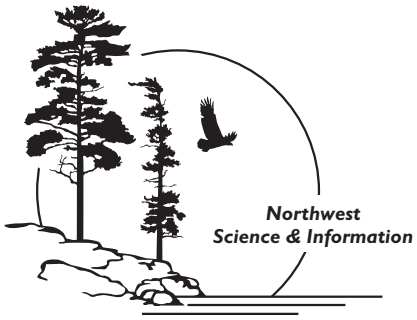


Preparing for Change: Climate Change and Resource Management in Northwest Region

NWSI Technical Workshop Report TWR-04

June 2005

Ontario

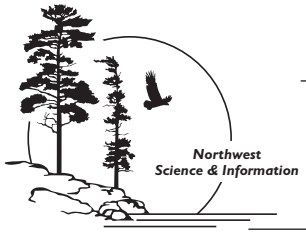
Preparing for Change: Climate Change and Resource Management in Northwest Region

NWSI Technical Workshop Report TWR-04

June 2005

by

G.D. Racey



developed and produced by
Northwest Science & Information

Ontario

51952
ISBN 0-7794-7975-0 (PDF)

Single copies of this publication are available from:

Ontario Ministry of Natural Resources
Northwest Science & Information
25th Side Road
Thunder Bay, Ontario
P7C 4T9

Phone: (807) 939-2501
Fax: (807) 939-1841
E-mail: nwst@mnr.gov.on.ca

Cette publication spécialisée
n'est disponible qu'en anglais

This publication should be cited as:

Racey, G.D. 2004. Preparing for change: Climate change and resource management in Northwest Region. Ont. Min. Natur. Resour., Northwest Sci. and Info. NWSI Technical Workshop Report TWR-04. 27 pp.

Abstract

Climate change will have profound implications for the ecology and economy of northwestern Ontario. Managers will have to adapt to these changes in forest, wildlife, fish, and water resources. A two-day workshop was held at Quetico Centre in November 2004 to inform Ontario Ministry of Natural Resources staff about climate change and its implications for the resources they manage. The 38 participants suggested 77 actions that may be considered as part of an adaptive response to climate change. These suggested actions pertain to almost all facets of core business including: direction, communication, training, protected areas, inventory and monitoring, fire management, planning, silviculture, forest modeling, wildlife and fisheries. The workshop set the stage for an expanding dialogue on climate change adaptation with staff, clients, and partners in natural resource management.

Acknowledgements

Funding for this project was provided through Ontario's climate change program and the Northwest Region planning office. The workshop was coordinated and delivered by staff of Northwest Science and Information Section. Many thanks to those who helped organize the workshop and assemble the workshop report. They include Kim Armstrong, Evan McCaul, Annalee McColm, Karen Punpur, and Bill Towill.

Table of Contents

Page

List of Appendices

Page

1.0 Introduction

The Ontario Ministry of Natural Resources (OMNR) has produced a document *Climate Change and MNR: A [Draft] Strategy and Action Plan.* It identifies three major themes: 1) understand climate change, 2) mitigate the impacts of climate change, and 3) help Ontarians adapt. Despite significant commitments to research and development, there is little evidence that OMNR is adapting its field program delivery to address the challenges of a changing climate. At the Northwest Region Management Team meeting April 28, 2004, managers were presented information on the changing climate of northwestern Ontario and the potential impacts on wildlife, fish, forests and other resources. They provided their support for a workshop involving their staff in order to provide advice to clients and help position the Northwest Region for adapting to climate change.

Climate change models suggest that Northwest Region will experience some of the most acute impacts of climate change in Ontario. In the next 90 years, the area will see a 5^{o}C increase in growing season temperature, no significant change to slight increase in precipitation, and an increased frequency of extreme weather events. Analysis suggests increases in fire frequency, shifts in forest species composition, reduction in amount of area of old forest, slight increase in forest productivity where moisture limitations are minimal, expansion of white-tailed deer range, increased risk to woodland caribou, an increasingly stressed water budget, and many other potential impacts. However, there has been little thought as to how OMNR within the region will adapt its management plans, processes, or decisions to address increased uncertainty regarding ecological/resource sustainability or the associated economic and social implications.

Some ecologically significant implications of climate change may be realized before the current set of forest management plans mature in 20 years. OMNR staff have the tools and insight that could be applied in current planning processes to reduce these risks. However, staff need more information and an opportunity to share concepts and discuss ideas among their peers. Most important, they need to be able to direct some of their insight and advice back to regional managers regarding options for a reasoned, adaptive response to climate change. This workshop was designed to identify adaptive responses and possible actions.

1.1 Workshop Goals and Objectives

The goal of the workshop was to position the Northwest Region to respond to challenges that climate change will impose on the management of natural resources.

Objectives included:

1. Increase awareness of regional staff of climate change evidence in northwestern Ontario, implications of climate change, and potential adaptive measures;
2. Share perspectives among disciplines and with peers; and
3. Generate advice and propose actions to assist regional managers in developing a reasoned, adaptive response to climate change.

The workshop was considered a “first installment” towards an ongoing dialogue with staff and clients. It was a forum for the people who provide advice to decision makers about the resources we monitor and manage in the Northwest Region. Over the longer term it was intended to encourage regional staff to adapt their practices to a steadily improving stream of knowledge

and recommendations regarding climate change impacts. This workshop demonstrates OMNRs commitment to protecting and managing the province's natural capital and ensuring that these resources are available for future generations.

2.0 Methods

The workshop was held at the Quetico Centre, November 30 to December 2, 2004 (Appendix 1). The 38 participants (Appendix 2) included OMNR foresters, biologists, planners as well as fire, parks, and water managers at the district and regional level and research specialists covering disciplines including climatology, forestry, fisheries, hydrology, fire, wildlife, and parks. The workshop consisted of four phases.

Phase 1 increased awareness among regional staff of the mechanisms, extent and currently understood implications of climate change to resource management. Six qualified researchers/analysts presented information and answered questions about the current understanding of climate change and the implications for the resources we manage. The major topics included climatology (Graham Saunders), forestry (Steve Colombo), fire management (Rob McAlpine), fish (Brian Shuter), hydrology (Robert Metcalfe) and protected spaces (Chris Lemieux). An example of a risk analysis for woodland caribou was presented by Gerry Racey.

Phase 2 suggested adaptive actions through a series of facilitated exercises led by Gerry Racey (wildlife, habitat and recreation), Bill Towill (forest production) and Kim Armstrong (water and fish). These working sessions (Appendix 2) identified pragmatic short-term actions that are intended to minimize risk to the resources we manage as well as to the economic and social environment. Suggested actions were discussed and evaluated within the breakout groups. Implications of potential impacts were analyzed by combining professional experience with guidance from the guest experts.

Phase 3 Compiled the workshop output into this workshop report. The reader should be aware that there was group consensus on some suggested actions but not others. In an attempt to compile results in an unbiased manner, some suggested actions may represent the majority of opinion from only one of the three breakout groups. There was no attempt to review all suggestions in a plenary or to ensure there was agreement among all participants.

Phase 4 was completed when this draft report was presented to the regional managers in January 2005. The ultimate success of the workshop will be evaluated on the comprehensiveness of the action plan implemented from the suggested actions. Some suggestions may have interest to provincial science, policy, and program levels.

3.0 Results (Guest Speaker Main Messages)

Key messages delivered to the participants by the speakers could be divided into: observed climate trends, future climate projections, observed natural resource trends, and natural resource projections and implications. These key messages were explicit, or implicit, from the speakers verbal or slide presentations. Specific results, presented by the speakers, have been generalized because most data was generated for either specific meteorological stations or for larger geographic areas (e.g. province or ecozone).

3.1 Observed Trends in Northwestern Ontario's Climate

- Ontario climate trends reflect national and global trends.
- 20th century temperature trends have not been linear: temperatures increased to the 1940s, decreased to the 1970s, and have increased to the present.
- There has been a steadily increasing rate of change in climatic attributes since the 1970s.
- Northwestern Ontario has warmed up more than any other area in Ontario (1 to 1.5°C in the past 100 years).
- Annual mean temperatures have increased by 1.2 to 1.4°C ($P < .001$) for Kenora, Dryden, and Sioux Lookout: greater to the west, less to the east.
- Maximum temperatures in northwestern Ontario are somewhat higher, and minimum temperatures are much higher than earlier in the 20th century.
- Spring and winter seasons are much warmer but autumn has changed little in temperature regime.
- Growing season is warmer but frost-free season has not changed appreciably.
- Growing season rainfall has experienced a small increase.
- Snowfall and duration of snow cover period is reduced.
- Total rainfall has increased slightly but precipitation is concentrated in fewer, larger rain events.
- During the normal snow season, there has been a large increase in the amount of rainfall, but a pronounced decrease in snowfall events from 1940 to present.
- Between-year variability in precipitation and temperature appears to be increasing.

3.2 Future Climate Projections for Northwestern Ontario

- Growing season temperature increase of 1 to 1.5°C by 2040 (April to July temperatures increase approximately 3°C).
- Growing season temperature increase of 4 to 6°C by 2090 (April to July temperatures increase approximately 6.5°C).
- Reduction in growing season precipitation: zero to five percent by 2040, and by zero to 20 percent by 2090 depending on the month (greatest moisture reductions from June to August).
- Increase in severe weather events such as super cells, wind storms and lightning (6% increase for each degree increase in temperature).
- Continued increase in variability of temperature and precipitation.
- Continued reduction in winter snowfall and snow depths.
- Continued increase in proportion of precipitation (winter and summer) occurring as part of "extreme" events.
- Frequency and severity of drought events and chronic moisture deficits could increase as a result of large increases in evapotranspiration while the amount of precipitation is stable or declining.

3.3 Observed Natural Resource Trends

- Expansion of white-tailed deer in the southwestern portion of the region.

- Retraction of moose numbers and range in southwestern portion of the region.
- Substantial increase in annual area burned over the last 40 years across Ontario and Canada.
- An increase in the fire season length by six to eight days in north-western Ontario.
- An increase in phase three fires in early spring (analysis from 1960 to present showed no change from June to August in phase three fires, but from April to May there was a marked increase).
- Insufficient monitoring of most species or ecosystems to determine if current trends exist in fish, wildlife, plant or ecosystem abundance, distribution, or condition.

3.4 Projections of Natural Resource Trends and Implications

3.4.1 Projections for Forests

- Climate range for boreal forest tree species will change faster than the ability of those forest tree species to migrate (limited by seed dispersal and propagation strategies).
- Southerly species will be increasingly suited to northwestern Ontario climate. Expansion will occur from epicentres of species formerly at northern limit of their range.
- Over short term, higher concentrations of CO_2 and temperature may increase growth of some species where moisture is not limiting.
- Over longer term, boreal species will experience range retractions due to inability to compete with more aggressive southern species.
- Plants with short life cycles will exhibit faster genetic adaptation and have the potential to increase competition with target crop species.
- Persisting forest types may experience a more stressful growing environment (higher temperatures, longer droughts, increased evapotranspiration, and sustained moisture deficits).
- Environmentally stressed trees will be subject to more aggressive disease and insect infestations, due to: more life cycles, better incubation conditions, reduced tree vigour, and reduced availability of natural enemies left behind with migration.
- Increase in temperature, moisture, and wind variability will lead to increased frequency of environmental damage such as late-season drought, winter desiccation, or frost damage.
- Extreme weather events may increase the amount of blowdown, breakage, and snow and ice damage.
- Increase in fire season length by 10 to 50 days over much of the boreal according to the Canadian and Hadley general circulation models. Forest fire seasons will start earlier and end later with larger areas burned.
- Increase in area burned and carbon emissions with subsequent decrease in wood supply.
- Increase in variable costs associated with fire management and increase in number of escaped fires.

3.4.2 Implications for Forest Management

- Shortened season of winter harvesting.
- More summer shutdowns due to high fire hazard.
- Wood shortages for some species over longer term (i.e. spruce in the western half of northwestern Ontario).
- Difficulty in achieving planned outcomes over 60 to 100 years when climate change impacts will begin to have significant impacts in 30 years.
- Increased pressure on forest land from agricultural land uses.
- Increase of four percent of escaped fires (by 2040) without increased resources.
- If we want to maintain the number of escaped fires at present levels, fire organization would need to increase resources 75 to 100 percent but even with added staff, still unable to achieve the same level of protection.
- Positive opportunities to modify forest management approaches to use different tree species, seed sources, or management practices to support an evolving forest industry. These strategies have not yet been defined.
- Climate change mitigation strategies might include:
  - Fertilization – net carbon storage gain through fertilization and subsequent tree growth offsets losses from fertilizer production;
  - Forest fire protection – reducing the area burned has a large positive effect on carbon storage. Forest fire suppression is the only significant practice for making a measurable difference in carbon storage in the short term;
  - Spraying for spruce budworm – prevent tree mortality and reduce growth losses; and
  - Increasing salvage harvest – using salvage would reduce the annual harvest resulting in retained biomass and carbon (only if salvage was compensatory and not in addition to approved harvest).
- Fire management adaptation may include fire-smart management practices in the vicinity of at-risk values, including managing species composition (conifer to mixedwood), more suppression resources, enhanced detection and prevention, acceptance of more area burned and pre-establishing priorities (protect certain habitats).

3.4.3 Projections for Water and Fish

- Increased precipitation in winter and spring, potentially increasing the magnitude and frequency of spring floods.
- Longer ice-free seasons, largely attributable to an earlier spring melt.
- General drying of watersheds expected during summer and autumn due to higher temperatures and increased evapotranspiration during a longer ice-free period.
- Warmer winter temperatures causing earlier snowmelt events and a corresponding decrease in runoff in summer period.
- Increased frequency of mid-winter break-up events and ice jams.

- Warmer water temperatures and reduction of cold water fish habitat.
- Deeper thermocline depths and a longer stratification period will lead to increased depletion of late summer hypolimnetic oxygen reserves.
- Reduced water volumes.
- Lake Superior water level decline by as much as 0.5 m.
- Reduced ice cover time on Lake Superior by 11 to 58 days by 2030.

3.4.4 Implications for Water and Fish Management

- Water flow/level objectives will need revision, based on most recent data (last 20 years).
- Structural characteristics of existing facilities may be incompatible with projected flow regimes.
- There will be less water for fish habitat.
- Warmer surface water temperatures will alter fish habitat quality.
- Perch and smallmouth bass range expansion is predicted (500 km) with 4°C increase in mean annual air temperature.
- Cold water fish species such as lake trout, salmon, whitefish, and herring will be at increased risk of loss in southern or marginal environments due to increased water temperatures and reduced O_2 levels.
- Increased risk to brook trout from reduced groundwater flows and stream volumes, increased groundwater temperatures and warmer water temperatures.
- Increased risk to walleye in shallow water bodies from warmer surface temperatures and increased competition from warm water fish.
- Cold water species will face greater risks and threats as aquatic habitats become more suitable for warm water species: increased risk for brook trout, lake trout (potential loss of southern lake trout populations).
- Change in overall fish production and relative productivity of individual fish populations may justify a change in sustainable harvest levels for all fish populations in the ecosystem.
- Reduced sustainable harvest levels or relative harvest effort for fish species at heightened risk, while more fishing opportunities may be available to those species better adapted to the warmer temperatures (e.g. centrarchids).
- Large-scale shifts in geographic distribution of species would cause a change in mixture of species that can be sustainably harvested within a specific geographic area.
- Small-scale shifts in the spatial distribution of members of a specific population would lead to a change in sustainable harvest for the population.
- Suggested climate change adaptation strategies include:
  - Refocus fishing on populations whose productivity may be improved by climate change, although increased productivity has a limit;
  - Focus on previously unused or underused populations;

Reduce impacts from other agents of stress (mitigate impacts of contaminants, limit competition between humans and fish for water); and

- Actively accelerate northward shift of warm water species and/or actively protect cold water species from competition with warm water species, although there is some debate about this scale of management.

3.4.5 Projections for Wildlife, Habitats, and Recreation (including protected areas)

- More early successional and less late successional habitats will be available
- Native wildlife species will face rapidly changing habitat conditions and associated changes in predation, competition and disease factors.
- Reduced winter recreation opportunities (reduced snowmobile season due to less snow cover).
- Increased opportunities for summer recreation.
- Reduced snowfall and warmer winters will lead to expanded deer range and increased parasite transmission potential.
- Decline of moose in southern portions of the region associated with disease and heat stress.
- Woodland caribou will experience an increase in risk factors associated with habitat availability, predation, and disease.
- Climatic conditions currently associated with the protected area network in northwestern Ontario, and which supports the current protected ecosystems, will change resulting in climatic conditions more suited to other forest tree species and ecological processes than those represented within the protected area boundaries.

3.4.6 Implications for Wildlife, Habitats, and Recreation Management

- Loss of suitable habitat may threaten species with limited range, adaptability, or ecological requirements.
- Wildlife species abundance and distribution may change more rapidly than habitat due to cumulative effects of biotic and abiotic factors.
- Protected area location and size based on current distribution and abundance of plant and wildlife species (gap analysis) may not be adequate to provide and protect the ecological services intended.
- Protected area plans emphasize current species representation over persistence/future/historic distribution. Future landscape management emphasis will have to be placed on species persistence, not just in-situ representation within protected areas.
- More site and specific species information will be required to determine effects of climate change rate on threatened and climate sensitive species and ecological processes.
- Wildlife or ecosystem management efforts may be misdirected because management priorities are directed towards resources that are not well adapted to altered climatic conditions and stresses.

4.0 Discussion and Recommendations

Discussion among workshop participants helped define and scope specific issues based on the evidence and advice provided by the invited experts. The essence of these discussions were summarized for each major topic addressed by the breakout groups. Each topic was summarized under the categories of issue, adaptive response, suggested actions and potential lead. The detailed description of the issue was based on an understanding of the concerns, issues and consequences identified by the breakout groups. A cross reference table was developed aligning the 77 suggested actions to the management categories of direction, communication, training, protected areas, inventory and monitoring, fire management, planning, silviculture, forest modeling, wildlife, and fisheries (Appendix 3).

4.1 Commit to Change and Adaptation

Issue: Climate change information has been abundant in the popular and scientific literature but there is little evidence that we are encouraged or permitted to respond in resource management direction or decision making. Although individual awareness is growing, no organizational commitment can be detected at the field level. Northwest Region has been experiencing the early effects of climate change for the past 35 years and the rates of change will accelerate over the next 30 years and beyond. Regional leaders are being advised by workshop participants that the future climate and environment will be very different than today and that we should be acting in anticipation of that change. OMNR staff need some signal from management that climate change is worthy of being addressed in our day-to-day decision making and management.

Adaptive Response: Send a clear signal to staff that the regional executive recognizes that climate change exists and progressive action (adaptation) is worthy of regional support in the short and long term.

Suggested Actions:

1. Produce a direction notice (regional), on behalf of the regional director that acknowledges climate change and indicates support for local and regional efforts to adapt to climate change, while protecting public interests through existing planning and management processes.

Potential lead:

- Regional Management Team supported by Landscape & Diversity Implementation Team (LaDIT)

4.2 Prepare Staff

Issue: OMNR district staff are being asked by clients to comment on climate change issues and staff may in the near future be required to implement climate change adaptation measures. The ability to focus on new issues at the field level is limited by capacity in terms of staff, resources, knowledge and direction. Immediate benefits would be realized by building awareness of climate change issues and potential responses. There is a need to communicate to and educate staff to deal efficiently and effectively with OMNR clients and partners in the evaluation of risk due to climate change, the effects of climate change, impacts on resources and potential adaptation strategies. Experiential learning using adaptive approaches is an important component of competency maintenance.

Adaptive Response: Initiate corporate culture adjustment through communication with, and education of OMNR staff.

Suggested Actions:

2. Assign one staff member from each district and section to be a liaison person and "local expert" on climate change issues in order to provide local support to climate change adaptation efforts by staff, industry and other clients (Performance Development Plan (PDP) component for additional training and education).
3. Host a regional staff day (workshop) for widespread dissemination of climate change knowledge or develop a travelling road workshop to visit each district within the Northwest Region.
4. Develop a condensed summary of information about climate change and the common understanding of ecological, economic, and social implications pertinent to northwestern Ontario. Distribute summary to staff.
5. Develop a communications plan to introduce climate change to staff across the province and make staff aware of the provincial level of commitment through policy, research, mitigation, and adaptation.
6. Produce a brief module for Forest Management Plan (FMP) training in Northwest Region pertaining to regional climate change and supported forestry responses.
7. Engage each forum (LaDIT, wildlife, forestry, fisheries, and information) to further examine and refine November 2004 workshop recommendations.
8. Foster experiential learning for OMNR and forest industry staff by assigning areas on each Sustainable Forestry Licence (SFL) to test adaptive silviculture approaches, before they are broadly applied on the managed land base (needs to be accompanied by monitoring and communication and needs some level of corporate endorsement).

Potential Lead:

- LaDIT: regional staff day or travelling workshop
- LaDIT or NWSI: condensed summary for distribution to regional staff
- Regional communications via regional director (internal communication plan)
- Forestry Forum and NWSI (silviculture test areas)

4.3 Increase Public Awareness

Issue: OMNR may become aware of, and decide to effect management actions in response to climate change impacts. Many potential actions regarding forest, wildlife, water, and protected area management may not be intuitive to the public. An educated public is essential to working cooperatively with OMNR and ultimately accepting climate change adaptation measures. Informing the public of OMNR's response to climate change is potentially a good news story. However, education is required to ensure the public has enough information to look beyond superficial responses such as the sudden increase in one species over another. This is well illustrated using a fish example. Allocation of target fish and catch levels have been influenced in the past by political objectives which have occasionally led to negative biological effects like with smallmouth bass, which previously did not exist in some lakes. Biologically, bass are having a negative affect by out-competing and

reducing native trout populations, but from an angling standpoint, they have become prized species both for anglers and outpost camps. A balance must be struck between biological integrity and user-group interests in order to protect aquatic ecosystem health. Public education will become an important factor for potential changes to guidelines regarding target fish and catch levels.

Adaptive Response: Educate public and stakeholder groups on climate change, the potential ecological, economic and social implications, and the options for adaptation. The desired outcome is to have an educated public that can participate constructively in the development and implementation of resource management adaptation strategies. Education should include the potential ecological, economic and social impacts of climate change and steps the OMNR is taking to alleviate the negative impacts of climate change on ecosystem health.

Suggested Actions:

9. Hold a large workshop or a series of travelling workshops targeting Local Citizens Committee (LCC) and Regional Advisory Committee (RAC) members to discuss climate change evidence, implications, and potential responses.
10. Promote a regional OMNR–Forest industry dialogue (workshop) to discuss and explore and promote adaptation strategies based on best scientific and management advice available.
11. Develop a province-wide communication effort using brochures, brief mass media commercials etc. targeting the general public under a larger provincial communications plan regarding climate change. Regional commitment should be to make a formal request for a communication strategy to Communication Services Branch (CSB).

Potential Lead:

- LaDIT: development of regional LCC workshop or road show in 2005
- Regional communications via regional director to CSB

4.4 Demonstrate Support for Mitigation

Issue: Climate change will continue even with the successful implementation of the Kyoto Accord. OMNR must focus on adaptation but may reinforce its leadership role by demonstrating even a token contribution to mitigation. Examples may be driving more fuel-efficient or hybrid vehicles, or implementing mitigating forestry practices. These will reaffirm OMNR regional commitment to climate change as a significant issue and may also provide a positive, good news story.

Adaptive Response: Promote mitigation.

Suggested Action:

12. Seek a practical but potentially high profile opportunity to demonstrate commitment to mitigation activities.

Potential Lead:

- Field Services

4.5 Adapt through Planning

Issue: OMNR oversees many different planning processes. Very few, if any, within the Northwest Region have acknowledged climate change let

alone described the climate change implications with respect to the values or resources being planned. These planning processes include the proposed regional natural resource strategies and existing forest management plans, water management plans, land use plans, environmental assessments, park management plans, fire management plans (strategies), municipal plans, and fisheries or wildlife plans. Climate change also needs to be addressed within strategies for silviculture, forest health, wood supply, biodiversity and green spaces. In the Northwest Region, two planning processes on adjacent land bases will occur in 2005 (Quetico Provincial Park plan and Crossroutes Forest Management Plan) and have the potential to demonstrate the consideration of and adaptation to climate change. The issue of climate change has significant implications for all the resources we manage and should be addressed, at least in a minimal way, in each and every planning process.

Adaptive Response: Each and every planning process led and supported within the Northwest Region should include climate change adaptation within the terms of reference, requiring at least a contextual description of climate change but preferably an assessment of climatic assumptions, change impacts to the resource, and management responses. This is an evolutionary process, and it will be important to learn as we go, share experiences, and foster appropriate action elsewhere within the OMNR.

Suggested Actions:

13. Draft and circulate a regional statement directing Northwest Region staff to recognize the climate change context within all planning processes and describing appropriate levels of involvement for different planning activities, including the development of resource management strategies for forests, fish, and wildlife.
14. Support the lead role that Quetico Provincial Park management plan and the Crossroutes FMP will share as "pilot" planning initiatives that begin to address climate change (possibly seek additional funds to support the "pilot" nature of these planning initiatives).
15. Make staff aware of issues related to addressing climate change in these ground-breaking plans by providing regular updates at forestry, wildlife, and fisheries forums.
16. Ensure those responsible for plan standards and coordination at the provincial level are aware that plans in the Northwest Region will address climate change within the current planning framework.

Potential Lead:

- Regional Management Team supported by LaDIT (direction statement)
- Northwestern Parks Zone and Fort Frances District Manager
- Forums as subcommittees of Regional Management Team (RMT)

4.6 Exercise Precaution in the Face of Uncertainty

Issue: OMNR strategic direction advocates use of the precautionary principle when faced with uncertainty over ecological sustainability. It is unclear how this precautionary principle should be applied when the very ecological parameters and processes of the ecosystems being managed are in a state of flux. Many strategies are possible when dealing with uncertainty and the OMNR needs to have a mechanism for deciding when to be proactive, when to be reactive, and when to do nothing and accept the consequences.

Generally the most important concept in the precautionary principle is ensuring resilience. Proactive processes may include specific interventions to introduce plant/animal community types to new areas when the migration rates of those communities are expected to be much slower than the rate of climate change. Reactive processes may include offering extraordinary protection to specific ecosystem components or processes under heightened risk. Most attention is warranted on species that are less adaptive and would be most disadvantaged in terms of migration rates, genetic diversity or susceptibility to limiting factors (competition, disease, or predation). There may be a need to provide a "leg-up" to species or communities that do not adapt or migrate quickly, or are currently so rare that chance of natural occupancy of a new but suitable niche is unlikely.

Adaptive Response: Ensure resilience through management and protection by offering more opportunity for landscape, community, species, and genetic components of biodiversity to ecologically adapt to the changing environmental constraints and opportunities.

Suggested Actions:

17. Design a set of criteria or considerations to guide district and regional response to climate change for specific wildlife, fisheries, species at risk (SAR), plant community and forest management issues. This would help staff determine if proactive or reactive measures are warranted.

18. Plan for enlargement of protected areas to ensure there is adequate space to foster resilience and to accommodate the more aggressive natural disturbance regimes associated with climate change. Acknowledge that some species such as fish may not benefit from this approach.

19. Designate more areas for ecosystem conservation through specific conservative management approaches (management approaches specifically designed to reduce climate change-induced risk to landscape species and genetic diversity outside of parks and protected areas).

20. Incrementally conduct a risk analysis for local or regional ecosystems or ecological components in order to determine degree of threat and suggest possible response (e.g. moose in wildlife management unit (WMU) 7, pine forests in Quetico, forest cover along the Manitoba/Ontario border, or lake trout in southern lakes).

21. Increase role for prescribed burning as a management tool to achieve ecological objectives by recognizing and supporting prescribed burning as an OMNR core business.

Potential Lead:

- Northwestern Parks Zone (expand protected areas)
- Northwest Region planning (explore alternate means of ecosystem protection to maintain resilience)
- LaDIT (proposed risk assessment methodology)
- LaDIT (criteria for response level)
- Northwest Fire Region (prescribed burning support)

4.7 Ease Conflict Through Clear Priorities

Issue: OMNR will be faced with more rapidly changing distribution and abundance of species and ecosystems. More management and social conflicts will develop over the resource that has traditionally been valued in one area

compared to the new resource or value that is expanding into that area (moose versus deer, forest versus grassland, tolerant hardwoods versus conifer, bass versus walleye etc.). The OMNR should begin an internal and external dialogue and develop a philosophical basis for setting management priorities or we may be wasting money and losing credibility. The need for this may not be imminent but this process will not be quick. It is expected that some prioritization decisions will have to be made within the next 20 years.

Adaptive response: Clarify management objectives and shift management priorities accordingly. This may have to be accompanied or followed by an official planning exercise (e.g. fish).

Suggested actions:

22. Develop a general discussion paper on the philosophy and practice of setting resource management priorities for wildlife or fish species on a changing landscape (e.g. ecoregion, forest management unit, WMU)

Potential Lead:

- Wildlife Forum (moose versus deer; caribou)
- Fisheries Forum (lake trout versus warm water fish)
- Forestry Forum (previously forested areas becoming Protection Forest (PF))

4.8 Adapt to Increased Fire Risk

Issue: The fire management strategy has been produced and has identified relatively little opportunity for differential fire management response. Climate change projections suggest an increase in lightning, lightning caused fires, escaped fires, area burned and fire intensity. Everything cannot and should not be protected. At the same time, increased pressure for urban and reserve expansion, remote outpost camps and recreational/seasonal dwellings will lead to more infrastructure encroachment into fire-prone areas. There is a need to further refine priorities for protection in terms of the geography and the values to be conserved. These priorities are required to address ecological issues as well as the economic pressures faced by the fire program and forest industry. This issue has been addressed and discussed for two years by LaDIT and has been captured as a concept. There is a need to define for each ecoregion, priorities for protection or renewal to achieve ecological or economic objectives.

Adaptive Response: Clarify priorities geographically and ecologically for fire protection or renewal efforts within each of the ecoregions of northwestern Ontario.

Suggested Actions:

23. Initiate a project to prioritize land units both within and outside of parks for fire protection or renewal. This would be incremental and would possibly be addressed through regional natural resource strategies (funding would be required).

24. Develop criteria and advice directed at Crown land and municipal planners regarding infrastructure development, land disposition and the increased risk of lightning, severe weather, flood events, and wild-land-urban interface fires.

Potential Lead:

- LaDIT in conjunction with Northwest Region planning and Northwest Fire Region
- Northwest Fire Region staff and regional planning (infrastructure and fire risk)

4.9 Track Change Through Quality, Current Inventory

Issue: Climate change is expected to introduce an ever increasing rate of change in the status, structure and organization of forest, fish and wildlife resources within the region. There is a strong need for more comprehensive, more current (updates), and more reliable inventories. This is a cornerstone of a useful adaptive management approach for climate change. There is a need to know if management actions are achieving desired results or if the projected ecosystem conditions are changing or performing the ecological services previously expected. This will require monitoring of meaningful indicators of ecological response to climate change such as wildlife populations (deer or wildlife diseases), forest cover or density, forest productivity or fish population health. These data are particularly valuable for feeding the science organization with data necessary to calibrate processes for predictive modelling. In addition these data may be useful for informing ongoing management activities/decisions.

Over the long term, predictability of resource abundance and distribution is the goal. There is serious risk in trying to conserve dynamics, composition and structure of ecosystems characteristics of an area which is now operating under a substantially different climatic regime (e.g. landscape guide characterizing a forest landscape under a benchmark disturbance regime of the last 100 years while trying to achieve it and evaluate its effectiveness under a climatic and disturbance regime that is substantially different). Quality inventory is essential for the effective and efficient application of guidelines and allocation of resources. Good data to support allocation decisions is particularly important in managing economic consequences of change. There is a need to integrate inventories further, featuring basic ecological descriptors that are useful for interpreting ecological consequences or responses.

Adaptive Response: Encourage organizational commitment to increased frequency and improved quality of inventory updates. Without adequate inventory or monitoring, there will be greater uncertainty how much of the resource to allocate and with greater consequences estimates are incorrect. The OMNR risks reduced revenues, lost opportunities and jobs along with greater risk to various components of the environment.

Suggested Actions:

25. Review inventory standards and procedures and recommend improvements required to address climate change uncertainty; support enhancements to forest, fish, and wildlife inventory standards to address the need for specialized information.

26. Encourage improvements to the continuous forest inventory update cycle with periodic reset and complete refresh.

27. Identify and document opportunities to enhance inventory quality and comprehensiveness in all current inventory and monitoring program areas including fish, forests, wildlife, and habitat.

28. Recommend highest priority inventory program enhancements based on degree of ecological or economic risk to the resource (preceded by a risk analysis).
29. Encourage expansion of inventory opportunities to include deer range and relative abundance as well as monitoring activities for brainworm to assist in evaluating wildlife impacts of climate change.
30. Review the new ecological land classification (ELC) architecture to ensure site and community level descriptors (vegetation types and ecosites) are adequate to reflect relevant changes in the forest structure and dynamics associated with climate change.
31. Facilitate easy access to and staff familiarity with complementary inventory information such as Landcover 2000, and all present and past versions of the forest resource inventory (FRI) in order to track changes in ecosystem structure and composition.

Potential Lead:

- Science and Information Branch and Northwest Region planning (recommendations to IMA)

4.10 Calibrate and Adapt Forest Planning Tools to Reflect Change

Issue: There is a heavy emphasis in forest management planning on working towards a desired and planned future forest condition to achieve ecological, economic, and social objectives. The desired forest condition relates to structure, composition, and the biological function of the forest (e.g. habitat). However, changes in ecological drivers such as climate and wildfire may begin to change the relationship between current ecological knowledge and management response. If there are future environmental changes, there is no way of knowing for sure what aspects of forest structure composition or function would change.

Forest planning tools need to be examined and modified to address the challenges of forest management under a changing climate. The ELC framework should continue to be a building block for planning and management interpretations and characterization of outputs. Ecoregion and ecodistrict definitions may need to reflect the changing climatic drivers (temperature, precipitation, extremes) of ecological relationships. There needs to be flexibility within the ELC to account for new categories of forests at the plant community level. All predictive tools are based on retrospective analysis as modeling incorporates analyses of historical plot data and uses this to forecast into the future. Ecological relationships may shift and therefore historical knowledge may not apply. Therefore, there is a need for predictive tools to project growth and yield into the future to improve the predictability of resource availability and supply. With the rate of change in climate there is a need for timely evaluation and response to change that will require a frequent examination of forest conditions and adjustment of strategic objectives. Prediction of a future forest condition based upon the current 10 year planning/modeling cycle may not be adequate to ensure timely adaptation.

Adaptive Response: Develop or adapt forest management planning tools to facilitate the tracking, analysis, and prediction of forest response to climate change.

Suggested Actions:

32. OMNR should consider a strategic review of forest condition and climate change impacts every five years.
33. Create a "disturbance cycle" index that incorporates fire, insects, blowdown, and disease as a measure of observed risk.
34. Improve fire cycle estimates within management units, based on new models that account for climate change. In addition, determine if there are differences in the fire cycle between forest units.
35. Review the ELC architecture to ensure it is not static and that the forest conditions of the future (savannah, open woodlands) are described.
36. Review and adjust forest units to accommodate structural and compositional attributes relevant to changing forest dynamics and management challenges associated with climate change.
37. Examine options for improved modeling of growth and yield, silvicultural response and succession under changing environmental conditions posed by climate change.
38. Encourage the development and application of process-based models to improve predictive modeling of forest succession and growth and yield.
39. Develop a framework for conducting trade-off analyses and quantifying social, ecological, and economic objectives within the context of climate change.

Potential Lead:

- Forestry Forum
- Terrestrial Assessment Unit (growth and yield program (G&Y))

4.11 Sustainability Through Forest Management Planning Improvements

Issue: Many strategic objectives in forest management are related to ecological sustainability or the forecast of sustainability indicators through the evaluation of modeled outputs. An optimum mix of forest management objectives is sought for achievement through forest management. Without a flexible and adaptive framework in this environment of increased uncertainty, forest managers may not have an adequate appreciation of the feasibility of objective achievement. This appreciation can only be achieved through a thoughtful and comprehensive analysis that incorporates the implications of climate change. Without this analysis, conflict will increase because management success will diminish (desired objectives may not be achievable or the attempt to meet one objective undermines attempts to achieve another objective; protected space, fibre, habitat, fibre quality, etc.). Currently, OMNR is not well prepared within its management framework to look at various opportunities and constraints associated with climate change.

Adaptive Response: Direct the development and implementation of forest management planning to accommodate and analyze the implications of climate change on objectives achievement using the best information available and to challenge current assumptions that may not hold under a changing climate.

Suggested Actions:

40. Develop direction to address climate change issues in the terms of reference for all FMPs.

41. Require a climate change scenario to complement the null and forest management alternative runs in FMP development in order to evaluate the range of uncertainty and consider adaptive strategies.
42. Direct planning teams to consider fire-smart technologies in the FMP.
43. Involve Aviation and Forest Fire Management Branch (AFFMB) in the planning process of FMPs.
44. Assign climate change advisor(s) to forest management planning teams to help guide FMP development.
45. Address disturbance cycles in the new Sustainable Forest Management Model models (SFMM) and determine if our best understanding of disturbance processes is currently being used.
46. Improve habitat suitability matrices by moving from expert opinion towards predictive models. Models should have links to improved inventory and be able to run multiple climate change scenarios.
47. Develop a regional or sub-regional modeling scenario for climate change incorporating revised and new inputs for "what if" comparisons that could improve ecoregional context for an FMP.

Potential Lead:

- Forestry Forum and LaDIT

4.12 New Knowledge in Support of Adaptation (Silviculture)

Issue: Climate change is expected to introduce an ever increasing rate of change in the status, structure and organization of forest, fish and wildlife resources within the region. From a silvicultural standpoint, there can be both positive and negative changes resulting from climate change. Examples of risk are range retractions of northern species, increased fire season and severity, increased insects and disease, shortened winter harvesting period and more frequent summer shutdowns due to high fire hazard. Potential opportunities presented by a warmer climate include longer growing seasons, increased growth rates where moisture is not limiting, and expansion of the range of productive trees (e.g. red pine). However, the silvicultural effectiveness monitoring program has inefficiencies that will make it difficult for the reporting, assessment, and monitoring of these changes. In addition, there is currently no silvicultural database to examine changes in early forest establishment. Consequently, delays in implementing adaptive measures can magnify the negative impacts of climate change while missing out on opportunities. It is paramount that information pertaining to the success, failure or unexpected response of silvicultural approaches be detected, documented and communicated at the earliest opportunity.

Adaptive Response: Clarify priorities in the silvicultural effectiveness monitoring program and develop effective trend analyses to ensure long-term success under a changing climate.

Suggested Actions:

48. Advocate rigorous silvicultural effectiveness monitoring across the region and the province by Forest Management Branch (FMB).
49. Develop a regional approach to conduct silvicultural effectiveness monitoring quantitatively and on a consistent basis across the regional landscape.

50. Build a database that will capture assessment and summary data that can be used in trend analyses to evaluate changes in regeneration and silvicultural success for FMPs, independent audits, status reports and evaluations of guideline effectiveness.
51. Develop status reports regarding silvicultural effectiveness on a timely and effective basis.
52. Include the characterization of the understorey plants and forest structural attributes as a change variable in silvicultural effectiveness.

Potential Lead:
- Forestry Forum (silvicultural effectiveness)
- Science and Information Branch
- Forest Management Branch (silvicultural effectiveness)

4.13 Adapt Silviculture Approaches

Issue: The silvicultural risks resulting from climate change include shifting species ranges and environmental conditions required for recruitment and survival, early stand break-up due to nutrient poor or drought conditions, reductions in soil moisture, and increased nutrient cycling and reduced duff. These conditions have the potential to increase reliance on artificial regeneration. Artificial regeneration will result in increased costs that may make conditions uneconomical for the forest industry. There is a need to define objectives and priorities for renewal efforts based on predicted climatic consequences.

Adaptive Response: Propose, test, and evaluate new silvicultural strategies to achieve desired future forest condition on specific sites in an economic manner while minimizing the increased risks associated with climate change.

Suggested Actions:
53. Establish readily accessible test areas to investigate new silvicultural approaches in terms of seedling size, planting season, and site preparation techniques, as well as intensive management of soil nutrient and moisture.
54. Increase monitoring of tree insects and diseases in managed stands to learn more about increased risk and mitigation approaches.
55. Increase intensive management to secure future wood in the face of increased risk.

Potential Lead:
- Forestry Forum

4.14 Fire Management in Protected Areas

Issue: Large provincial parks in northwestern Ontario (Quetico, Wabakimi, Opasquia and Woodland Caribou) have been trying to satisfy their ecological integrity mandate by planning for fire renewal strategies where appropriate. They contribute valuable habitat components for older forest species such as woodland caribou, marten, wolverine, and raptors and partially compensate for the adjacent managed land base where habitats may be under greater stress. Climate change will increase fire frequency and severity putting older forests at greater risk both inside and outside protected areas.

Adaptive Response: Adapt fire management strategies in or near protected areas to accommodate or balance ecosystem conservation with increased fire risk.

Suggested Actions:

56. Ensure regional natural resource strategies provide an ecoregional context for climate change and the potential impact on the abundance, distribution, and function of ecosystem components.

57. Review park plans for risk, hazard, and conservation objectives associated with climate change. This should be a mandatory component of regularly scheduled management plan review.

58. Create a clear statement linking fire management intent and priorities related to achievement of protected area objectives. Ensure consideration of current and future management objectives from adjacent land area.

Potential Lead:

- Northwestern Parks Zone
- Northwest Fire Region
- Field Services Division (same actions for conservation reserves)

4.15 Adapt Protected Area Management Strategies

Issue: Large provincial parks in northwestern Ontario (Quetico, Wabakimi, Opasquia, and Woodland Caribou) are perceived as having the mandate to perpetuate the vegetation community conditions and relationships that existed in the past (L-V types etc.). Climate change projections demonstrate that this will become harder to do and the climatic patterns will become less suited to support these community types. The landscapes defined by existing boundaries will develop different ecological attributes over the next 90 years, possibly even at the biome scale. Park management plans may have to recognize that a shift is required in both corporate and public thinking about the role of protected areas as the climate changes. There may need to be a greater focus on maintaining some values such as wilderness and recreation potential while increasing effort in monitoring the change in natural dynamics and vegetation composition. This increased monitoring effort would supplement adaptive management efforts at the local FMU and provincial level.

Adaptive Response: Consider a shift in protected area paradigm toward accepting, observing, and documenting the changing ecological processes associated with climate change except for identified specific protective measures for high-risk features or values (e.g. species or communities at risk).

Suggested Actions:

59. Develop a discussion paper (may already be in the works) for both OMNR and the public on the challenges of climate change for protected areas and the need for a changing paradigm.

60. Review park plans and ensure this changing paradigm is reflected in the objectives and strategies. This should be a mandatory component of the next regularly scheduled management plan review.

Potential lead:

- Northwestern Parks Zone working collaboratively with Ontario Parks main office and Ontario Parks Board

4.16 Ecosystem-based Adaptation Strategies

Issue: The accelerating rate of change of ecological conditions and environment will put more and more species and communities at risk. OMNR must recognize that ecosystem-based approaches to conservation may be more efficient than single species conservation approaches. It may be necessary to use focal species to define the nature of the ecosystems in need of conservation (caribou, piping plover, marten). Although concern will often be expressed by the public for the conservation of specific species, OMNR must try to implement adaptation strategies for ecosystems and not individual species.

Adaptive Response: Encourage ecosystem-based approaches for evaluating climate change risk, conserving environmental values, and maintaining ecological processes.

Suggested Actions:

61. Develop a risk analysis protocol for northwestern Ontario ecosystems.

62. Conduct climate change risk analysis and adaptation strategies for ecosystems at risk in northwestern Ontario.

63. Incorporate climate change and ecosystem conservation messages into the Northwest Region biodiversity road show.

Potential Lead:

- Regional planning and Northwest Science and Information (forest management planning, biodiversity road show)
- LaDIT risk analysis protocol

4.17 Strategic Management of Fisheries Resources

Issue: Most fisheries management activities take place in response to stress applied from activities other than habitat management. From a historic perspective, fisheries management has been fairly effective in dealing with resource issues in the absence of accounting for climate change. As temperature has increased over the last four decades productivity may have increased for some species thereby masking issues of over-allocation. However, impacts such as less water, longer ice-free periods, and warmer surface water temperatures will influence which fish species will be able to inhabit the changing aquatic environments and how many can be removed by anglers or commercial fishermen. For example, it is anticipated that species such as lake trout, which prefer cold water environments, will have trouble adapting and may disappear from some water bodies.

Adaptive Response: Incorporate a climate component into management models to introduce active, flexible, forward-looking approach to fisheries management.

Suggested Actions:

64. Implement the fisheries management framework and account for risk factors associated with climate change as well as incorporating adaptive measures into management.

65. Include temperature as a variable in decision support systems.

66. Increase public awareness of the impacts of climate change on the productivity of the aquatic environment particularly with reference to new and invasive species.

67. Actively protect vulnerable cold water species from competition with warm water species.

68. Ensure that OMNR is continually reporting on the status of aquatic resources as well as tracking changes to biodiversity (additions as well as extirpations).

69. Refocus fishing pressure onto populations whose productivity is improved by climate change.

Potential Lead:

- Fisheries Forum

4.18 Hydrological Knowledge

Issue: Climate change will alter the quantity as well as the temporal and spatial distribution of precipitation. Design flows and flood risks will become outdated. Improved knowledge of hydrological parameters is important for managing risk to natural resources infrastructure and human life. Historically, water management has been driven by economic and safety concerns. Dams were constructed for uses such as generating power, transporting lumber, or mitigating flooding effects. During these times there was little regulatory control of water use. It is anticipated that climate change will cause an increase in extreme events (flooding, drought) that will require strategies on how to dampen the associated environmental impacts. There is a need to develop an approach to describe, predict, and assess impacts of climate change on water resources within the region. This may be coordinated with ongoing water management reviews.

Adaptive Response: Improve our understanding of climate change on hydroclimatological variables and their linkages to altered ecological responses attributed to climate change. Refine management decisions using dynamic quantitative decision analysis.

Suggested Actions:

70. Identify unaltered reference basins for long-term hydrological monitoring.

71. Monitor more natural processes, using an undisturbed, unaltered reference basin as a control. The information that is learned through monitoring a "natural" context can be used to provide a more accurate link to assess and predict climate change impacts on the provinces' ecosystems and natural resources.

72. During site release review, explore what is feasible (economically and environmentally) under various predicted flow regimes.

73. Keep all water management planning guidelines current to reflect new knowledge (e.g. specify analyses using the most recent data (20 years) to establish flow/level objectives).

74. Consider the potential changes in the hydrologic regime during land management activities particularly land disposition for cottages, etc. on regulated waterways.

75. Incorporate hydrologic considerations into forest management guidelines (e.g. recharge areas for small brook trout streams).

76. Utilize existing hydrometric networks to support ecological monitoring and include ecological criteria in network design.

77. Continue to develop tools that provide hydroclimatological information to support resource management decision making.

Potential Lead:

- Fisheries Forum

Appendix 1. Workshop Agenda

Preparing for Change: Climate and Resource Management in Northwest Region

November 30 - December 2, 2004, Quetico Centre, Atikokan

November 30

15:00 Check in
18:00 Dinner
19:00 Introduction to the workshop: Gerry Racey
19:10 The changing climate and weather patterns of northwestern Ontario: Graham Saunders, Climatologist, Lakehead University
20:10 A risk analysis example: Gerry Racey
20:50 Adjourn

December 1

07:00 Breakfast
08:00 Overview to the workshop and breakout sessions: Gerry Racey
08:15 Forests: Steve Columbo
09:15 Fire: Rob McAlpine
10:15 Break
10:45 Hydrology: Bob Metcalfe
11:30 Fish: Brian Shuter
12:15 Lunch
13:15 Parks and Landscapes: Chris Lemieux
14:00 Assignment of breakout groups: Identify issues and responses to each of the following
- wildlife, habitat, and recreation
- forest production / management
- water and fish

16:15 Adjourn
17:00 Dinner
18:30 Plenary review and of preliminary issues / recommendations list, group feedback, and advice from experts preliminary identification of redundancies and best bets
20:00 Adjourn

December 2

07:00 Breakfast
08:00 Reconvene working groups with some mixing and reassignment: Refine actions list, examine pros and cons. Identify what MNR must do, allocate, or facilitate in order to satisfy these actions.
- wildlife, habitat and recreation
- forest production / management
- water and fish

10:00 Break
10:30 Plenary: Review of recommendations, analysis of pros and cons, receive feedback; prioritize recommendations
12:30 Lunch
13:30 Departure of participants:
Planning team and facilitator debriefing (1 hr)

Appendix 2. Workshop participants organized by breakout group. Facilitators (F) led the discussion of issues, impacts, and response options.

Wildlife, Habitat and Recreation	Forest Production	Water and Fish
Leo Heyens	Steve Allen	Kim Armstrong (F)
Annalee McColm	Dave Barker	Gary Davies
Audrey Goodwin	Colin Bowling	Brian Jackson
Chris Lemieux	Pat Corbett	Terry Marshall
Evan Simpson	Grant Craig	Rob Swainson
Gerry Racey (F)	Mike Pettit	Mike Schillimore
Glen Hooper	Pat Harvey	Tom Mosindy
Graham Saunders	John Sills	Leslie Barnes
Leona Tarini	Bill Towill (F)	Bob Metcalfe
Mike Davis	Gail Wong	Brian Shuter
Robyn Riley	Al Douglas	
Steve Kingston	Vivienne Scott	
John Wilkinson	Rob McAlpine	
Evan McCaul	Steve Columbo	

Appendix 3. Cross reference of suggested actions to selected management categories.

Management Category	Suggested Action Number
Direction	1, 13, 17, 24, 28, 40, 42
Communication	1, 2, 3, 4, 5, 6, 7, 9, 11, 12, 13, 15, 22, 59, 63, 66
Training	2, 3, 6, 8, 9, 10, 15, 31, 63
Protected Areas	7, 15, 18, 19, 20, 22, 23, 27, 31, 56, 57, 58, 59, 60, 61, 62
Inventory and Monitoring	25, 26, 27, 28, 29, 31, 35, 48, 49, 50, 51, 52, 53, 54, 68, 70, 71, 76, 77
Fire Management	20, 21, 23, 24, 33, 34, 42, 43, 45, 56, 57, 58
Planning	5, 14, 16, 17, 19, 20, 21, 22, 24, 32, 35, 36, 39, 40, 41, 42, 43, 44, 45, 46, 47, 56, 57, 58, 60, 61, 62, 64, 65, 67, 69, 71, 72, 73, 74, 75, 76, 77
Forest Management/Silviculture	7, 8,10, 15, 20, 22, 25, 26, 27, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 61, 62, 75
Forest Modelling	32, 33, 34, 37, 38, 39, 45, 46, 47
Wildlife	7, 15, 20, 22, 25, 27, 29, 31, 46, 61, 62
Fisheries/Hydrology	7, 15, 20, 22, 25, 27, 61, 62, 64, 65, 66, 67, 68, 69, 71, 72, 73, 74, 75, 76

51952
(.0 k P.R., 05 06 30)
ISBN 0-7794-7975-0 (PDF)