practices, but those outcomes will be foreseeable to some degree. There are also some multi-year projects commenced earlier that have not yet come to fruition. As well, work is already underway to identify priorities for the upcoming fiscal year (2006/07).

Selection of Case Studies

Over the decade under review, administrative boundaries for conduct of research have varied with changes in funding agencies, as have resource administration boundaries. For this project, the three Ministry of Forests and Range Forest Regions are used as expedient surrogates for ecological differentiation across the province (coast, southern interior and northern interior). The FIA-FSP administrative framework is built on Forest Districts that can be aggregated to this level.

The report portrays the scope of research benefits by selecting two Timber Supply Areas from each Forest Region to serve as case studies for more detailed documentation of forest policy and management issues, and the advances that have been enabled by research. The case studies that are listed below were selected based on the following criteria:

- TSR 1 analysis report completed in 1993 or 1994, just prior to introduction of the Forest Practices Code
- TSR 2 analysis report completed approximately 5 years later (1998 or 1999)
- TSR 3 analysis report completed or an extension rationale available that outlines why a new AAC decision can be postponed

The Timber Supply Areas selected for case studies are:

Coast	Strathcona
Coast	Fraser
Southern Interior	Golden
Southern Interior	Arrow
Northern Interior	Prince George
Northern Interior	Kalum

A short summary of the timber supply outlook for each of the selected TSA case studies is shown below, with more information in Appendix 1. Descriptions of management and policy issues, and the state of related knowledge, contained in the timber supply analysis reports provide insights into how research has contributed over the 3 successive Timber Supply Reviews.

The focus of the case studies is on timber supply because that is the most quantifiable aspect of the suite of resources in each TSA. However, input received during this project indicated that science has provided equally remarkable, albeit qualitative, benefits to other sectors. The latter benefits are manifest in two ways – first, improved certainty in attaining goals for biodiversity, ecosystem health, and sustainable management of a full range of resource values; and second, more efficient integration of timber production with other goals thus enabling higher harvest levels than would have been attained without the new scientific knowledge, and probably lower costs. In general, ecosystem research and improved knowledge about wildlife habitat and other resources have created certainty in land use planning and, in some cases, enabled more innovative and flexible management practices. Increased deviation from strict cut block sizes and distributions are examples that may reduce forest harvesting costs and increase government revenues.

Subsequent to completion of the case study reviews, the Forest Science Board requested that the Merritt TSA be added to the discussion of the Southern Interior Region. Although this TSA does not satisfy the requisite dates for completion of the three Timber Supply Reviews, it provides a contrast to the findings for the Golden and Arrow TSAs. It illustrates that in some management units, application of scientific findings can lead to an increase in short-term harvest rate, not just a mitigation of declines.

Summary of Case Studies

Coast Forest Region. The two case studies, the Strathcona and Fraser TSAs, illustrate the critical downward pressures on coastal timber supplies during the 1990's. These units had seen many decades of accelerated timber harvests based on liquidation of abundant inventories of old-growth forests. Because harvest levels were leveraged upward based on the allowable cut effect, they were particularly vulnerable to any constraints that reduced access to mature stands, including integrated resource management constraints and land allocations to non-timber uses. Land-base reductions for parks, improved operability assessments and non-timber uses totaled about 30% over the decade. An additional problem was that the volume of timber in mature stands had been overestimated, especially in the Fraser TSA where the overestimate was 23%. AAC reductions of about 30% would have been as high as 40% if these challenges had not been offset by research on forest growth and model development. It is noteworthy that the Long Term Harvest Level (LTHL) has shown a stable or increasing trend because of the improved estimates of forest growth, even after accommodating new goals for biodiversity, sustainability and species at risk and identified wildlife such as Marbled Murrelet, Spotted Owl and grizzly bear.

Southern Interior Forest Region. The two case studies, the Golden and Arrow TSAs, portray a different scenario from that on the coast. The Timber Harvesting Land Base (THLB) has been relatively stable but in spite of that, AACs have decreased because of constraints applied to sustain non-timber values in the short and mid-terms. The LTHL has shown a 50 to 60% increase over the decade, based on improved estimates of timber growth and, in the Arrow, the application of PEM and SIBEC. These increases are net of downward forces including root rot, increased green-up requirements for visual quality, and considerations of biodiversity and sustainability.

The Merritt TSA is managed under Innovative Forest Practices Agreements (IFPA) and has been intensively analysed to show the implications of recent research findings for timber harvest levels. Compared to the AAC determined from the first Timber Supply Review in 1996, a re-analysis on behalf of the IFPA holders in 2003 indicated a potential 30% increase in short-term harvests, and a similar increase in mid- and long-term forecasts. Much of this increase resulted from application of research developments including Predictive Ecosystem Mapping, revised site productivity estimates, growth gains from genetic improvements in regenerated managed stands, refined definition of deer winter ranges, and revised landscape level management practices for retention of older forests. This analysis did not, however, lead directly to a new allowable annual cut determination because of over-riding concerns about the expanding Mountain Pine Beetle infestation. In 1999, the Chief Forester increased the AAC by 550,000 m^3 to 2,004,250 m^3, and again in 2005 to 2,814,171 m^3 to enable intensified beetle control treatments and salvage of infested stands. In making the latter decision, the Chief Forester referenced the new timber supply analysis and noted that its findings provided a suitable basis for forecasting the TSA's timber supplies (in other words, the 30% increase provides a reliable measure of the benefits of science).

Northern Interior Forest Region. The two case studies, the Prince George and Kalum TSAs, speak to the robustness of timber supplies in the north. In spite of a 6% decrease in the THLB, the Kalum has shown only a 3% AAC reduction, and an 8% increase in LTHL. The Prince George TSA, even with a similar THLB reduction, could have seen a non-declining harvest rate from the current decade through another 180 years. Impacts of lower volume estimates for mature stands have been offset by better information about growth of future stands. In both units, uncertainties continue about possible over-estimates of operability in economically marginal stands.

The Prince George TSA provides a stark illustration of how natural events can overtake forest management plans. Although the impending risk of mountain pine beetle attacks and wildfire in aging pine forests has been well recognized, the geographic extent and sheer ferocity of the current epidemic exceeded wildest predictions. Timber harvest rates are now being driven by the beetle, with long-term consequences yet to be addressed. Currently, the AAC includes an "uplift" of 6 million m^3 per year. Undoubtedly, this accelerated harvest will reduce the supplies of mature timber that were being relied upon to sustain the forest industry through the middle part of the harvest cycle. A potential benefit of the accelerated harvest is that more land will be brought back into production sooner, leading to greater overall growth. This may assist in bolstering mid-term harvests if ways can be found to recover merchantable volume from immature stands, either through partial cutting or clearcutting at pre-culmination ages. Managing forests of this nature is uncharted territory and will require new knowledge through research to enable management of extensive areas of immature stands for multiple values.

A benefit of existing research on biodiversity and ecosystem management was that a bark beetle control and salvage strategy could be implemented quickly. By providing a scientific rationale for increasing retention of productive forest from 8% to 20% in order to protect biodiversity, logging could be accelerated elsewhere in beetle-infested stands. These retained areas will eventually become key elements of biodiversity in the future forests that will become established.

Benefits of Selected Research Topics

Research projects may be categorized in a variety of ways, including by scientific discipline, intended application of results, geographic area, and research agency or institution. FRBC identified five funding envelopes and FII utilized nine theme areas that equate to two of the FRBC funding envelopes (Environment, and Land and Resources). The FIA-FSP now divides forest management research activities into those that support the sustainability program and those that support the improved timber growth and value program. Within each of these programs are themes that were identified in the 2005/06 call for proposals, and each is further subdivided into investment topics.

This project focuses on the nine themes in the two FIA – FSP research programs of Improved Timber Growth and Value, and Sustainability (the third program, Extension, is a complementary set of activities and services that do not deal with the conduct of research per se). Discussion of these themes is directed to topics that are perceived to demonstrate the biggest advances in knowledge through research over the decade.

Research topics are organized in the following discussion according to the programs and themes as recommended by the FIA – FSP Program Advisory Committees. These themes differ slightly from the FIA – FSP Strategic Plan in that the latter includes a theme entitled 'Synthesis of best available information to improve policies and practices' under both the Sustainability and the Timber Growth and Value programs. In the PAC recommendations, any synthesis of information is included under the other themes or under the Extension program. Also, the FIA – FSP Strategic Plan included silvicultural systems under both the Sustainability and Timber Growth and Value programs; that theme is now placed under the Timber Growth and Value program only, although there is continued recognition that appropriate silvicultural systems are critical to achieving goals under both programs.

There are two exceptions to inclusion of research topics under the FIA – FSP programs and themes. Biogeoclimatic Ecosystem Classification and Ecosystem Mapping Tools are umbrella topics that enable progress under both programs and all themes. They are therefore shown separately, below.

Biogeoclimatic Ecosystem Classification (BEC).

Although most of the conceptual development was completed prior to 1994, adoption of BEC in all manner of forest management and policy applications continues today. Recent research initiatives have addressed the creation of new applications of BEC such as in improved estimation of site indices. Specific applications of BEC are included as separate topics under the appropriate themes.

In January, 2005, Vis-à-vis Management Resources Inc.[2] was commissioned by the Ministry of Forests and Range Research Branch to evaluate the BEC program and to recommend how to maintain its long-term viability. Part of the review was to identify benefits that have been attained to date, and to solicit client input about future needs. The findings confirmed the wide application of BEC in forest management, and the continued benefits being derived from the $75 million (2004 $$) that has been invested over the past 30 years. Categories of documented use include silviculture, gene resource

[2] Vis-à-vis Management Resources Inc. A Review of the Biogeoclimatic Ecosystem Classification Program. Unpublished report.

management, inventory-growth & yield-timber supply analysis, timber revenue, protection, land use planning and landscape management, conservation-restoration, ecosystem management, research, range management and product marketing. Some conservative estimates of the financial benefits of BEC are given in that report, and are summarized later in this paper.

BEC is anticipated to respond to new challenges in the future, especially in relation to climate change, seral classification and non-forested ecosystems. There is also a continuing need for interpretations for other values such as non-timber forest products, cultural or ethnobotanical uses, recreation, water supplies, species at risk, wildlife and wildlife habitat, and land use conversion.

Ecosystem Mapping Tools

Modern forest management is requiring ecosystem identification and mapping at progressively more localized scales. Past refinements to Terrestrial Ecosystem Mapping (TEM) have been accomplished through aerial photo interpretation and ground checking, a slow and costly procedure. Through advances in research, localized ecosystems can now be described in a quick and accurate manner with a modeling approach called Predictive Ecosystem Mapping (PEM). Benefits include cost savings that result from the new approach, but more importantly, information is available in a more timely manner to enable better forest management decisions and to provide a foundation for certification initiatives.

Development of PEM has allowed timber supply analyses to be conducted at the ecological unit level or spatially specific level if desired to overcome problems with aggregation of analysis units. Coupled with the benefits of better, quicker and more comprehensive models that are capable of integrating ecological and multi-resource issues with timber analysis, PEM is enabling more robust and credible allowable annual cut decisions by the Chief Forester.

Benefits of Research Related to the FIA-FSP Program: Sustainability

Theme 1. Ecosystem structure, function, and processes, and biodiversity related to forest management

Natural Disturbance Ecology

Understanding of natural ecological processes has enabled refinement of forest practices. As a result, greater flexibility now exists in selection of appropriate silvicultural systems, including a greater range in size of harvested openings and in the dispersal of harvesting. Benefits occur in reduced logging and reforestation costs and in improved ability to provide habitats for important wildlife. Quantification of these benefits may be difficult but it is worth comment that the research enabled rapid development of a tactical response to the Mountain Pine Beetle infestation in the Prince George TSA. That plan provides for protection of biodiversity in the face of accelerated timber harvests. Without that background research, there would be much more concern about the biodiversity risks associated with the accelerated harvest.

Biodiversity

Biodiversity has emerged as a fundamental concept in forest management over the past decade. Whereas previously forest management tended to focus on maintenance of individual components of ecosystems, it is now recognized that the collective whole is what needs to be considered in sustainable management. A problem was that biodiversity, while understandable in a general sense, was neither definable nor measurable at a scale that was relevant to forest management. Research efforts have focused on developing conceptual models and defining criteria and indicators that can be used to assess how well biodiversity is being maintained, and to enable a coarse filter approach at the landscape level. Studies of non-migratory and breeding birds and canopy lichens form part of a knowledge base for a coarse-filter management approach to biodiversity. Benefits include building a credible knowledge base that supports biodiversity components of certification systems as well as day-to-day decision-making about forest practices.

Watershed science

Research in watershed science includes terrain stability, sediment sources, water quality, quantity and timing, options for riparian harvesting, and stream temperatures. When the Forest Practices Code was introduced in 1995, some of the greatest changes in forest practices were with respect to protection of streams and riparian zones. The importance of these areas was recognized but the knowledge base to support the prescriptions was relatively weak. Initial guidelines were based on blanket prescriptions that severely restricted forest harvesting operations but that were of uncertain efficacy in meeting objectives for streams and riparian areas. Investments by FRBC led to better knowledge about upslope processes and to guidance on how to rehabilitate problems related to debris flows, unstable cut banks and other hydrological risks. More recent research includes assessing the effects of harvesting level on streamflow and evaluating the equivalent clearcut area, an important tool for determining appropriate harvesting levels within a watershed so that riparian and water quality protection is achieved, while minimizing the effects of harvest levels. Benefits include improved protection of fish habitat and improved water quality in community and domestic watersheds. There has been a significant reduction in landslides over the past decade. Research has enabled design of more effective and efficient watershed management regimes and is enabling better integration of protection objectives with timber production.

Recent research has also investigated watershed, riparian, and aquatic interactions and processes, including the function and dynamics of coarse woody debris. By assessing the effects of various riparian management strategies on biotic and abiotic variables for streams of different sizes and within various ecosystems, it is now possible to give better predictions of the effects of various forest harvest treatments on stream structure, biota and water quality.

Soil biology

Soil biology research includes soil conservation, nutrition, site productivity and rehabilitation. Selected benefits over the past decade include techniques to enhance ectomycorrhizae and rooting structure in nursery and planted seedlings; better understanding of the effects of sulphur fertilization on lodgepole pine growth; and rehabilitation of soil conditions to improve tree growth on landings and degraded sites.

A major initiative in soil biology research is the long-term site productivity study (LTSP). It includes detailed analysis of climate, physical and chemical properties of soils, soil biology, litter decomposition, vegetative cover, and total site productivity. One of the indirect benefits of LTSP is development of expertise among soil scientists who are responsible for recommending improved policies and practices.

Habitat requirements for wildlife species

There has been a major shift in emphasis in wildlife research over the past decade from a concentration on larger herbivores and carnivores, to inclusion of a broad range of birds, mammals, reptiles and amphibians. Research results in some cases are targeted at improved management of individual species while in other cases are intended to form a stronger knowledge base for retention of biodiversity. There has been a particular emphasis on identified wildlife and on species at risk. Research has improved knowledge about habitat identification, habitat requirements and population dynamics of wildlife species such as caribou, grizzly bear, Marbled Murrelets, mountain goats, tailed-frogs, mountain beavers, and Goshawks. Benefits include the ability to create management prescriptions that will be effective in achieving species protection and recovery, eliminating or modifying practices that are proven to be inappropriate, and avoiding unnecessary restrictions on parts of the forest that can be shown to be of lesser importance to the species. Numerous new stand level practices have been introduced including leaving wildlife trees and stub trees, coarse woody debris and flexible riparian and streamside protection.

Theme 2. Decision tools

Decision tools include both computer-based and knowledge-based systems to help make better decisions on stand level operating activities or investments. The improvements in modeling and information for models now makes it possible for companies and government managers to test which options provide the best financial or biological returns. Returns on silviculture investments can be analysed at the forest level as well as the stand level, forecasting benefits in timber growth, wildlife habitat and other values over time.

Decisions are supported by collection of data on soils and vegetation to define terrestrial ecosystems, and development of remote sensing techniques to monitor and measure various ecosystem and landscape attributes. Results enable direct application of knowledge towards meeting land-use planning targets and objectives, recovery plan preparation and implementing provincial policy initiatives for species at risk, and enable integration of wildlife habitat requirements with timber harvesting.

Theme 3. SFM indicators, targets and monitoring systems

Over the past decade, sustainable forest management has progressed from a vague concept to a fundamental principle that underlies responsible stewardship of natural resources. Benefits of research include development of a framework and processes to support ecosystem based management and criteria and indicators to monitor performance in relation to sustainable forest management objectives. While there is a need for continuous improvement to refine current criteria and indicators, and for more research to develop new ones, the benefits to date have enabled licensees to demonstrate adherence to practices that meet requirements for forest certification.

Some specific benefits of research include decision tools to optimize ecological, social and economic criteria in SFM planning, and compare alternate scenarios, and cost-efficient and appropriate standards for monitoring forest certification criteria. New tools are available that enable aggregation of forest polygons into appropriate stewardship units and analyze tradeoffs between the value of timber and the effect of harvesting methods on SFM indicators. Public involvement methods have been developed to identify locally relevant criteria for sustainable forest management, including improved methods for joint forest management with First Nations and other stakeholders, and a 3-D landscape visualization tool is available to assist in public planning processes.

Theme 4. (Scientific information to inform policy, regulations, and forest and range practices requirements)

This theme identifies a specific purpose for conducting research, rather than the type or nature of the research being conducted. For the purposes of this paper, research funded under this theme is considered as part of the other themes.

Benefits of Research Related to the FIA-FSP Program: Timber Growth and Value

Theme 1. Tree growth and stand development

Forest genetics

Tree improvement gains are now built into TIPSY for modeling future forest growth. Tree species are at different stages of improvement but on average the current gains in genetic worth are about 11%. It must be recognized, however, that much of current second growth is based on older genotypes so these gains cannot be realized immediately. Eventually, the gains will equate to about 7.7 million m^3 of harvest per year commencing about 7 decades in the future. There may be some shorter-term benefits in harvest rates in some management units if there is sufficient mature stock for harvest during the transition period. In particular, some crops of improved stock on high sites may reach growth culmination in as early as 40 years, thereby offsetting critical shortfalls of timber supplies in the mid-term. These faster-growing crops may also play a role in mitigating the impacts of mountain pine beetles on the availability of mature, harvestable timber in the interior.

It should be noted that although research enables gains from tree improvement, realization of those benefits requires major investments in infrastructure and seed management through the Tree Improvement Program. Any accounting for benefits in relation to costs would therefore have to be inclusive of Tree Improvement Program costs.

Other benefits from tree breeding research include increased resistance to pests and pathogens and improvements in tree conformation and wood qualities. An example is weevil resistance in spruce where results of research are being implemented to improve both wood supply and wood quality in the interior.

Forest genetics research has demonstrated that many seed sources can be moved beyond restricted elevational and latitudinal bands thereby enabling selection of the best available parent stock and deployment of improved seed to a wider range of sites. As a result of this research, the number of seed zones has been reduced from 14 to 2, and that should have resulted in cost savings in nursery production and in deployment of seedlings. As more companies adopt the use of improved seed, the benefits of this research will become more apparent.

Seed and seedling physiology

The science supporting seed handling and seedling production was relatively mature prior to the 1990's. A solid body on knowledge existed at that time, based on research efforts under FRDA 1, enabling improved reforestation practices and increased predictability of success. While advances continue to occur, they are incremental in nature. The most significant impact of research in this area over the past decade has been the development of a knowledge-based industry. Costs of seedling production have been reduced to the benefit of BC's forest industry, and the leading-edge technology has led to contracts for seedling production for use outside the Province. Research has also enabled a reduction in the use of chemicals and development of new purpose-built stock types.

Inventory and monitoring

A variety of research has addressed applications of remote sensing tools and merging data across scales and from different sources to provide information for improved management decisions. GIS has become a common tool for compiling and analyzing data, and for making presentations to facilitate public participation. IKONOS and Landsat have proven very useful for monitoring natural disturbance events such as windthrow and beetle damage.

Theme 2. Design and analysis of silvicultural systems

Research on silvicultural systems has enabled forestry practices to shift in accordance with a changing forest management paradigm. Over the past decade, emphasis has moved from mitigating ecological impacts of primarily clearcut logging, to managing forests as sustainable ecosystems. Changes include introduction of alternative harvesting systems, use of increasingly complex mixes of species including deciduous, and reforestation treatments that are tailored to different ecosystems. It has become evident that best practices can be highly specific to small areas even within fairly homogenous forest cover and improved knowledge from research is enabling management strategies for current and alternate forest practices to benefit both timber and non-timber resources.

Research addressed a variety of silvicultural related questions including examination of leave tree retention practices, regeneration dynamics in partial cut/variable retention and clearcut systems, and stand-level responses to stand management activities such as fertization, thinning, and operational brushing. Specific research applications have included use of landscape modeling to assess management options for meeting timber and habitat objectives in Interior dry-belt and high elevation forests, ecological impacts of alternative harvesting practices in high-elevation ESSF and survival of Douglas-fir retained in harvested sub-boreal spruce forests.

Long-term research installations have played a major role in silvicultural systems research. Sites such as Opax Mtn., Sicamous Cr., Pothole Cr. and the MASS project on Vancouver Island provide opportunities for testing operational scale practices, with data collection over long periods of time. The data history at these sites enables modified practices to be assessed more quickly than at new locations where baseline data must first be gathered.

Theme 3. Growth and yield modeling/predictions

Site Productivity

By using BEC to refine estimates of site index through SIBEC, forest growth potential can now be localized to a finer geographic scale. One benefit is that silviculture investments can be targeted more precisely to elicit desired responses. Another benefit is that site indices can be determined for the Timber Harvesting Land Base, rather than for productive forest land in general which was the basis of the original sampling. Because the former tends to have higher quality timber-producing land on average, site indices have shown an upward trend. Site productivity R&D has enabled moving beyond initial best-guess estimates for managed stands which came from pre-harvest inventory data for old-growth stands.

Application of SIBEC depends upon availability of PEM/TEM eco-mapping so in not yet in widespread use in timber supply analyses for Timber Supply Areas but is common for Tree Farm Licenses. To date, the Arrow is the only TSA where SIBEC has been applied in a base-case analysis although some other sensitivity analyses have been done to forecast the eventual application of SIBEC. For example, the latest timber supply analysis for the Fraser TSA included refined site productivity estimates that drew on information emerging from SIBEC. The Chief Forester has used those sensitivity analyses as evidence to counterbalance a range of unquantified downward pressures on allowable annual cuts.

Growth and productivity research has enable assessment of the effects of stand treatments and alternative management applications on future projections of timber production, wood quality, regeneration and stand structure. New variables include environmental protection, changing social attitudes, greater species utilization, value-added wood industry, sustainability and certification. Research includes measurement and prediction of the effects of stands treatments such as fertilization and thinning and management strategies such as mixed species, complex stands and variable retention on growth and yield, wood quality, regeneration and stand structure. Benefits include reduced uncertainty through scientifically defendable and adaptable tools. Information supports silvicultural planning, stand treatments, inventory, timber supply analysis, land use planning, and AAC determinations.

Old-Growth Site Index (OGSI)

As timber harvesting has progressed through the province's standing inventory of mature forests, growth of future forests has become an increasingly deterministic factor in setting allowable annual cuts. Research on growth intercept estimates for site productivity indicated that basing yield estimates for new managed forests on the volumes in existing stands was highly suspect and likely overly conservative. The conclusion was that site index values derived from old growth stands needed to be revisited.

Application of results from OGSI research has resulted in a much more optimistic forecast for timber supplies in many management units throughout the province, often more than offsetting the downward pressures on timber supplies that have resulted from introduction of sustainable, ecosystem-based forest management.

Note that research related to SIBEC and OGSI has enabled more accurate predictions of future timber supplies, but the gains would have been recognized empirically over time as growing stands were observed and eventually harvested and scaled. At least a portion of the above benefits would therefore have been realized even in the absence of research.

Growth and Yield

The first application of managed stand yield curves from TASS/TIPSY around 1990 made a very big impact on timber supply projections. By that time, the second growth component of the forest inventory had become a significant factor not only in projecting future timber harvests, but short-term harvest rates as well. Because of the policy that enables short-term harvests to be accelerated relative to long-term projected harvests, provided that a downward transition can be phased in gradually without supply gaps, managed stand yield curves enabled harvests to be maintained when they would otherwise have been decreased. For some management units, the gain from using managed stand yield curves was as high as 30%.

Those gains arose from research conducted in the previous decade but new research has continued to improve growth and yield estimates. In particular, growth and yield has served as the integrator of a wide range of research and development benefits, including genetics, fertilization, forest health and many non-timber resources such as wildlife habitat, visuals and biodiversity. It is the prediction of the future forest that enables the practice of sustainable forest management, a fundamental condition for certification.

Growth & yield research over the past decade has tracked the rapid shift in forestry paradigms. By anticipating the shift, research was able to prepare the knowledge base that was needed to introduce partial cutting, variable retention and mixed-species management. That knowledge also enables the effects of mountain pine beetle infestations to be predicted, and management options to be evaluated.

Research has provided knowledge to support model development and refinement, modeling of complex and deciduous stands, and understanding implications of partial cutting silviculture systems including variable retention. The research initiatives have responded to rapid changes in silvicultural practices, from predominantly clearcutting of coniferous stands, to a wide range of partial cutting regimes applied in a wider range of stand types. Benefits include the ability to design management prescriptions to achieve desired multiple use benefits and ecosystem sustainability, to ensure effective reforestation efforts, and to understand timber supply implications of the new harvesting regimes.

In combination, improved estimates of forest growth and yield have shown major impacts on long-term timber supply projections. They have increased very significantly between TSR1 and TSR3. Assuming an average of about 25.5% (based on the sample of 6 TSAs there is a net increase of 15% in Long Term Harvest Level (LTHL) after accounting for a reduction in the Timber Harvesting Landbase of 10.5%), that translates into 18 million m^3 of harvest per year commencing about 7 decades in the future. There are some positive benefits in the shorter term as well in projections of timber supply outlooks but the results are variable between management units and highly dependent upon current availability of mature stocks for harvest.

Theme 4. Timber losses to environmental factors (wind, drought, insects, disease)

The current epidemics of mountain pine beetle have become a centre of attention for forest managers and researchers, but that is only one of the many forces that can impose timber losses in BC’s forests.   Over the past decade, considerable research effort has been expended on studying the timber supply impacts and developing mitigative forest practices for root rots, insects and diseases. Some examples of research benefits can be seen in new knowledge about the biology, population dynamics, impacts, outbreak patterns, improvement of remote sensing and predictive modeling. Timber loss agents where progress has been made include seed-borne fungal disease; Armillaria; biocontrol of western hemlock dwarf mistletoe; western balsam bark beetle; western hemlock looper; western blackheaded budworm, forest tent caterpillar; mountain pine beetle; wildfire risk assessment and management.

While destruction of whole forests is dramatic, much of the loss of timber supply to environmental factors occurs in a more subtle way through death of individual trees, and inhibition of growth in others. Historically, these impacts have been ignored because they are naturally factored into the volumes achieved in pre-existing mature stands. However, there needs to be explicit consideration of potential losses in future managed stands, and these losses have been underestimated in some circumstances. Definitive research is now enabling better understanding of the effects of environmental factors on timber supplies.

Theme 5. Analytical techniques and models for strategic analysis

The Timber Supply Review process which began in 1992 marked the introduction of simulation modeling for timber supply analysis. Although more flexible and faster than the linear program model, TimberRam, that had been used previously, the early version of FSSIM had limited capability to model the complexities of new management practices required by the Forest Practices Code. Refinements continued through much of the 1990's in order to more effectively account for a greater range of silvicultural practices, and to introduce some degree of geographic discrimination (still non-spatial but better able to simulate spatial effects at a subunit level).

More recently, attention has shifted toward development of better modeling techniques for complex stands including partially-harvested stands with resulting uneven ages, and mixed-woods. Newer models are also evolving that can cost-effectively incorporate a degree of spatial discrimination. These developments are producing usable products that will continue to be developed and refined over the next decade.

Financial Benefits of Research

The benefits of research in improving achievement of most forest resource management goals are not amenable to assessment in financial terms. There is widespread agreement that such benefits have occurred and that they are of significant importance, as described in the previous section. The purpose of the following discussion is to simply tally up the financial impacts that can be measured, to provide a partial description of the benefits of research. These estimates reflect the findings of the case studies described earlier.

It is significant that feedback received on an earlier draft of this report was strongly critical of the implied bias toward timber rather than other resource values. These reviewers expressed opinions that the benefits of research in enabling sustainability of ecosystems and biodiversity, and maintenance of multiple resource values, were at least equal to the financial benefits associated with timber production. While it is clear that these benefits have enabled huge advances in resource stewardship, depiction of those values remains largely qualitative. The focus of this section of the report is not on timber per se, but on what can be quantified directly or through conservative assumptions. As it turns out, the most readily measured financial value is for timber.

It can be calculated that each 1 m^3 of annual timber harvest equates to about $14 in direct provincial revenue and $180 in provincial gross domestic product[3]. Benefits of research may be reflected in increased harvest levels, or in offsets to harvest declines that would otherwise have occurred. These financial numbers are crude indicators of value because they do not consider the timing of benefits (whether or not the income stream should be discounted), the possible higher value of timber at the supply margin as opposed to average values, or the quality characteristics of the timber actually being made available. As will become evident, however, the values are so great that even if they were in error by an order of magnitude, research would still be portrayed as an attractive investment.

Research Topic	**Annual Direct Prov. Revenue or Value of Non-Market Public Benefits**	**Contribution to Annual Prov. GDP**	**Cost Savings**
SIBEC (1%)[4]	$10,080,000	$129,000,000	
Trade benefits of BEC eg, certification (1%)[4]		$129,320,000	
Silvicultural benefits of BEC (1%)[4]	Captured under G&Y	Captured under G&Y	$1,800,000
Forest genetics/ tree improvement	$107,800,000	$1,400,000,000	
Growth & Yield (incl. OGSI)[5]	$252,000,000	$3,240,000,000	
Seed/nursery ($0.01/ seedling savings)[6]			$2,500,000
Subtotal	$370 million	$4.9 billion	$4.3 million
Protection of species at risk	??		
Protection of identified wildlife	??		
Non-timber forest products	??		
Sustainable ecosystems	??		
Maintenance of biodiversity	??		
Etc	??		
Total	Probably exceeds $1 billion		

[3] As calculated from data in "A Review of the Biogeoclimatic Ecosystem Classification Program", 2005 unpublished report by Vis-à-vis Management Resources Inc.
[4] 1% was selected by Vis-a-vis Management Inc. for illustration purposes; the actual value is unknown but is believed to be substantially higher than this
[5] based on an average 25% increase in forecast timber supplies as shown in the six case studies
[6] conservative estimate provided by Jack Woods, pers. comm.

The Cost Side of the Equation

Over the past decade, expenditures on forest resource management research in BC have averaged about $50 million per year (total average expenditures on forest science and technology were in the range of $70 to $75 million per year, including about 30% directed to development of forest products and forest engineering technology).[7] There has been a distinct downward trend from peak expenditures on forest resource management research in the mid- to late- 1990's, to about $40 million in 2000, and to less than $35 million at present.

These numbers, however, are not truly indicative of forest science expenditures because they include salaries for forest science experts who would need to be retained by various agencies and institutions even if they were not undertaking research. In universities, for example, faculty members are both educators and researchers. In the Ministry of Forests and Range, forest science staff provide scientific and technical advice to decision-makers, in addition to undertaking research projects. These multiple roles are synergistic and to a large extent inseparable, so no attempt has been made here to isolate the costs except to caution that research expenditures are probably overestimated to some degree – perhaps by 20 to 25%.

Regardless of how the costs of forest management research are calculated, the measurable benefits exceed those costs by a very large amount. Based on a ten-year average, there is at least a 7:1 ratio of direct revenues to research costs. Based on current research expenditures, those benefits are in the range of 10:1. Accounting for other unquantified benefits could easily double or triple those ratios. Expressing the benefits as impacts on provincial GDP magnifies them by another order of magnitude. Although the latter approach is not strictly a valid measure of economic returns (the forest research investment should be compared to GDP impacts of the next best alternative investment), it serves to illustrate how relatively modest expenditures in forest research can multiply into substantial returns in overall economic activity.

It is illustrative that the continuing annual financial gains from the past decade of research, calculated for only the readily quantifiable research benefits, are sufficient to pay for the entire forest management research program in perpetuity, without counting the value of benefits to be derived from future knowledge gains. Or, more simply, the financial benefits of research on the Biogeoclimatic Ecosystem Classification program and its applications alone are probably sufficient to support the entire forest management research program on a continuing basis.

The Decade Ahead:

Looking ahead to 2014, there are already clear trends that define the type of new knowledge that will be needed, and the benefits that will be derived from its application.

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[7] "Moving Ahead": Science and Technology in BC Forest Resource Management, August 2000. Prepared for COFRA by FORUM Consulting Group Ltd.

FIA-FSP research projects have already been approved and implemented for the first two years of the decade, and planning is well underway for the third year. In general, these three years show is a continuing shift from conducting research to mitigate the ecological impacts of resource management, to management of forests in accordance with their ecological values.

Funded projects for 2004/05 and 2005/06, plus priorities for 2006/07, summarized in the following table, illustrate the major research activities that are likely to continue throughout the decade.

Summary of Current Forest Management Research Activities	
Topic	**Research Emphasis**
Species at risk and identified wildlife	Habitat requirements; general ecology; effects of forest practices options
Management of complex stands	Multi-resource implications of choosing mixed age, mixed species management regimes; growth and yield under various silvicultural treatments; options for sustainable habitat production; emulating natural conditions through alternative harvesting systems
Climate change	Effects of global warming on established forests and on regenerating forests, including timber and non-timber values; risks of fires, pests and other disturbances; policy implications of shifting carbon balances
Biodiversity	Identifying and maintaining old-growth attributes in managed forests; options for large-scale forest zoning to maintain biodiversity
Watershed and riparian management	Assessment of alternative management practices for riparian areas; cumulative effects of forest practices on watershed dynamics; recruitment of LWD; long-term implications of static reserves
Forest health	Improved knowledge and management responses to insects, root diseases and rusts; current heavy emphasis on mountain pine beetle
Criteria and indicators of sustainability	Selection of additional species as indicators including mammals, amphibians, insects, birds, lichens and bryophytes
Model development and application	Improved ability to model complex stands; inclusion of variable retention treatments in spatially explicit models; inclusion of ecosystem values and multiple resource values in multiple accounts forecasts
Vegetation management	Improved vegetation management regimes to optimizing timber production in complex stands;

In addition to the topics in the table, there are other issues that will demand attention for forest researchers before 2014. Foremost among these is continuing population growth and its demands for land for settlement and support infrastructure. In addition, this growth will add demands for domestic water and other amenities from our forests. In combination with escalating fuel prices, the energy demands of a larger population may trigger a resurgence of interest in hydro-electric development, and its consequent pressures on productive forest lands for impoundments and transmission corridors. Over the decade, what is now narrow bands of interface between settlement areas and resource lands will become more pervasive over much larger portions of the forest, requiring significant shifts in the objectives and practices of forest management.

Another major issue is the continuing transition from meeting multiple resource objectives during the initial harvesting of pre-existing forests, to managing for multiple values in primarily second-growth forests. While research work is already underway to produce some necessary knowledge, such as maintenance of old-growth attributes in second-growth stands, there is much more that will be needed to ensure sustainability of the array of plant and animal species that rely on the current characteristics of our forests.

The primary benefits of research will be seen in producing sufficient knowledge to enable timely adaptation to these and other changes. The priorities established by the Forest Science Board would appear to be aligned well with anticipated information needs and the selection of funded projects is comprehensive enough to strength the web of knowledge to support informed decision-making, and to enable informed consideration of risks and uncertainties.

Appendix 1. TSA Case Studies

Strathcona TSA

The AAC prior to TSR1 was 1,693,745 m^3, less a reduction of 188,000 m^3 that was made as a temporary measure pending decisions on Protected Areas. The THLB was estimated to be 236,000 ha.

The TSR1 analysis showed that the current AAC could not be sustained even for the first decade. An immediate reduction to 1.45 million m^3 would be needed to avoid major disruptions in future timber supplies. The projected harvest declined steadily for 4 decades, reaching a low of 940,000 m^3. At the end of 11 decades, the projected harvest recovered to a LTHL of 1.10 million m^3. The new AAC was determined to be 1.42 million m^3.

The principle new constraints on timber supplies were exhaustion of old-growth forest and the consequent transition to second growth, increased provisions for wildlife habitat, and protection of scenic values.

TSR2 assumed a reduced THLB of 177,797 ha. The reduction was due primarily to economic inoperability, avoidance of unstable soils and deletion of forests with low site productivity.

The base case analysis required a starting point of 1.25 million m^3 (13% below the AAC) in order to avoid major disruptions in future timber supplies. The harvest schedule decreased over 2 decades to 970,000 m^3/yr, and remained at that level until decade 11 when it rose to a LTHL of 1.07 million m^3/yr. The new AAC was determined to be 1.28 million m^3.

TSR3 also required a new starting point below the current AAC. The harvest schedule began at 1.12 million m^3 and declined over 2 decades to 800,000 m^3. It recovered to 912,000 m^3 after 7 decades, and to a LTHL of 970,000 m^3 after 14 decades. A significant downward pressure on the harvest schedule was the impact of an additional 18,000 ha of riparian reserve. Although only a small proportion of the THLB, these were highly productive lands. The transition to second growth continued to be exacerbated by loss of short-term available mature timber to meet other objectives for integrated resource management.

In the base case analysis, SIBEC was not assigned to previously harvested stands that are less than 20 years old. Another scenario that applied SIBEC to these stands showed that mid-term harvest rates could be sustained at 1.10 million m^3/yr, and the LTHL increased to 1.13 million m^3/yr, a gain of 20% and 16%, respectively.

The new AAC has not yet been determined but is expected to be approximately 1.10 million m^3.

Fraser TSA

The Fraser TSA entered TSR1 with an AAC of 1.76 million m^3. The analysis assumed a timber harvesting landbase (THLB) of 275,000 ha which was a 25% reduction from the previous estimate. The reduction was primarily because of redefinition of harvesting operability. The analysis forecast the timber supply to decline to 1.18 million m^3/yr over a period of 3 decades. The new AAC was set at 1.55 million m^3.

TSR2 analyzed the effects of new large parks, completion of a Spotted Owl management plan and an inventory audit. The THLB was estimated at 281,479 ha. The inventory audit indicated that mature stand volumes (over 60 years old) were over-estimated by 23%. The analysis showed a decline in timber supply to 1.02 million m^3/yr over a period of 3 decades, gradually rising to 1.2 million m^3/yr in the long term. The AAC was set at 1.27 million m^3.

TSR3 analyzed the effects of improved estimates of site index and growth of immature stands, as well as inclusion of some previously unmerchantable stands. The THLB was reduced further to 260,910 ha as a result of additional measures to achieve integrated resource management and to maintain biodiversity. In spite of the land base reduction, the timber supply was forecast to maintain the current AAC of 1.27 million m^3/yr for over 10 decades before increasing to a long-run sustainable level of 1.52 million m^3/yr. Overall, this amounts to a 25% increase compared to TSR2, almost all attributable to research on forest growth and model development.

Golden TSA

The Golden TSA has had a history of timber supply issues resulting from overly optimistic assumptions about economic operability of marginal stands, and exacerbated by decisions to allow logging to be concentrated in high-value, close-in stands in order to avoid mill closures. By the time TSR1 was conducted, the timber supply analysis was dismal. The then-current AAC would have to drop from 650,000 m^3 to 605,000 m^3 immediately, followed by further decreases of 10% per decade until a LTHL of 309,000 m^3/yr was reached in 80 years. The THLB was estimated to be 174,600 ha. Because the analysis was based on assumptions that staff believed were still optimistic, including volume in mature stands and size of the economically operable landbase, and because current harvests were depressed below the AAC as a result of a market downturn, the Chief Forester chose to reduce the AAC immediately to 535,000 m^3.

The analysis for TSR2 showed that the AAC of 535,000 m^3/yr could be sustained for 2 decades from a THLB of 167,000 ha. The AAC would then drop to a LTHL of 446,000 m^3/yr over the next 2 decades. The AAC was set at 530,000 m^3.

The analysis for TSR3 showed that the THLB had increased to 196,500 ha but that timber availability was greatly constrained by provisions for sustainability of non-timber values over the short- and mid-terms. An AAC of 530,000 m^3 could be sustained for 1 decade, then it would decline over the next 2 decades to 440,000 m^3 and remain there for the following 9 decades. Subsequently, the AAC could rise to a LTHL of 463,000 m^3.

Arrow TSA

The AAC for the Arrow TSA at the beginning of TSR1 was 619,000 m^3, produced from a Timber Harvesting Land Base (THLB) of 217,000 ha. The analysis showed that the AAC could be sustained for 7 decades before dropping sharply over the next 4 decades. By decade 11, the timber supply would reach the LTHL of 422,000 m^3/yr. It was noted that 42% of the land base was assigned to special management zones (SMZ) that were modeled according to a 4-pass system. It was expected that new management requirements for at least part of the SMZ would require 5 or 6 pass systems, resulting in a faster decline to a lower LTHL. The AAC was determined to be 609,300 m^3.

TSR2 showed greater constraints on timber supplies in the short term, but a much higher LTHL. The THLB was estimated to be 202,000 ha. The AAC of 609,300 m^3 could be sustained for 1 decade before dropping over the next 2 decades to 493,500 m^3/yr. By decade 9, the forecast harvest increased to 544,000 m^3/yr and then to the LTHL of 557,000 m^3/yr by decade 16. Pressures on timber supplies included loss of land base, effects of root rot on forest growth, increased green-up requirements for visual quality; these were offset by increased estimates of timber volume in existing mature stands. Substantial uncertainties included biodiversity management guidelines, estimates of yields from regenerated stands, and site productivity of current old-growth stands. The AAC was determined to be 550,000 m^3.

TSR3 was predicated on a THLB of 211,700 ha. The increase resulted from careful review of operability lines. The analysis showed that the AAC of 550,000 m^3 could be sustained for 7 decades and then could increase to the LTHL of 690,000 m^3/yr after 8 decades. The large gain relative to TSR2 was attributed by the analyst to the “impressive positive impact” of predictive ecosystem mapping (PEM) and site index-biogeoclimatic ecosystem classification (SIBEC).

The overall effect of new information between TSR1 and TSR3 was minimal in the short term (a 13% decline relative to TSR1, half of which could be attributed to changes in estimates of the operable land base) then an increase of over 60% after decade 7.

Prince George TSA:

The starting AAC leading into TSR1 was 9073661 m^3, not including Woodlot Licenses. The THLB was estimated to be 3,620,000 ha.

The analysis for TSR1 showed that the AAC could be increased to 9,630,000 m^3 without declining over the 250-year planning horizon. There were significant uncertainties identified, especially the increase in the amount of marginally economic stands in the THLB. The north-western extension of the TSA known as Supply Block A was of particular concern in this regard. Offsetting this uncertainty to some degree was the expectation that using managed stand yield tables for newly regenerated stands would increase yield estimates for those areas by up to 20%. The new AAC was set, effective Feb 1, 1996, at 9,363,661 m^3 plus 106,838 m^3 for Woodlot Licenses. The AAC included a temporary uplift of 290,000 m^3 for harvest of looper-damaged cedar-hemlock stands.

The analysis for TSR2 was predicated on a reduced THLB of 3,409,280 ha. Results showed that the current AAC could be maintained for 170 years before dropping to a LTHL of 8,800,000 m^3. A sensitivity analysis indicated that the LTHL might increase to 1,025,600 m^3/yr as a result of revised old growth site indices. On the other hand, uncertainties around the standing volume in existing mature stands suggested that the mid-term harvest rates might be overestimated by 21%. The harvest rates predicted by the base case analysis would have to be reduced by almost 10% as a result. A further uncertainty was that Supply Block A might not be economically operable to the level anticipated in the base case analysis. Mountain pine beetle infestations were reaching epidemic proportions in the TSA and would require concerted efforts to attempt control and salvage.

The new AAC was increased substantially, mainly in response to the mountain pine beetle epidemic. The AAC was determined to be 12,244,000 m^3, including partitions of 3,000,000 m^3 as a temporary uplift for mountain pine beetle control and salvage, 400,000 m^3 attributable to Supply Block A (i.e., the harvest could only be applied within that supply block), 160,000 m^3 for harvest of deciduous-leading stands, and 110,000 m^3 for harvest of looper-infested cedar-hemlock stands.

Although TSR3 is still in its early stages for the Prince George TSA, the AAC was revisited in 2002 because of continued devastation by mountain pine beetle. The AAC was increased by a further 22% to 14,944,000 m^3 with the intention that harvests would be devoted almost exclusively to stands that were infested by beetles, or under imminent threat of infestation.

The rationale for the new AAC decision addressed a number of factors that would affect management of the TSA. It noted that 37% of the productive forest land was devoted to critical wildlife habitats, wildlife tree patches, riparian reserves, environmentally sensitive areas, plus some uneconomic low productivity stand and non-merchantable forest types that contributed in some ways to biodiversity. Plans to manage for these values were being overtaken by mountain pine beetles or salvage efforts. A decision was made to increase retention areas to 20% of the productive forest (as opposed to the previous 8%) in an effort to retain biodiversity while logging was accelerated elsewhere.

The Forest Science Program was involved in production of a report entitled “Forest Stewardship in the Context of Large-Scale Salvage Operations (June 10, 2004)”. This report recommended offsetting the impacts of larger openings resulting from mountain pine beetle control and salvage operations with increased retention areas to maintain biodiversity. The recommended amount of retention area was 20%, up from the previous 8%. This report and its recommendations were built on a solid body of research information that addressed the special ecosystem characteristics of Natural Disturbance Types across the province.

Kalum TSA

The current AAC at the time of TSR1 was 480,000 m^3, and the THLB was estimated to be 104,000 ha. The analysis showed that the AAC could not be sustained for the first decade, and that the forecast harvest level needed to be reduced to 464,000 m^3 for decade 1 and then to 400,000 m^3 by the end of decade 2. The LTHL was 400,000 m^3. Significant uncertainties included volume of existing stands and growth rates of regenerated stands. The AAC was determined to be 459,684 m^3 (plus 4316 m^3 for Woodlot Licenses).

The analysis for TSR2 showed that the current AAC could be maintained for 3 decades before declining to 387,000 m^3 over the subsequent 2 decades. It would remain at that level for the next 8 decades before rising to a LTHL of 431,500 m^3 by decade 12. The THLB was reduced to 98,000 ha but that reduction was offset by a 13.3% increase in the estimate of old growth site index (OGSI). There continued to be uncertainty about existing stand volumes in mature forests, and growth rate and volume of regenerated stands. The AAC was determined to remain unchanged at 459,684 m^3 but was subsequently reduced by 22,800 m^3 to 436,884 m^3 as a result of the Nisga'a Final Agreement Act.

TSR3 has been postponed by the Chief Forester until November 2007. In making this decision, he noted that there is still uncertainty regarding major determinants of timber supply, namely operability and existing stand volumes. However, "there is no specific data that demonstrates there is an immediate risk to timber supply."

Appendix 2. Information Requested From FIA-FSP PAC Members and Other Experts

Questions for Consideration:

1. Do the topics listed in the text capture the main areas for advances through forest research over the first decade (1994 to 2003)?

    a) Please identify topics that in your opinion should be **deleted** from the list

    b) Please identify topics that in your opinion should be **added** to the list

2. Do the descriptions of benefits capture the main research contributions from your perspective?

    a) Please provide additional summary level information of which you are aware, or indicate where such information may be found (a regional breakdown would be helpful but a general province-wide description would suffice)

    b) Please provide any specific benefits that pertain to the individual case study areas

3. Are there specific research topics, or theme areas for multiple projects, that you view of being especially beneficial in advancing forest management and forest policies over the past decade (within the FIA FSP themes of Timber Growth and Value, and Sustainability)?

    a) Please note whether each topic on your list applies to the province, a region or one or more case studies

    b) Please elaborate on the benefits from your perspective

4. Are there specific research topics, or theme areas for multiple projects, that you believe will be especially beneficial in advancing forest management and forest policies over the next decade (within the FIA FSP themes of Timber Growth and Value, and Sustainability)?

    a) Please provide a rationale for your selections

    b) Please provide an overview of expected benefits