COLLABORATION IN SCIENTIFIC RESEARCH

Factors that Influence Effective Collaboration during a Period of Transformational Change

by

BARBARA THERESA WARUSZYNSKI

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Royal Roads University

Victoria, British Columbia, Canada

Supervisor: Dr. Brian Belcher

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Collaboration in Scientific Research: *Factors that Influence Effective Collaboration during a Period of Transformational Change*

COMMITTEE APPROVAL

The members of Barbara Theresa Waruszynski's Dissertation Committee certify that they have read the dissertation titled *Collaboration in Scientific Research: Factors that Influence Effective Collaboration during a Period of Transformational Change* and recommend that it be accepted as fulfilling the dissertation requirements for the Degree of Doctor of Social Sciences:

Dr. Brian Belcher [signature on file]

Dr. Wendy Schissel [signature on file]

Dr. Michael Beyerlein [signature on file]

Final approval and acceptance of this dissertation is contingent upon submission of the final copy of the dissertation to Royal Roads University. The dissertation supervisor confirms to have read this dissertation and recommends that it be accepted as fulfilling the dissertation requirements:

Dr. Brian Belcher [signature on file]

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ABSTRACT

In an era of fiscal restraint, federal science and technology organizations are promoting more advanced whole-of-government solutions to complex problems through effective intra-organizational and inter-organizational collaboration. Although the literature reveals that there are several factors which influence the effectiveness of collaborations, there remains a major gap in determining which factors affect researchers' attitudes and behaviours to collaborate during periods of organizational change. This ethnographic study aims to bridge this gap by: (1) identifying the factors that influence researchers' attitudes and behaviours in scientific research collaborations; (2) establishing if these factors affect team outputs and outcomes; and (3) understanding if organizational change impacts the effectiveness of research collaborations.

Theories on teamwork, collaboration, social interdependence, social systems, and organizational change are incorporated to examine effective collaboration practices in one case study. The Canadian Wood Fibre Centre (CWFC) under the Canadian Forest Service (CFS) within Natural Resources Canada (NRCan) is the case under study, and is employed to understand the effectiveness of scientific research collaborations during a period of transformational change. Twenty-six participants took part in this qualitative study, including 13 researchers and 13 managers.

Based on interviews with federal researchers and managers, and industry managers, and a focus group with federal managers, the findings reveal that there are several factors that influence effective collaborations: (1) collaborative culture (e.g., shared vision, governance, and values of mutual trust and respect); (2) leadership (i.e., visionary, collective, and team leadership); (3) human and financial resources; (4) team integration and synergy (i.e., shared commitment and team cohesion); (5) shared communications (e.g., face-to-face communications); and (6) interpersonal relationships that are enabled by social interdependence.

The findings also suggest that the above factors positively influence the quality of collaborative team performance in the following ways: (1) ability for researchers to work in a collaborative culture through

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a shared vision, an established governance, and values; (2) visionary, collective, and team leadership styles that enable an integrated collaborative environment and goal attainment; (3) human and financial resources that support the right team composition and funding to successfully complete the projects; (4) team synergy for accomplishing goals and generating good quality outputs; (5) shared communications to foster greater information sharing and trust between researchers; and (6) social interdependence to nurture relationships over time. Team viability is dependent on how well the team performed together to achieve its project goals, and if researchers trusted each other and shared information throughout the collaboration. Individual and team satisfaction is based on participants' overall contentment (individually and as a team) in producing scientific or client-related outputs and outcomes.

This study has also shown that organizational changes have an impact on the factors that influence effective collaboration. The findings suggest that effective collaboration is contingent on researchers' adaptability to organizational change. Although the transformation of the forest sector generally fostered positive change, there were specific factors of organizational change that challenged the effectiveness of collaborations. These factors include: (1) the lack of integrated research programs and processes between the CWFC and its main industry partner; (2) new government administrative processes that impacted scientific productivity; and (3) the lack of face-to-face interactions due to government travel restrictions.

Based on the literature review and this doctoral study, a new model on collaboration is proposed and provides a list of factors that are considered to be important in facilitating effective collaboration. Additional research is required to better unfold the interrelationships between these factors and how their interrelationships impact effective collaboration, particularly during periods of organizational change. Recommendations are put forward on how to improve collaboration in the workplace and are intended to inform departmental policies, practices, and programs on ways to enable better collaboration. Recommendations are also suggested for the conduct of future research on team science and propose ways to improve collaboration in scientific research.

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DEDICATION

To all of the researchers in the federal community — this is my dedication to you!

May you all find the social interdependencies that bring you together as an integrated team of collaborative researchers. Continue to create and innovate for the collective good; and may your contributions always challenge and enlighten the dynamic world of science!

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CHAPTER ONE: INTRODUCTION

In an era of fiscal restraint, federal science and technology departments and agencies are undergoing a period of transformational change, and are advocating for more advanced whole-of-government solutions to complex problems based on effective collaboration practices. The *Nineteenth Annual Report to the Prime Minister on the Public Service of Canada* highlights that the Public Service needs to embrace more collaborative ways of working together to ensure that the federal government is delivering the best services and programming to Canadians (Wouters, 2012). Excellence in Public Service stems from "engagement, collaboration, effective teamwork, and professional development," and is driven by a whole-of-government approach to service delivery (Government of Canada, 2014). According to the Canadian federal government's *Blueprint 2020* vision, the Public Service of the future needs to incorporate a whole-of-government approach to enable more effective service delivery and programming (Government of Canada, 2013). Part of this visioning includes "an enterprise-wide management culture and supporting structures that enhance collaboration on complex, cross-cutting issues and solutions, and that simplify the web of rules and reporting requirements while maintaining transparency and accountability" (Government of Canada, 2013, p. 6). Federal science and technology departments and agencies acknowledge the importance of working collaboratively on complex problems that require multiple scientific disciplines, teamwork, collaboration, and open communication. Accordingly, this study examines the factors that influence effective collaboration, and the implications of organizational change on the internal team processes, products, and outcomes that result from successful collaborations.

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Critics agree that during periods of organizational change, employees may experience negative attitudes, behaviours, and emotions which can have an impact on their performance (Decker, Wheeler, Johnson, & Parsons, 2001; Fedor, Caldwell, & Herold, 2006; Mdltye, Coetzee, & Ukpere, 2012; Van Tonder, 2004). Lee and Kamarul (2009) demonstrate that in innovative and supportive organizational cultures, employees' commitment and job satisfaction are positively affected, whereas in bureaucratic cultures, commitment and job satisfaction are more negatively affected. During periods of organizational change, employees who work within bureaucratic cultures may experience more negative attitudes and behaviours toward collaboration. For instance, do researchers feel that collaboration enables them to produce successful outputs and outcomes? Do researchers perceive a greater need to collaborate with colleagues both internally and externally to address national priorities and goals? Do researchers prefer to collaborate with other researchers during a period of fiscal restraint or do they feel greater competition? How does organizational change impact collaborations? These are some of the questions guiding this study.

My qualitative research study seeks specifically to explore the factors that influence researchers' attitudes and behaviours in collaborative scientific research projects during a period of transformational change in the Canadian federal government. I examine the factors that influence collaboration, and how these key factors affect the quality and quantity of team outputs and outcomes. My study also looks at organizational change, and if and how it affects research collaborations. By employing one case study, I embrace an ethnographic strategy of inquiry to

provide rich descriptions of the factors that influence researchers' attitudes and behaviours in intra-organizational and inter-organizational collaborations.

This chapter begins with the background and context to my study, and outlines the problem statement, research purpose, research questions, and research objectives. I use operational definitions to present a better overview of the research context, and how the main concepts are employed throughout this study. The chapter concludes with a brief summary of the dissertation chapters.

1.1   Problem Statement

Federal science researchers work in collaborative teams to better address the answers to complex research questions that impact national priorities. Collaboration leads to improved performance through shared knowledge and skills, interactive communication, integrated teamwork, and cohesive communities and networks (Beaver & Rosen, 1978; Bond & Thompson, 1996; Katz & Martin, 1995; Lin & Beyerlein, 2006). Collaboration enhances the sharing, transfer, and mobilization of knowledge to help address complex problems (Beaver & Rosen, 1978; Katz & Martin, 1995; Katzenbach & Smith, 1993a, 1993b; Larson & LaFasto, 1989). Collaboration also leverages scientific and financial resources, and the infrastructure to advance knowledge innovation and creation (Katz & Martin, 1995). However, challenges to scientific collaborations are many, and may include competitiveness, concerns about individual recognition versus group acknowledgment, protection of intellectual property, organizational cultures with poor incentives to collaborate, lack of trust, and ineffective implementation of collaboration models (Bond & Thompson, 1996; Department of Fisheries and Oceans, 2011;

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Government of Canada, 2006; Turnley & McNamara, 2007). During periods of organizational change, the above benefits and challenges undergo additional scrutiny that may impact the quality of collaborations.

Research has examined the impacts of organizational change and people's ability to cope with the stressors emanating from transformational changes in government (Robinson & Griffiths, 2006); the effects of transformational and change leadership on employees' commitment to a change (Herold, Fedor, Caldwell, & Liu, 2008); organizational culture, organizational change, and emotions (Smollan & Sayers, 2009); organizational performance and change (Burke & Litwin, 1992); and the effects of organizational change on individual employees (Decker, Wheeler, Johnson, & Parsons, 2001). However, there is a major gap in the literature on the factors that influence researchers' attitudes and behaviours to collaborate during periods of organizational change, and how organizational change influences scientific research collaborations. This ethnographic study explores the factors that govern researchers' attitudes and behaviours in collaborative scientific research projects within a federal science and technology organization during a period of transformational change. By looking at more integrated ways of working together, science-based departments and agencies have an opportunity to learn how to be more effective in their collective problem-solving and decision-making capabilities.

1.2   Research Purpose and Application

The purpose of this study is to determine what factors contribute to improved collaboration in the federal government during and after periods of organizational change. The

research findings help to inform federal science-based departments and agencies on the factors that promote successful outputs and outcomes of collaborative research projects. This study can impart new knowledge to science-based leaders and managers on how to improve policies, directives, strategies, programs, and practices that impact research collaborations in the federal government. The implications of organizational change on collaboration provide an in-depth understanding of the opportunities, constraints, and recommendations for improving collaboration in scientific research, and offers new knowledge to the science of team science. This study also contributes to a better alignment of government strategies for the further development and exploitation of collaborative scientific research.

1.3   Research Questions

My study addresses the following three research questions:

(1) What factors influence researchers' attitudes and behaviours in scientific research collaborations (i.e., intra-organizationally and inter-organizationally)?

(2) How do the key factors that influence researchers' attitudes and behaviours in scientific research collaborations affect the quality and quantity of team outputs and outcomes?

(3) What impact, if any, does organizational change have on the effectiveness of scientific research collaborations?

The answers to these questions can provide greater insights into the factors that influence researchers' attitudes and behaviours in collaborative research projects, and may help address the impacts of organizational change on the effectiveness of collaborations.

1.4   Research Objectives

This research aims to fulfill the following objectives: (1) to better understand the factors (and their interrelationships) that influence effective research collaborations; (2) to learn about organizational change and how it influences effective collaboration practices; and (3) to develop a new model that will support improved research collaborations.

1.5   Operational Definitions

The operational definitions of the concepts employed in this study are defined below.

Organizational Change: Organizational change is the shift from an organization's current work structures, procedures, culture, and behaviors to a desired new state in order to increase organizational effectiveness. It is "a process that occurs in an organizational setting where the aim of reshaping, altering, or transforming is to move something from one state to another, with the intention of improving the organizational performance, production, or interaction with the individual or the external environment (Anand & Nicholson, 2004; Beer & Nohria, 2000; Dawson, 2003; Marcus, 2000)" (cited in Flakke, 2008, pp. 3-4).

Transformational Change: Transformational change is one type of organizational change that denotes a radical change to organizational strategies, business processes and practices, culture, and personnel. This type of change differs from incremental change (i.e., small developmental steps leading to improved organizational systems, processes, and practices), and

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transitional change (i.e., intermediate steps to reorganize or restructure organizational systems, processes, and practices). Transformational change refers to significant changes in organizational business strategies and policy development (e.g., vision, mission, and values), and in the reorganization of employees, processes, systems, projects, structure, power, and culture (Kotter, 1995; Robinson & Griffiths, 2005). Transformation initiatives change the mandates, processes, structures, programs, and service delivery, and they impact organizational cultures (Canada School of Public Service, 2016). According to the Canadian federal government, "Transformation, which can be government-wide, department-wide or within an organizational unit, is inevitable in an environment where the role, mandate, and size of government are changing" (Canada School of Public Service, 2016).

Collaboration in Scientific Research: Collaboration in scientific research is defined as a social behavioural process where researchers are working and interacting collectively to achieve a common goal in the pursuit of producing new scientific knowledge or technology (Amabile, Patterson Nasco, Mueller, Wojcik, Odomirok, Marsh, & Kramer, 2001; Bond & Thompson, 1996; Bozeman & Corley, 2004; Jassawalla & Sashittal, 1998; Katz & Martin, 1995; Lin & Beyerlein, 2006; Smith & Katz, 2000). People enter into a working relationship by sharing information, knowledge, experiences, and skills, and by generating shared insights, innovations, and creations while fulfilling a common goal (Beyerlein, 2011; Powers, 2004). Collaboration represents "an interactive process, using shared rules, norms, and structures, to act or decide on issues related to a [problem] domain" (Wood & Gray, 1991, p.146) and augments teamwork.

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Intra-organizational Collaboration: Intra-organizational collaboration is defined as people working together within an organization to achieve common goals by communicating and sharing information, knowledge, and resources (Whitford, Lee, Yun, & Jung, 2010).

Inter-organizational Collaboration: Inter-organizational collaboration is defined as two or more organizations that enter into a mutually beneficial relationship by working together [and by communicating and sharing information, knowledge, and resources] to achieve common goals and objectives (Mattessich, Murray-Close, & Monsey, 2001).

Effective Collaboration: In this study, effective collaboration refers to the successful outcomes that are based on the social behavioural processes that enable researchers to work together and interact collectively in the pursuit of achieving common goals. The successful outcomes are based on team performance (e.g., the quantity and quality of outputs and outcomes), team viability, and perceived individual and team satisfaction. Metrics that measure effective collaboration can include product quality and quantity, team efficiency, team behaviours (e.g., collaborative processes), and team or individual members' understandings (Noble, Buck, & Yeargain, 2001). Collaborative processes comprise "dynamic, interwoven, and disciplined exchanges of knowledge and information, participative decision-making, and co-created solutions to emerging problems" and highlight "responsiveness to customer needs, quality of products and services, cost management, innovation, and speed" (Beyerlein, Freedman, McGee, & Moran, 2003, p. 15). Collaborative processes enable researchers to deliver high-quality outputs to clients with the anticipation of generating successful outcomes.

1.6   Dissertation Overview

This chapter has presented the problem statement, the research purpose, the research questions, and the research objectives that frame the context of collaboration in scientific research in this qualitative study.

Chapter Two provides an overview of the theoretical and empirical literature on collaboration in scientific research. It sketches a theoretical framework on effective collaboration in scientific research, and highlights key models of effective teamwork and collaboration performance. It also examines social interdependence and its influence on effective collaborations. The interrelationships within a social system are examined, along with the human relationships found within organizational cultures. The factors that influence effective collaboration in scientific research are examined, both individually and in their interrelationships, to determine if and how they contribute to effective collaborative research. Finally, the chapter postulates the need to explore the impacts, if any, that organizational change has on the effectiveness of collaboration.

Chapter Three presents the research design, methodology, and procedures for carrying out the study. It provides an overview of the case study, including the background, history, research focus, services, employees, the context of how researchers work across the organization, the collaboration practices, and the context within the Canadian federal government during a period of transformational change. It also provides the rationale for employing ethnography as a methodology to capture the lived experiences of the participants. The data collection methods are described in detail, including the processes for coding the transcripts and establishing the

categorical themes. Research ethics outline the standards that were employed for the proper conduct of this study.

Chapter Four reports the findings based on individual ethnographic interviews with federal researchers and managers, and industry managers, a focus group with federal managers, and fieldwork observations. A descriptive overview outlines the characteristics of the sample and highlights the organizational context of the collaborative project teams. The findings summarize the thematic categories that help to answer all three research questions.

Chapter Five presents the answers to the three research questions, including the interpretations and discussions of the factors that influence perceptions of effective collaboration. The major study findings demonstrate how the factors are linked to the literature on teamwork and collaboration, particularly the key characteristics that enable effective collaboration. The interrelationships between the themes demonstrate the linkages to the theoretical models on the effectiveness of teamwork and collaboration, and the impacts of organizational change. Interpretations of the findings outline new insights into collaboration in scientific research as well as a new model for enabling effective collaboration.

Chapter Six puts forward the conclusion, implications, limitations, and recommendations, including the potential impacts on evidenced-based policy development. The implications of the findings are discussed in relation to a set of recommendations for practical application and for future research to enable effective collaboration in scientific research during and after organizational periods of change.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The rapid pace of technological advances and the complexity of national priorities are challenging organizations to work more interdependently to improve the value of science-based outcomes (Council of Canadian Academies, 2012; Government of Canada, 2006). The need to work more interdependently is attributed to the increasing complexity of scientific problems and challenges, fiscal realities restricting how and with whom we work, and the rising expenditures of developing, operating, and maintaining technologies and infrastructure. For example, the federal Science and Technology Integration Board proclaimed that there is a requirement for more effective research collaborations within government, and with industry and academia (Department of Fisheries and Oceans, 2011). The Canadian federal government's *Blueprint 2020* strategy for the Public Service examines whole-of-government approaches and collaborative practices aimed at improving service delivery and programming for Canadians (Government of Canada, 2013). Given the rate and measure of change, it is obvious we need to look at more integrated approaches to enhance the quality of science-based outputs and outcomes.

This chapter synthesizes the theoretical and empirical literature on the effectiveness of teams and collaborations. The theoretical framework incorporates the factors that influence effective collaboration and teamwork, namely: shared leadership, shared culture, shared commitment, team cohesion, mutual trust, shared communications, and clarity of roles, responsibilities, and accountabilities. These key factors and other relevant factors are examined

to determine if and how they contribute to team outputs and outcomes. The theoretical framework also incorporates social systems theory and social interdependence theory to help identify the factors that influence effective collaboration. Organizational change theory is applied to further examine the implications of change on the factors that influence collaboration in scientific research.

2.2   Collaboration in Scientific Research

Collaboration is regarded as a social behavioral process where people are working and interacting collectively to achieve a common goal. Collaboration is different from teamwork because it is based on a "mutually beneficial and well-defined relationship entered into by two or more organizations [or people] to achieve common goals", in which "the relationship includes a commitment to mutual relationships and goals; a jointly developed structure and shared responsibility; mutual authority and accountability for success; and [the] sharing of resources and rewards" (Mattessich, Murray-Close, & Monsey, 2001, p. 4). Teamwork, on the other hand, is defined as a joint action in which two or more people work cooperatively to achieve a goal by sharing their knowledge, skills, and abilities. In comparison to teamwork, collaboration is a "higher-order type of collective action" (Thomson & Perry, 2006, p.23), in which people engage in social and interactive behavioral processes using shared norms, rules, and structures to enable decisions related to a research area (Wood & Gray, 1991).

This study examines collaboration from a socio-cognitive perspective. Collaboration is essentially a social behavioural process evidenced by individuals, groups or teams, or organizations who work together to achieve a common goal (Katz & Martin, 1995).

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Collaboration in scientific research "is shaped by the social norms of practice, the structure of knowledge, and the technological infrastructure of the scientific discipline" (Hara, Solomon, Kim, & Sonnenwald, 2003, p. 952). According to Sonnenwald (2006), "scientific collaboration can be defined as human behavior among two or more scientists that facilitates the sharing of meaning and completion of tasks with respect to a mutually-shared superordinate goal and which takes place in social contexts" (p.3).

Scientific collaborations can be complex in nature. Sonnenwald (2006) states that scientific collaborations go through a specific process that includes four stages: foundation, formulation, sustainment, and conclusion. The *foundation stage* includes all of the underpinnings that start a collaboration (e.g., priorities, knowledge, expertise, and relationships). There are five factors that make up this stage, namely "scientific, political, socio-economic, resource accessibility, and social networks/personal factors" (Sonnenwald, 2006, p. 7). These factors determine whether there is a requirement for a collaboration to occur. For example, scientific or professional factors refer to the requisite to discover new knowledge to produce answers to highly complex research questions in a timely fashion (e.g., SARS outbreak); the requirement for specialized expertise to address research problems; and the opportunities to build the research scope. Political factors represent influences that stem from national and international directives and policies that impact scientific collaborations (e.g., national security implications, emergency preparedness, natural disasters, or health outbreaks). Socio-economic factors contribute to the economic benefits derived from scientific collaborations (e.g., diffusing financial risks or sharing financial resources). Resource accessibility is based on leveraging the human and financial

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resources, information/data, facilities, technologies, and tools that are required to carry out complex research. Finally, social networks and personal factors "provide a foundation for collaboration"… [where] "personal factors play a role in establishing and sustaining social networks and subsequently collaborations" (Sonnenwald, 2006, p. 11).

During the *formulation stage*, researchers begin the collaborative planning of research projects (Sonnenwald, 2006). This stage requires a research vision with clear goals, roles, and tasks; (shared) leadership responsibilities, and an organizational structure of the collaborations; information and communications technology; and intellectual property collaborative agreements.

During the *sustainment stage*, researchers look at how to maintain the collaboration over a period of time until the goals have been completed (Sonnenwald, 2006). There are a number of potential challenges, including difficulties in team norming, withdrawn human or financial resources, changes in policies or team membership, lack of trust, and poor communication. Challenges related to learning and communication may arise during this stage if the knowledge between the collaborators is not exchanged in an open environment, irrespective of whether team members are collocated or distributed across research projects.

During the *conclusion stage*, researchers realize the successful impacts of the collaboration (Sonnenwald, 2006). Examples of successful outputs include new high-quality products or processes designed to address a research problem, team efficiency in completing tasks, and completed research reports and publications. Successful outcomes may include new scientific knowledge/innovations, new theories or models, continued or new collaborations, newly developed tools and techniques, or new/amended policies, programs, and practices.

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Dissemination of results plays an important role in scientific collaborations, and includes discussions about co-writing publications/presentations, selecting journals for publication, and agreeing upon authorship (Sonnenwald, 2006). The conclusion stage is key to this study because this stage describes the quality and quantity of science-based outputs and outcomes.

Throughout the above stages, team members may experience a number of benefits and drawbacks to collaboration. These benefits and drawbacks are explored next, and help to contextualize researchers' collaborative experiences and motivations to collaborate, including the impacts resulting from the collaborations.

2.3   Motivations to Collaborate

2.3.1   Benefits and Incentives to Collaboration

The primary benefits of research collaborations include the sharing of knowledge, skills, and techniques; transfer of knowledge (particularly tacit knowledge); cross-fertilization of ideas; intellectual companionship; and the creation of wider social networks (Katz & Martin, 1995). When the Canada School of Public Service (2007) prepared a report, *Learning Needs Assessment of the Science and Technology Community of the Public Service* for the Federal Science and Technology Community Management Secretariat, it affirmed that there are significant benefits to collaboration. The study based on interviews with 34 science and technology managers and workers revealed that the benefits of collaboration include "increased efficiency and effectiveness, increased impacts, avoiding duplication, synergistic expertise outputs, and access to and increased use of specialized equipment" (Canada School of Public Service, 2007, p. 8).

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Researchers' incentives to collaborate depend on organizational and individual needs. Organizational factors that influence researchers to collaborate predominantly involve access to a wider network of skills, knowledge, resources, equipment, and facilities (Beaver & Rosen, 1978). With the escalating costs of conducting research, and a greater need for researchers to interact and network to advance science (Katz & Martin, 1995), organizations see collaboration as a mechanism to solve complex and challenging problems and to enhance competitive power (Beaver & Rosen, 1978; Dodgson, 1992). Moreover, the propensity to collaborate is contingent on several additional variables, including "individual versus collective research orientations; perceived level of scientific competition; ease of collective credit attribution; attributes of work; field of focus; perceived level of resource concentration; agreement on quality of research; and the need for and availability of help" (Birnholtz, 2007, pp. 2227-2228).

The factors that influence researchers' attitudes and behaviours to engage in collaborations need to be better understood in relation to the quality, quantity, and outcomes of collaborative team performance, the propensity to collaborate again, and the level of individual and team satisfaction that ensues at the conclusion stage of the collaboration. With organizational transformations, these factors may be hindered as people face a cultural shift characterized by a realignment of people and social norms, work and business practices, processes, and policies (Canada School of Public Service, 2016). Organizational transformations are large in scope, disrupt the status quo, and potentially may impact the incentives to collaborate, both organizationally and individually.

2.3.2 Drawbacks of Collaboration

There are several studies that demonstrate the pitfalls of collaboration. Bond and Thompson (1996) reveal that collaborations can lead to conflicting perspectives, loss of visibility through multiple authors, disagreements about the division of workload, inability to manage the workload, and different standards and expectations of work. Moreover, a Government of Canada (2006) report identified several obstacles to collaboration. These obstacles can be based on existing regulations, policies, and guidelines that interfere with effective collaboration, or a lack of funding mechanisms and models to enable collaboration. Insufficient resources (e.g., people, funds, and infrastructure) or training that enable collaboration can negatively affect collaborations. The lack of incentives to collaboration at the individual and organizational levels also has the potential to thwart collaborations.

Human resources issues tend to have the biggest impact on inhibiting effective collaboration and integration. These impediments may be based on several factors, namely "corporate culture as a barrier to collaboration; compensation gaps within academia and private sector which inhibit science-based departments' and agencies' abilities to recruit and retain the best scientists; lack of specific S&T [science and technology] skill sets/expertise/inventories required to support collaboration and integration; insufficient HR [human resources] infrastructure to support S&T community needs; and lack of equivalency for similar work" (Government of Canada, 2006, p. 23). For example, organizational culture is the most difficult barrier to overcome. Corporate cultures require a focused vision and strong leadership to enable effective collaboration. The Government of Canada (2006) report suggests that science-based

departments and agencies need to examine the cultural challenges associated with organizational success:

> Working across traditional boundaries may not allow for a common S&T culture, but
> there needs to be greater awareness of the impacts of organizational culture on S&T
> collaborations and at least a better appreciation of each others' culture and the
> associated frame of references that the players bring to the table. (p. 24)

Similarly, the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine (1999) also report that cultural issues, goal alignment, incentives, and proprietary rights create barriers to collaborative research. As a result, differences in organizational cultures need to be understood by the collaborative parties. Both individual and organizational incentives play significant roles in fostering successful science-based outputs and outcomes. This study, therefore, examines the benefits and drawbacks to collaboration to determine the factors that influence effective collaborations.

2.4   Effective Collaboration—A Theoretical Framework

2.4.1   Models on Effective Teamwork and Collaboration

In this study, there are several models on effective teamwork and collaboration which guide the interpretation of the findings. Team effectiveness is examined because teams represent the "forum for the collaborative processes" and can be considered to be "effective or ineffective at collaboration, both within the team and between the team and other individuals and teams

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inside and outside of the organization" (Beyerlein, Freedman, McGee, & Moran, 2003, p. 23). A team is defined by "a small number of people with complementary skills who are committed to a common purpose, set of performance goals, and approach for which they hold themselves mutually accountable" (Katzenbach & Smith, 1993a, p. 1).

In general, the determinants for the effectiveness of collaborations are based on the processes that enable researchers to collaborate successfully, and the products and outcomes that are achieved as a result of the collaboration. The models serve as the underpinnings of effective collaboration, and are used to discern the processes that impact collaborative team outputs and outcomes. For example, McGrath (1964) put forward the Input-Process-Output (IPO) model to examine the area of team effectiveness. The IPO model proposes that the inputs influence the outputs via the interaction processes that take place between team members. *Inputs* are made up of individual factors that are founded on skills or competencies, attitudes, and personalities. Inputs include team factors such as group structure, member cohesion, and size of a group. Inputs refer to organizational factors that include task characteristics of the group, reward structures, and environmental stress levels. These inputs stimulate the interactive team processes that produce team outputs.

Interaction processes are observed by the team members, and contribute to the quality of the outputs and outcomes. Interaction processes can include the manner in which communication is exchanged between team members or the commitment and trust experienced by the team members. For example, team members who are highly communicative in a team setting may be more constructive in decision-making or conflict resolution. Also, team members may work

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more efficiently in completing their task if they know and trust each other in comparison to team members who are somewhat unknown to each other or who have not established trusting relationships. Thus, team interactions impact the attitudes and behaviours of the members, which in turn, influence the outputs and outcomes of team performance.

The *outputs* are characterized by the group's perceived quality of the team product. The outputs can be based on task specific goals or individual/team satisfaction in completing the goals. Group or team effectiveness is based on the inputs that impact the team and the mediating factors of group interaction that influenced the outputs and outcomes. In this study, the IPO model serves as a rudimentary theory to explain the impacts of the interaction processes or the internal team dynamics stemming from the input-output relationship and the outcomes of the relationship.

Although many advancements have been made in explaining team success, the IPO model has served as a foundational theory on team effectiveness. Elements of the IPO model have been employed in other team effectiveness models (e.g., Hackman, 1987; Salas, Goodwin, & Burke, 2009) and have advanced the area of team effectiveness. For instance, Hackman (1983) introduced a normative model of group effectiveness to determine what factors enhance or weaken a group's task effectiveness. Hackman (1987) states that group effectiveness is based on "(1) the design of the group as a performing unit, (2) the supports provided by the organizational context in which the group operates, and (3) the synergistic outcomes of the interaction among group members" (p. 331). The group's design includes the team composition, the task structures, and the norms for working together (Hackman, 1987). The organizational context provides the

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supportive mechanisms that enable a group to carry out its goals. These mechanisms could include systems related to reward structures, educational systems, and information systems (Hackman, 1987). Group synergy is instrumental to the team's effectiveness. Hackman (1987) states: "Positive synergy—that is, when the synergistic gains from group interaction exceed group process losses—can help a group overcome the limitations of a poor performance situation; [while] negative synergy, when process losses exceed synergistic gains, has opposite effects" (p. 332).

Hackman (1990) purports that group effectiveness is contingent on the amount of collective effort and motivation put into fulfilling the group's tasks and overall objectives; the collective employment of knowledge and skills required to work on the tasks; and the task performance strategies (i.e., steps and procedures) employed by the team in fulfilling its tasks. According to Hackman (1983), these elements (i.e., collective effort and motivation, collective knowledge and skills, and task performance strategies) represent the "process criteria of effectiveness" (p. 23). Effectiveness is attributed to (1) how diligently the members are working towards the completion of the tasks; (2) how efficiently the members are applying their knowledge/skills to complete the tasks; and (3) how successfully the members are employing a group approach to task completion.

Hackman (1987) outlines that group effectiveness is determined by three main criteria: (1) a "task output acceptable to those who receive or review it"; (2) the "capability of members to work together in [the] future is maintained or strengthened"; and (3) "members' needs are more satisfied than frustrated by the group experience" (p. 331). In this study, these three

attributes represent collective teamwork and outline processes that yield successful collaboration outputs and outcomes.

Salas, Sims, and Burke (2005) state that evaluation of team effectiveness needs to be based on team performance and outcomes. Effectiveness is an assessment of how well the team performs in meetings its goals, and is grounded on objective and subjective standards. These standards are in alignment with the team or organizational goals. Salas, Sims, and Burke (2005) claim that the set of processes that enable effective teamwork include team leadership, mutual performance monitoring, adaptability, backup behavior, and team orientation.

Team leadership plays a critical role in effective teamwork (Salas, Sims, & Burke, 2005). Such leadership is characterized by "social problem-solving that promotes coordinated, adaptive team performance by facilitating goal definition and attainment" (Salas, Burke, & Stagl, 2004, p.343). Team leadership has an impact on team effectiveness through the facilitation of team processes (i.e., cognitive, motivational, affective, and coordination), which in turn, enable collective decision-making and team performance (Zaccaro, Rittman, & Marks, 2001). Team leadership also refers to shared leadership, in which there is a transference of leadership functions among team members based on their knowledge, skills, attitudes, perspectives, interactions, and time availability (Burke, Fiore, & Salas, 2004).

Mutual performance monitoring denotes a culturally accepted practice of ensuring that each team member is carrying out his/her roles and responsibilities in fulfilling team tasks and overall performance (Salas, Sims, & Burke, 2005). This type of monitoring allows team

members to ensure that the tasks are being completed through collective efforts in catching task shortfalls. Salas, Sims, and Burke (2005) state that "information gathered through mutual performance monitoring…affects team performance by identifying errors or lapses, and this information, expressed through feedback and backup behavior, boosts the team from the sum of individual performance to the synergy of teamwork and ultimately to team effectiveness" (p. 576).

Adaptability is characterized as a team's ability to adjust its performance in response to environmental cues that enable a team to deliver its project outcomes (Burke, Stagl, Salas, Pierce, & Kendall, 2006). Adaptive team performance is achieved once team members go through four phases, namely "situation assessment", "plan formulation", "plan execution", and "team learning" (Salas, Goodwin, & Burke, 2009). The last phase of team learning is based on the evaluation of the team's performance, in which the cognitive and affective states that resulted in previous performance influence future team performance.

Back-up behavior refers to supportive behaviour among team members to ensure successful team performance (Salas, Sims, & Burke, 2005). Supportive behaviours allow members of a team to provide timely feedback and assistance to each other in order to complete tasks, and to readjust strategies and processes when there is an imbalance in the workload.

Finally, *team orientation* refers to the inclination of team members to work within a team, and to organize, assess, and incorporate the contributions of team members into fulfilled tasks

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(Salas, Sims, & Burke, 2005). These five main process components represent the "Big Five" factors that enable effective teamwork (Salas, Sims, & Burke, 2005).

There are three coordinating mechanisms that enable the above five core processes, including shared mental models, closed-loop communication, and mutual trust (Salas, Rosen, Burke, & Goodwin, 2009, pp. 45-47). *Shared mental models* refer to a team's common understanding of the tasks that need to be accomplished to enable goal attainment. Salas, Sims, and Burke (2005) note that "teams that share similar mental models communicate more effectively, perform more teamwork behaviors (i.e., backup behaviors), are more willing to work with team members on future projects (Rentsch & Klimoski, 2001), and generally perform better (e.g., Griepentrog & Fleming 2003; Mohammed, Klimoski, & Rentsch, 2000)" (p.566).

Closed-loop communication refers to effective communication processes that enable team members to better grasp the intent and relevance of information (Salas, Sims, & Burke, 2005). In closed-loop communication, the intent is to improve information exchange among team members to ensure a collective understanding of the intended message. In its simplest form, communication is a transfer of information between the sender and receiver (Deetz, 1994; cited in Salas, Shuffler, Thayer, Bedwell, & Lazzara, 2014). Closed-loop communication procedures ensure that team members acknowledge the receipt of information and take the time to clarify the interpretation of the information (McIntyre & Salas, 1995; Salas, Shuffler, Thayer, Bedwell, & Lazzara, 2014).

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According to Webber (2002, p. 205), *mutual trust* in a team environment refers to "the shared perception…that individuals in the team will perform particular actions important to its members…[and] will recognize and protect the rights and interests of all the team members engaged in their joint endeavor" (cited in Salas, Sims, & Burke, 2005, pp.568-569). A culture of mutual trust is a core element for enabling effective teamwork, and fosters a greater willingness to openly share information (Salas, Sims, & Burke, 2005). These core processes and coordinating mechanisms are integrated into this study because they are part of the internal processes that affect collaboration.

Gray and Wood (1991) outline the preconditions, processes, and outcomes to better understand collaboration alliances. *Preconditions* refer to the motivations and conditions that bring people together to engage in a collaboration (e.g., shared complex problems and goals, use of common resources, specialized skills, or fiscal restraints). *Processes* include factors that enable collaboration to take place, and rely on the interdependencies of internal factors and team processes such as governance, roles and responsibilities, and trust and respect. The *outcomes* determine if the goals that were set out at the beginning of the collaboration were successfully achieved. The outcomes help to determine if the team was successful in achieving collaboration. Gray and Wood (1991) purport that outcomes can be attributed to different dimensions, including: "Were problems solved? Were shared norms achieved? Did the alliance survive? Did survival occur through transformation?" (pp. 18-19).

Finally, Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) provide the most comprehensive model on the effectiveness of collaboration in research. A provisional model on

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scientists' collaboration looks at *external factors* (e.g., field/discipline characteristics and commerce), *collaborator characteristics* (e.g., factors related to work-style fit, career-stage and motives, and gender), and *team management factors* (e.g., collaboration management structures). Upon analyzing the findings from interviews with 60 academic faculty researchers in the United States, Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) refined their model describing the effectiveness of collaboration in research to include additional factors that are based on subjective accounts of satisfactory and unsatisfactory experiences of collaboration. The new model proposes several factors that are attributed to effective collaboration.

Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) state that *external factors* include field/discipline characteristics (e.g., differences in scientific domains), commerce (e.g., agreements or discords between the norms of science and the norms of commercial goals), and organizational/institutional relations (e.g., management related structures that enable or disable collaboration). *Team characteristics* include communication quality, team members' trust, personality mesh, work-style fit, gender-related issues, complementary expertise, career stage and motives, and investment symmetry. *Individual team members'* characteristics are related to team members who are individual team players (or selfish), science and technology human capital, individual fairness (or exploitativeness), and personal pathology. *Team management* characteristics include management structures for collaboration, and crediting procedures and consensus. Collaboration management strategies "refer to a range of activities such as developing processes for group-decision making, handling conflict, and establishing crediting procedures" (Bozeman, Gaughan, Youtie, Slade, & Rimes, 2015, p. 4).

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Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) state that most quantitative studies predominantly include publications, citations, and patents to determine the effectiveness of collaboration in research. However, they say, quantitative measures fall short of understanding the conditions and factors that impact collaborations. Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) highlight four main reasons why we need to move beyond quantitative measures. First, when collaborators are asked their perceptions of what constitutes effective collaboration, they rarely cite publication outcomes. Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) state that researchers do not wait for the outcomes of their publications before they assess the effectiveness of their collaborations. Second, even though researchers get their results published, it may take a while before they benefit from their research. Third, researchers' publications may not provide enough evidence to assess the impact of the collaboration. Finally, there may be motives to collaborate other than patents and publications (e.g., mentoring, scientific and technical skills development, or building organizational cultures).

Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) highlight key findings from their research that indicate additional determinants for the effectiveness of collaborations. External factors related to disciplinary/interdisciplinary dynamics reveal that "the vast majority of respondents saw having collaborators from different disciplines in a positive light…[because] different disciplines develop different research skills, which encourage scientific complementarity among research collaborators" (p.6). Among the collaborator factors, problems relating to work-style fit represent the most important finding: researchers have different attitudes toward pace of work, control over tasks, work styles, personalities and egos, time

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management, and productivity. As one of their participants expressed, "I think the most successful people are the ones who are most adaptable, who can say, okay, I have talent here but I need to adjust my expectations" (p.8). Also, the older researchers get, the more selective they become in choosing their collaborators. The point is to enjoy the collaboration, and derive satisfaction from being in the collaboration. Gender-based issues generally stemmed from missed career opportunities attributed to maternity leave. Collaborative management strategies include informal management structures to enable good experiences (e.g., discussions on credit sharing).

Factors that determine good collaborators include personality (e.g., mature egos and common passion), effective communication skills, productivity, commitment, and interpersonal trust (Bozeman, Gaughan, Youtie, Slade, & Rimes, 2015). Some of the main factors that determine poor collaborators include the inability to meet work commitments, disputes over crediting authors for publications, personality clashes, self-interests, ghost authoring, exploitation, and asymmetric investments (Bozeman, Gaughan, Youtie, Slade, & Rimes, 2015). The most effective collaborations occur amongst individuals who have already had good experiences in previous collaborations in research (Bozeman, Gaughan, Youtie, Slade, & Rimes, 2015). As a result, researchers tend to work with those they know, trust, and can rely upon to fulfil their commitments and obligations in the collaborations.

The above models on the effectiveness of teams and collaborations contribute to the theoretical framework on the effectiveness of collaborations in this study. McGrath (1964) and Hackman (1987) provide the foundation theoretical basis for distinguishing the elements that contribute to effectiveness in collaboration. McGrath's IPO model and Hackman's team

effectiveness model define the relationships among team inputs, internal processes, outputs, and outcomes. The model proposed by Salas, Sims, and Burke (2005) define teamwork in relation to team leadership, mutual performance monitoring, back-up behaviour, adaptability, and team orientation which are all supported by three coordinating mechanisms (i.e., shared mental models, closed-loop communication, and mutual trust). These factors are aligned with the internal team processes that define effective collaboration in this study. Similar to the IPO model proposed by McGrath (1964), Gray and Wood (1991) propose a three-stage model that helps us to examine the preconditions, processes, and outcomes of effective collaboration alliances. Finally, the model proposed by Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) examines researchers' perceptions of effective collaboration, and outlines the factors related to the external environment, team and individual characteristics, and team management to help define the effectiveness of collaborations. Moreover, these models contextualize the interaction of the factors that influence effective collaborations.

2.4.2   Factors that Influence the Effectiveness of Collaborations

The research on teamwork and collaboration outline several key factors that influence effective collaboration. The literature suggests that effective collaboration is associated with shared leadership, shared culture, shared commitment, team cohesion, mutual trust, shared communications, and clarity of roles, responsibilities, and accountabilities. These factors represent the interdependent elements that influence researchers' attitudes and behaviours in intra-organizational and inter-organizational collaborations.

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2.4.2.1   Shared Leadership

Leadership is essential for enabling effective collaboration (Dean, 2010; Keyton & Stallworth, 2003; Lafond, Irandoust, Tremblay, Price, & Benaskeur, 2009; Larson & LaFasto, 1989; Pallot, Bergmann, Kühnle, Pawar, & Riedel, 2010; Perrault, 2008). In the traditional sense, vertical leadership can be defined as "a process whereby an individual influences a group of individuals to achieve a common goal" (Northouse, 2007, p. 3). The focal point is on follower and leader interactions, and how team leader behaviours influence team effectiveness. In a collaborative setting, team leadership is based on managing a group of individuals who are working towards a common goal (Katzenbach & Smith, 1993b). For example, a study looking at the distinct factors which affect collaborative working environments reveals that among the structural dimensions of collaboration, a lack of leadership negatively affects collaboration and overall performance (Pallot, Bergmann, Kühnle, Pawar, & Riedel, 2010). A lack of leadership hinders shared purpose, vision, goals, and objectives among distributed group members (Pallot, Bergmann, Kühnle, Pawar, & Riedel, 2010). In their study on teamwork, Larson and LaFasto (1989) found that effective team leaders need to be personally committed to achieving team goals and team autonomy. Larson and LaFasto (1989) assert that team leaders must incorporate enduring principles to inspire and influence people through a shared vision by empowering groups to unleash their abilities. Katzenbach and Smith (1993a) reveal that through dedicated and decisive leadership, team members are able to maintain balanced performance goals and results, concise and stimulating objectives, team motivation, core skills and competencies for competitive advantage, and open communication channels.

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Shared leadership moves away from the mainstream forms of traditional leadership practices and highlights a decentered form of leadership (Vangen & Huxham, 2003). Shared leadership refers to "a team property" in which the leadership is spread out across team members rather than focused on a single team leader (Carson, Tesluk, & Marrone, 2007). Shared leadership is the "transference of the leadership function among team members to take advantage of member strengths (e.g., knowledge, skills, attitudes, perspectives, contacts, and time availability) as dictated by either environmental demands or the developmental stage of the team" (Burke, Fiore, & Salas, 2004, p. 105). According to Carson, Tesluk, and Marrone (2007), "Shared leadership originates with individual members of a team engaging in activities that influence the team and other team members in areas related to direction, motivation, and support, and through the series of interactions that team members have with each other involving the negotiation and sharing of leadership responsibilities" (p. 1219). At any point in time, team members both lead and follow each other by providing the leadership on aspects of team functioning and fulfilling the tasks at hand (Carson, Tesluk, & Marrone, 2007). Shared leadership is relational, as leaders concentrate on the values and beliefs of their followers, and regard leadership as collective and purposeful (Burns, 1978). Shared leadership enables researchers to foster effective collaboration (Murrell, 1997) by adapting relational skills such as patience, compassion, integrity, and respect (Eckert, 2001; Fletcher, 2001). Based on their study on shared leadership in teams, Carson, Tesluk, and Marrone (2007) state that team members perform better if they rely on multiple members for leadership. Shared leadership in a team is positively related to team performance (Carson, Tesluk, & Marrone, 2007).

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A study on organizational change toward greater collaboration purports that collective or shared leadership optimizes collaborative working environments (Clark, 2008). According to Clark (2008), such leadership is viewed as a shared process and centers on the collective ways of engaging in leadership. Similarly, in her study on community-university inter-organizational collaboration, Perrault (2008) uncovered three themes related to shared leadership, namely "norm of shared leadership, process for shared decision-making, and shared ownership" (p. 251).

In this research, I examine shared leadership as it is recognized as an important factor for enabling successful team performance (Carson, Tesluk, & Marrone, 2007; Kazantzi, 2010; Kozlowski & Bell, 2003). I define shared leadership as a dynamic and collaborative process whereby leadership is distributed among team members to achieve a collective goal (Pearce & Conger, 2003). I examine shared leadership to see if this form of leadership enables researchers to collaborate more effectively. Carson, Tesluk, and Marrone (2007) reveal that a team is able to develop a leadership network that possesses high levels of mutual influence and shared leadership responsibilities when its internal environment has a clearly defined and understood sense of direction, and a strong interpersonal support mechanism that enables team members to feel recognized and encouraged as team members.

2.4.2.2 Shared Culture

Successful collaborations stem from team members who share a common understanding of a problem and work within a unified culture of shared vision, mission, goals, and values. Nadler and Tushman (2007) state that "values, culture and shared goals are replacing formal structures as the glue that holds organizations together" (p. 653). Researchers also propose that

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shared values are at the core of collaboration (Branson, 2008; Fitzpatrick, 2005; Hansen & Nohria, 2004; Rokeach, 1968), and that they tend to influence attitudes and behaviours among individuals, teams, and organizations. Effective collaborations occur when members contribute to a common vision, mission, goals, and objectives, and have shared authority and decision-making capability (Clark, 1992). Research on the perceptions of Canadian senior scientists and science managers working in government laboratories in large-scale international collaborations reveals that a shared vision among researchers enables effective collaboration (Isabelle & Heslop, 2011). Larson and LaFasto (1989) also state that successful teams need to have a clear and shared understanding of the importance of the vision, and must have a clear "elevating goal" that helps to create team identify. This understanding leads to a "collective purpose" with which individuals realize collective goals and actions (Leana & Van Buren, 1993). Keyton and Stallworth (2003) likewise reveal that effective collaboration is contingent on collaborators having a shared goal. A study on organizations in China emphasized that "goal interdependence is highly predictive of effective collaboration among departments; departments with cooperative goals were described as having a high-degree of collaborative effectiveness and those with competitive and independent goals are unable to work together" (Chen & Tjosvold, 2008, pp. 104-105).

In this research, I define shared culture as a set of perceptions that delineate an integrated working environment based on a common vision, mission, goals, values, thoughts, beliefs, and expectations that are upheld by the team members and are acquired through socialization and learning (Rousseau, 1990). I examine shared culture specifically in relation to how scientific

researchers view their culture and sub-cultures, and the elements that enable them to be part of an integrated culture that fosters effective collaboration (e.g., a collective understanding of the vision, mission, goals, and values of the team).

2.4.2.3 Shared Commitment

Shared commitment is a critical factor in the success of collaborations (Isabelle & Heslop, 2011; Mohr & Spekman, 1994), and it is defined as "team spirit…a sense of loyalty and dedication to the team…an unrestrained sense of excitement and enthusiasm…a willingness to do anything that has to be done to help the team succeed" (Larson & LaFasto, 1989, p. 73). Possessing a shared commitment is the most important characteristic for enabling team effectiveness (Heimeriks, 2002; Larson & LaFasto, 1989). Each team member's commitment to the overall project has a significant effect on the quality of the collaboration (Dietrich, Eskerod, Dalcher, & Sandhawalia, 2010). According to Dietrich, Eskerod, Dalcher, and Sandhawalia (2010), "commitment increases collaborator's genuine interests to participate, engage in mutual support, and [sets] actors' priorities to favour the collaborative task at hand" (p.68).

In this research, I define shared commitment as the dedication of team members to work collectively to achieve the team's goals (Heimeriks, 2002; Katzenbach & Smith, 1993a, 1993b; Larson & LaFasto, 1989). My intent is to determine if shared commitment is one of the factors that influence researchers' attitudes and behaviours in collaborative research.

2.4.2.4 Team Cohesion

Team cohesion is defined as "a dynamic process reflected in the tendency for a group to stick together and remain united in the pursuit of its instrumental objectives" (Carron, Brawley,

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& Widmeyer, 1998, p. 213). A cohesive team embodies the collaborative fortitude among group members and "feelings of belongingness or attraction to the group" (Lieberman, Yalom, & Miles, 1973, p. 337). Cohesive groups embody "social aggregates of two or more individuals who possess a common identity, have common goals and objectives, share a common fate, exhibit structured patterns of interaction and modes of communication, hold common perceptions about group structure, are personally and instrumentally interdependent, reciprocate interpersonal attraction, and consider themselves to be a group" (Carron & Hausenblas, 1998, pp. 13-14). Cohesiveness is the degree to which members experience interpersonal or mutual attraction, rely on each other to fulfill tasks, and share values or beliefs (Dose & Klimoski, 1999).

In this research, I define team cohesion as a dynamic process that creates incentives for a team to cooperate and remain unified in the pursuit of a common goal (Carron, Brawley, & Widmeyer, 1998). Research reveals that individuals in cohesive teams reach group goals more efficiently because less time is required for group maintenance (Dose & Klimoski, 1999). In their study on collaboration in network centric warfare, Lyons, Swindler, and White (2008) reveal that dimensions of organizational collaboration (e.g., collaboration effectiveness, collaboration adaptability, collaboration enablers, and job characteristics) are positively related to cohesion and trust. A cohesive culture that embeds a foundation of trust creates a sense of community (Beyerlein, Freedman, McGee, & Moran, 2003), which results in reduced levels of interpersonal conflict among team members (Dose & Klimoski, 1999).

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2.4.2.5 Mutual Trust

Trust is commonly referred to as the "hallmark of effective relationships" (Dirks, 1999), and it is an important factor for enabling effective collaboration. Mishra (1996) depicts trust as "a party's willingness to be vulnerable to another party, based on the belief that the latter party is competent, open, concerned and reliable" (p. 265). Trust is a "psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another" (Rousseau, Sitkin, Burt, & Camerer, 1998, p. 395).

In a team environment, a culture of trust includes four essential factors: honesty, openness, consistency, and respect (Larson & LaFasto, 1989). Effective communication and improved outcomes of collaboration depend on trust amongst collaborators; however, a single transgression of trust can compromise a relationship (Larson & LaFasto, 1989). A survey looking at distinct factors affecting collaborative working environments reveals that among the social dimensions of collaboration, having a lack of mutual trust is the most significant factor hindering collaboration performance and effective collaboration (Pallot, Bergmann, Kühnle, Pawar, & Riedel, 2010). According to Vangen and Huxham (2003), trust building becomes essential when there needs to be a mutual understanding among the partners about the future of the collaboration, and when partners need to trust each other enough to risk collaboration. Although there is a "common wisdom" that trust is a precondition for effective collaboration, Huxham (2003) reveals that suspicion between partners is more prevalent than trust. Fitzpatrick's (2005) study also reveals the inability of individuals to trust in a common vision because of unclear and inconsistent expectations from management.

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In their study on collaboration in network-centric warfare, Lyons, Swindler, and White (2008) reveal that effective collaboration is positively related to organizational trust. Trust promotes information-sharing, cooperation, and generates collective goals (Lyons, Swindler, & White, 2008). The "level of trust depends on the ability and amount of shared knowledge and strategic information (e.g., purpose, vision, goals, and objectives) among distributed team members" (Pallot, Bergmann, Kühnle, Pawar, & Riedel, 2010, p. 8). Trust is also a critical success factor in large-scale international scientific collaborations (Christiansen & Vendelo, 2003; Isabelle & Heslop, 2011). Trust can bring about "cooperative behaviour among individuals, groups, and organizations" (Jones & George, 1998, p. 531).

In this study, I define mutual trust as the shared belief or expectation held among team members that they can depend on each other to meet their commitments to one another (Dasgupta, 1988). Shared trust is an essential component of collaboration (Heimeriks, 2002) because mutual trust enables team members to achieve a "collective purpose" in which individuals realize collective goals and actions (Leana & Van Buren, 1993).

2.4.2.6 Shared Communications

Quality in collaborations is based on information-sharing through effective communication (Heimeriks, 2002). The *Merriam-Webster Collegiate Dictionary* (2003) defines communication as "a process by which information is exchanged between individuals or groups through a common system of symbols, signs, or behavior" (p. 287). Turnley and McNamara (2007) reveal that shared communications help to develop strong and trusting relationships among individual analysts. Similarly, Dietrich, Eskerod, Dalcher, and Sandhawalia (2010)

disclose that the quality of collaboration and the integration of knowledge in multi-partner projects are dependent on the interrelationships of specific factors such as communication, coordination, mutual support, aligned efforts, and cohesion. Pallot, Bergmann, Kühnle, Pawar, and Riedel (2010) assert that a lack of shared knowledge and a lack of sense-making have the most significant impact on collaboration performance. In other words, communication is contingent on people's willingness to exchange information while developing and maintaining collaborative relationships (Turnley & McNamara, 2007).

In this research, I examine shared communications as the open exchange of ideas in frequent conversations among team members to create a common situational awareness (Dietrich, Eskerod, Dalcher, & Sandhawalia, 2010; Hoegl & Gemuenden, 2001). When ideas are openly shared and communication is frequent, individuals are informed of any changes in activities (Dietrich, Eskerod, Dalcher, & Sandhawalia, 2010; Hoegl & Gemuenden, 2001).

2.4.2.7 Clarity of Roles, Responsibilities, and Accountabilities

The clarity of team members' roles, responsibilities, and accountabilities is essential for effective collaboration. Larson and LaFasto (1989) state that team success is based on members needing to be clear about their roles, responsibilities, and accountabilities. Teams also need to possess an effective communication system, monitor their individual performance and provide feedback, and generate factually-based decisions (Larson & LaFasto, 1989). A study on community-university inter-organizational collaboration reveals that team members need to have a clear understanding of their roles and expectations (Perrault, 2008). Themes related to clear

roles and policy guidelines include "role and responsibility clarification, role flexibility, sub-committee role, program manager's role, and collaboration agreement" (Perrault, 2008, p. 228).

In this research, I examine the clarity of roles, responsibilities, and accountabilities in relation to effective collaboration. I define the clarity of roles, responsibilities, and accountabilities as team members having a clear understanding of their individual and collective duties that contribute to team goal achievement and successful performance.

The above factors delineate the interdependencies that are required before effective collaboration and teamwork can occur. Appendix A also outlines several research studies that highlight the factors that enable effective collaboration and teamwork. To further explore these factors and their interrelationships, I examine the fundamentals of social interdependency theory and their influence on effective collaboration.

2.4.3   Social Interdependence Theory and Effective Collaboration

The literature review on team effectiveness suggests that individual team members need to work within a cooperative context of social interdependence in the pursuit of a common goal (Johnson & Johnson, 1995; Luca & Tarricone, 2001; Scarnati, 2001; Tarricone & Luca, 2002). Social interdependence theory helps to explain the characteristics of effective collaboration and how members can work more productively within a collaborative team environment.

The origin of social interdependence theory is based on Kurt Lewin and the Gestalt School of Psychology. In 1947, Lewin suggested that "the essence of a group is the interdependence among members, which results in the group being a dynamic whole so that a

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change in the state of any member or subgroup changes the state of any other member or subgroup" (qt. in Johnson, 2003, p. 935). In 1949, Morton Deutsch expanded Lewin's theory to develop a theory of cooperation and competition. Interdependency among team members can be positive, negative, or may not exist at all (Deutsch, 1949). According to Deutsch (1949), team members are interdependent as a result of their common goals. A positive interdependence outcome exists when each team member knows that individual member goals can only be achieved through their *mutual dependence on each other* (Deutsch, 1949, 1962). Positive interdependence results in promotive interaction, in which individuals encourage and facilitate each other's efforts to complete tasks in order to reach the group's goals. Negative interdependence results when individuals believe that they can attain their individual goals only if the other team members fail to attain their respective goals and consequently obstruct other's efforts to achieve their goals (i.e., contrient interaction). No interdependence exists when members believe that they can reach their individual goals regardless of whether other team members can attain their goals or not. Goal interdependence among individuals can influence cooperative or competitive behaviour in work teams.

Johnson and Johnson (1995, 1999) put forward elements of positive interdependence that enable effective teamwork. First, team members provide support to each other for both task-related and personal issues. Second, team members share information and resources. Third, team members provide advice and feedback on the accomplishment of tasks and team behaviours. Fourth, team members challenge and influence each other's thoughts and opinions. Fifth, team members encourage and inspire each other to achieve their tasks and goals. Sixth, team members

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apply their social skills to promote teamwork. Finally, team members reflect on the team's

effectiveness and improvement, and acknowledge their collective achievements.

Social interdependence exists when the achievement of each member's goal is shaped by

the actions of others (Johnson & Johnson, 1995). According to Johnson and Johnson (1995),

"social interdependence exists when individuals share common goals; each individual's

outcomes are affected by the actions of others" (p. 206). Social interdependence is reached when

individuals promote cooperative attitudes and behaviours, and concentrate on mutual interests.

Johnson and Johnson (1995) state that positive interdependence (which includes individual

responsibility and accountability) leads to promotive interaction (e.g., social skills and group

processing).

Social interdependence theory helps to explain what factors influence researchers'

attitudes and behaviours in scientific collaborations. Research on social interdependence

examines the internal dynamics of cooperation, where effective cooperation is contingent on

positive interdependence, individual accountability, promotive interaction, interpersonal and

team skills, and the processes that enable group effectiveness (Johnson & Johnson, 2005).

Accordingly, there is a strong relationship between social interdependence theory and successful

teamwork (Tarricone & Luca, 2002). Johnson, Heimann, and O'Neill (2000) and Smith (1996)

state that successful teams are based on several factors: positive social interdependence that

relies on face-to-face promotive interaction; positive interdependence (i.e., reliance on each other

to succeed as a team); individual responsibility and accountability for the completion of tasks; a

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team environment that encourages learning and working together to enable better individual and collective performance; teamwork skills that promote communication, trust-building, and conflict management; and team decision-making and problem-solving for completing the project (cited in Tarricone & Luca, 2002). Conversely, ineffective collaboration among team members can result in workers isolating themselves from the group and thereby decreasing their level of interdependence in fulfilling tasks and goals (Van der Vegt & Van de Vliert, 2001). According to Cheruvelil, Soranno, Weathers, Hanson, Goring, Filstrup, and Read (2014), effective or successful collaborations are the result of the combined efforts of team members in accomplishing their project goals. Such teams demonstrate "positive interdependence of team members, effective communication, and individual and group accountability" (Cheruvelil, Soranno, Weathers, Hanson, Goring, Filstrup, & Read, 2014, pp. 31-32).

Team diversity and interpersonal skills are two important elements that enable social interdependence and impact the success of research outcomes. Team diversity is based on several factors: stage of members' careers; familiarity of members' positions; members' modes of interaction with others; the discipline-type and the number of people per discipline; and different individual perspectives (Cheruvelil, Soranno, Weathers, Hanson, Goring, Filstrup, & Read, 2014). High-performance in collaborative research teams is based on team members who possess interpersonal skills that involve greater "social sensitivity" and the need for "emotional engagement" (Cheruvelil, Soranno, Weathers, Hanson, Goring, Filstrup, & Read, 2014, pp. 33-36). Social sensitivity and emotional engagement contribute to team cultures wherein team members develop their interpersonal skills and learn to trust each other. Team members who

have these interpersonal skills are also able to positively influence the interactions among team members (e.g., team functioning and communications), and ultimately the research outcomes (Cheruvelil, Soranno, Weathers, Hanson, Goring, Filstrup, & Read, 2014). Teamwork exercises and team assessments related to emotional engagement and team diversity, effective communications, team conflict, and team management contribute to greater cohesiveness and effective team functioning.

2.4.4   Social Systems Theory and Effective Collaboration

In this section, I look at social systems theory for what it offers us in understanding how researchers as social actors interact and influence each other's collaborative behaviours within their social environments. Systems theory supports a worldview that looks at the natural world as being integrated and holistic as a result of the interconnections and interrelationships among the parts that make up a system (Meadows, 2008). Social systems theory stems from a narrower branch of systems theory, and explains how individuals or groups of individuals (e.g., families, organizations, communities, societies, and cultures) interact and influence each other's behaviours within a system (CSUB, 2010). According to Talcott Parsons (1951), "a social system is a system of processes of interaction between actors…it is the structure of the relations between the actors (i.e., a network of relationships)" (p. 25). Cohen and Bailey (1997) state that "groups are embedded in larger social systems that influence how they behave and perform" (p. 280).

Social systems theory outlines the cultural elements and relationships that explain how researchers within a social system collectively make sense of the world around them. The culture

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of an organization can be assessed by observing individual, group, and organizational behaviours (Branson, 2008) using a social systems framework. Within the context of collaborative scientific research, a social systems' perspective looks at how researchers construct and understand their subjective experiences of collaboration. Collaboration in scientific research is based on the interconnectedness of scientists; the scientific community lives within a self-organizing system (Wagner & Leydesdorff, 2005). Social systems theory enables us to examine the cultural elements that promote organizational collaboration. The communication of shared assumptions, beliefs, norms, customs, rules, traditions, values, and artefacts (Schein, 2004) within a social system play a major role in defining and shaping interpersonal relationships within organizations. Organizational culture represents 'a set of cognitions including values, common understandings, and patterns of beliefs and expectations that are shared by all or many members of a social unit, and are acquired through social learning and socialization processes' (Rousseau (1990), cited in Maierhofer, Rafferty, & Kabanoff, 2003, p. 18). The factors that influence collaboration may be evidenced within a social system that consists of interdependent parts (e.g., alignment of shared vision, goals, values, commitment, and trust) that enable teams to meet organizational goals. Shared vision refers to a group's ability to have a common identity and sense of destiny (Senge, 1990). Shared values, norms, and guiding beliefs of organizational members generate opportunities for potential collaborators (Kraut, Galegher, & Egido, 1987).

Cultures that accentuate organizational values are more likely to experience a better quality of work life (Goodman, Zammuto, & Gifford, 2001). Researchers have put forward different definitions of values and what values entail. Values can be defined as a set of core

generalized beliefs about how individuals "should" or "ought" to behave (Rokeach, 1973). Values are also depicted as "concepts or beliefs, about desirable end states or behaviors that transcend specific situations, guide selection or evaluation of behavior and events, and are ordered by relative importance" (Schwartz & Bilsky, 1987, p. 551). Values include "collective goals or explicit purposes," and "standards in terms of which specific criteria may be established and choices made among alternatives" (Burns, 1978, p. 74). Values are stable and directly influence people's cognitions, perceptions, and behaviours (Nicholson, 1998). Values can be instrumental or terminal (Rokeach, 1973). Instrumental values refer to preferred modes of behaviour (e.g., courage, honesty, and responsibility), while terminal values center on desirable end-states (e.g., self-respect, happiness, and wisdom). Values are acquired throughout one's life and are influenced by familial, societal, and cultural factors. In sharing similar values and vision, an organization is enhanced through the establishment of trusted relationships that become the foundation for employee pride, respect, dedication, and shared meaning (Campbell, 2007).

Organizational core values are values that are generally shared across an organization (Maierhofer, Rafferty, & Kabanoff, 2003). These values represent the "foundation on which the system is built," one in which the "system includes organizational strategies, processes, and behaviours, which are affected by values" (Fitzpatrick, 2007, p. 286). According to Maierhofer, Rafferty, and Kabanoff (2003), "the strength of a value system is influenced by the degree to which members agree with the system as a whole (the system's intensity) and the number of members sharing the central values (the breadth of the system)" (p. 5). Although groups can

maintain different sets of values within an organization (Champoux, 2011), organizations typically communicate specific core values as value sets that they expect employees to uphold.

A social system also takes into consideration the alignment of values. The alignment of values has been studied by researchers to determine the impact on the congruency between individual and organizational value systems. For example, Fitzpatrick (2005) examined the alignment of values as a strategy to improve collaboration in a Manitoba government agency. This action research assessed the alignment of organizational values, and how these values enable a collaborative culture and a proactive approach to conflict. Fitzpatrick (2005) looked at the alignment of individual and group values, and if they were congruent with the organizational values and strategies of the agency. Fitzpatrick (2005) conducted workshops to explore different approaches to fostering a collaborative culture for the agency; and in turn, outlined four variables that explain how the system functioned: common purpose, consciousness, communication, and trust. According to Fitzpatrick (2005), participants did not seem to have a common understanding of the agency's values, goals, and strategies, and their personal values were not aligned with the organization's values. Lack of communication defined the incongruence between how people communicated and espoused their values. Factors related to command and control and trust, as well as an overall lack of alignment of values, were the most significant issues inhibiting a collaborative culture for the agency. Fitzpatrick (2005) concluded that the foundation of a collaborative culture is dependent on the alignment of organizational values.

In their research on 387 highway and transportation departmental executives, Boxx, Odom, and Dunn (1991) conclude that organizational values and value congruence positively

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impact satisfaction, commitment, and cohesion. These researchers state that an "organization's performance should be greatly enhanced if the cultural values are congruent with the desired beliefs and values of its employees" (Boxx, Odom, & Dunn, 1991, p. 195). In their example, employee satisfaction, commitment, and cohesion improved when there was alignment between the organization's value system and the employee's value system.

Team values refer to a commitment to a common purpose within a collective group that shares the responsibility and accountability for the outcomes (Katzenbach & Smith, 1993b). Jehn, Northcraft, and Neale (1999) examined group value congruence, and revealed that value diversity decreases group satisfaction and morale, the intent to remain within the group, and the overall commitment to the group. Research teams engage in self-organizing, collective behaviour when the dynamism experienced within the research team is a result of the energy derived from member interactions (Vasleiadou, 2011).

The interdependencies of personal and organizational values may also affect collective group behaviour (e.g., team collaboration). Branson (2008) states that "as a collective, the group, team or organization does not possess a set of values unless a majority of the individuals that have formed this group, team, or organization personally and authentically embrace each value" (p. 381). Team or organizational values serve as guiding posts by which individuals may choose to align their behaviours in accordance with these collective values. Once these values are established, they begin to "influence what is deemed as important by the group, the group's activities, and individuals' fit to the group" (Maierhofer, Rafferty, & Kabanoff, 2003, p. 13).

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In sum, social systems theory takes into account the cultural elements that foster organizational collaborations. The interdependencies of these elements are based on individual and collective assumptions, beliefs, norms, customs, rules, traditions, values, and artefacts that generate a social system. Organizational culture is about how people within a specific social system collectively make sense of the world around them. Organizational culture also influences researchers' attitudes and behaviours in achieving effective collaboration. Within this study, a social systems view of collaboration helps me to examine the factors within a system that influence collaborations (e.g., leadership, shared goals, norms and values, mutual trust, cohesion, relationships, roles and responsibilities, and communication), and how these elements become mutually interdependent within the system to enable collaboration, particularly during a period of organizational change.

2.4.5   Organizational Change Theory and Effective Collaboration

Organizational change theory looks at the processes and impacts of change on individuals, teams, and organizations as a whole, and also the relationships at the employee and managerial levels (Van Tonder, 2004). For example, Kurt Lewin (1947) proposed a three-step model on organizational change: unfreeze, change, and refreeze. *Unfreeze* refers to discarding old behaviours or typical ways of doing things. *Change* refers to taking on new behaviours that are acceptable to the organizational culture. *Refreeze* refers to maintaining the newly learned behaviours that are part of the culture change. Organizational change is described as a process that takes place within an organizational context "where the aim of reshaping, altering, or transforming is to move something from one state to another, with the intention of improving the

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organizational performance, production, or interaction with the individual or the external environment (Anand & Nicholson, 2004; Beer & Nohria, 2000; Dawson, 2003; Marcus, 2000; cited in Flakke, 2008, pp. 3-4). Organizational changes can lead to adjustments or reforms in business practices, organizational structures and infrastructure, administrative procedures, power structures, and programs and services.

Organizational change is categorized under several types of change. For example, organizational change may be described as first-order or incremental change (e.g., small developmental steps that lead to improved organizational systems and processes), or second-order change which is more radical and transforms the core organizational elements (e.g., transformational change). For example, Jick and Peiperl (2003) provide a three-level schema of organizational change—developmental, transitional, and transformational. Developmental change differs from transitional and transformational change because the intent is to improve the current systems, processes, and practices, without undergoing any dramatic changes or alterations to the existing organization. Transitional change involves taking several small incremental steps to modify existing organizational processes, systems, and programs. Transformational change is the most disruptive of all, and highlights the need to change the existing vision, mission, structures, systems, people, and programming. Transformational change represents the context of organizational change for this case study and is further illustrated in the background of the case study in Chapter Three.

Kotter's (1995) portrayal of organizational change provides a good overview of organizations that undergo transformational change. According to Kotter (1995), organizations

go through eight particular steps. First, organizations need to determine if there is a sense of urgency to change. Second, organizations need to assemble a coalition to lead the change. Third, organizations need to develop a vision and a strategy to direct and implement the change. Fourth, the coalition needs to develop a communications strategy of the change vision. Fifth, the coalition needs to empower employees with the vision. Sixth, organizations need to look at short-term successes and reward people for embracing the new vision. Seventh, organizations need to consolidate the new changes and generate more change. Finally, organizations need to secure and institutionalize the new changes and behaviours to enable cultural change. The goal is to empower people to accept and adapt to new organizational changes.

Burke and Litwin's (1992) model of organizational change also looks at both transformational factors (i.e., new behaviours as a result of the organizational change) and transitional factors (e.g., intermediate steps taken to change organizational systems, processes, and structures). At the individual level, organizational changes can negatively affect people's emotions (e.g., anxiety, fears, doubts, uncertainty, sadness, confusion, bitterness, anger, depression, and stress) or may elicit more positive emotions (e.g., happiness, motivation, and excitement) (Mdltye, Coetzee, & Ukpere, 2012). Organizational change impacts employees' job responsibilities, reduces job security, and alters perceptions of career progression and expectations (Decker, Wheeler, Johnson, & Parsons, 2001). As employees go through organizational change, they experience periods of insecurity and uncertainty about their future (e.g., potential job losses, changes in position and rank, and low self-esteem) (Nadler, 1982). Employees become confused and anxious about the overall change (Kanter, 1983) and how the

organizational change can affect them in their everyday lives. Organizational change can affect the level of trust among employees, with managers, and in the whole organization, undermining employees' levels of loyalty and commitment to the organization (Kanter, 1983; Mdltye, Coetzee & Ukpere, 2012). Organizational changes that involve budget cuts and major restructuring negatively affect morale, job satisfaction, and perceived performance (Decker, Wheeler, Johnson, & Parsons, 2001). Organizational change can arouse emotional reactions, and may also affect employees' interpersonal working relationships as they engage in collaborative research projects.

Organizational change can impact individual commitment to change (Fedor, Caldwell, & Herold, 2006). Based on their study of 32 public and private organizations, Fedor, Caldwell, and Herold (2006) reveal that commitment may be best understood in how people favor the change, the degree of organizational change in the work unit, and the overall impact on employees' jobs. Moreover, creativity and the ability to be productive during organizational change may be affected by negative attitudes. In one study on organizational downsizing, 754 employees felt a substantial decline in creativity, experienced less freedom and challenge, and had limited access to resources, and work group, supervisory, and organizational support (Amabile & Conti, 1999).

Organizational culture and its underlying sub-cultures play an important role in generating emotions during change, and influence employees' attitudes and behaviours (Smollan & Sayers, 2009). Innovative and supportive cultures create strong positive influences on employees' commitment and job satisfaction, while bureaucratic cultures can create more negative effects (Lee & Kamarul, 2009). Moreover, cultures can be adaptive or non-adaptive to

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change (Daft, 1986). Employees who reside in adaptive cultures experience more positive attitudes to organizational change in the forms of greater cohesion, job satisfaction, and trust (Daft, 1986). People who reside in non-adaptive cultures to organizational change exhibit more negative attitudes, including uncertainty about their future, competitiveness among colleagues, mistrust, and fear of not being able to fulfill personal goals and interests (Daft, 1986). Adaptive cultures enable teams to interact effectively even during moments of organizational change. For example, high performance teams are able to maintain high levels of collective performance even though environmental conditions may change over time (Zaccaro, Rittman, & Marks, 2001). High performance teams need to develop norms and operating strategies that encourage "individual and collective flexibility and adaptability" (Zaccaro, Rittman, & Marks, 2001, p. 457).

An organization's ability to adapt to change may be contingent on several specific factors (e.g., structural, environmental, societal, and interpersonal). Organizational change may influence employees' perceptions of collaboration, particularly the common characteristics that define effective collaboration within a social system. For example, Guzzo and Dickson (1996) state that the effectiveness of teams needs to be understood within the larger social system. Social systems provide a major context in which to study team performance. McGrath (1991) notes that teams or groups are "partially nested" within a social system and are indirectly linked to other social systems. Partially nested refers to groups being tied to other groups or to other social systems where teams perform multiple tasks across different groups (Guzzo & Dickson,

1996). As a result, changes in one part of a system affect the behavioural changes within the entire system.

A team's effectiveness at the individual, team, and organizational levels is affected by its being embedded within a specific organization. In other words, "changes in team effectiveness can thus have consequences for change in the larger system, such as when improved performance by a team or set of teams is thought to yield greater profits for a business" (Guzzo & Dickson, 1996, p. 327). However, Guzzo and Dickson (1996) point out that it would be incorrect to state that changes in team effectiveness and performance impact the changes in the larger organizational context. Accordingly, "changes in the larger social system can bring about change in the teams situated in it;" and "interventions into the surrounding organizational system may bring about improved (or if the intervention is a poor one) reduced team performance" (Guzzo & Dickson, 1996, p. 327). In this study, my main concern is to determine if and how organizational change influences researchers' collaborative behaviours during a period of transformational change. The changes and impacts of the wider social system are important to understand in relation to the effectiveness of collaborations.

2.5   Summary

The above theoretical framework creates the underpinnings for an overarching model of effective collaboration that helps to guide this study. Effective collaboration is contingent on the interaction processes that enable researchers to collaborate successfully, and how these processes impact team outputs and outcomes. Theories of effective teamwork and collaboration outline the

important processes and characteristics that enable successful collaborations. Inputs, interaction processes, and outputs reside in dynamic interpersonal team structures and also live within the larger social system. Theories that examine holistic social systems (e.g., organizational culture) explain the inter-relationships and social interdependencies that enable effective collaboration. This larger organizational system encompasses an overarching vision and mission, systems and structures, processes, programs, and human resources that may influence team behaviours. The elements that impact organizational change in a larger system may impact effective collaborations. Organizational change theories help to contextualize the type of change found in this case study, and the processes that researchers go through to better adapt to the changes that can enable more effective collaboration in scientific research.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

My ethnographic study employs a qualitative research design and methodological framework to address the research questions on the factors that govern researchers' attitudes and behaviours in collaborative scientific projects. I use a social constructionist worldview or epistemological framework and look at how researchers socially construct their knowledge within collaborative research projects. Categories of knowledge and reality are actively shaped by their social relationships and interactions (Bryant & Wolfram Cox, 2006). Collaboration is fostered culturally through researchers' social relationships with others, and the types of interactions that enable collaboration to ensue. As a result, the social construction of collaboration shows how researchers' attitudes and behaviours influence their interactions in collaborative projects, and denotes a useful way of exploring the interaction between collaboration, culture, and organizational change.

3.2 Ethnography

Ethnography captures the routine daily lives of people within their cultures and sub-cultures by enabling researchers to observe human behaviour and patterns (Fetterman, 1998). In this study, I used ethnography to examine collaboration as a social construct, and looked at how researchers create social systems of meaning (Lin & Beyerlein, 2006). Knowledge of shared and learned patterns of values, behaviours, beliefs, and language (Creswell, 2007) contribute to a holistic understanding of how motivations and working relationships enable collaboration. As a

result, ethnography provides a holistic approach by which to uncover the cultural and sub-cultural social systems found within the researcher community.

Ethnography has been employed to study collaboration in game development, technologies, organizational practices, and team-oriented work practices. For example, an ethnographic study of collaboration in a game development team context revealed that a collaborative organizational culture fosters innovative gaming designs; however, innovation within a team environment is highly dependent on the effectiveness of interpersonal relationships (Tran & Biddle, 2008). Tran and Biddle (2008) developed a framework and put forward their interpretation of a successful collaboration process. The important attributes of this model include respect for individual roles and how each person contributes to the game product, a spiral developmental or iterative process that demands constant interaction among team members, and a shared vision for the end product. In turn, the collaborative spirit is reinforced and strengthened by the socio-technical infrastructure. These researchers conclude that "effective collaboration requires a team that respects each other's contributions, communicates frequently, and shares a similar conceptual model of the product and goals" (Tran & Biddle, 2008, p. 18).

Another ethnographic study examined the culture and collaborative technologies in the United States intelligence community (Turnley & McNamara, 2007). The study examined the role of collaboration within the analytic environment and how technology could support collaboration. These researchers wanted to discern if organizational values attached to the production of work products drive analysts to collaborate. An ethnographic approach facilitated the examination of the socio-cultural dimensions of collaborative activities within the

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intelligence community. This approach also helped to unfold what collaboration meant to the analysts, and what role technology played in supporting collaboration. Based on narratives, reports/publications, interview data, and field observations, Turnley and McNamara (2007) discovered that collaboration is indicative of a "cooperative communicative event" in producing strategic intelligence. Communication is based on the willingness to exchange information while developing and maintaining collaborative relationships, the coordination of activities and products using a peer-review approach to ensure the quality of a product, and the need for collaboration to further develop strong trusting relationships among the individual analysts.

Rolls-Royce Aerospace in the United Kingdom also employed an ethnographic study on engineering design teams, and concentrated on the roles of socially-mediated communication and how organizational changes affect team performance (Baird, Moore, & Jagodzinski, 2000). Ethnography enabled these researchers to examine the human concerns over technological issues from the beginning to the end of the design process within multi-national collaborative projects. By employing ethnography, Baird, Moore, and Jagodzinski (2000) were able to assess the task-based knowledge of design teams in their natural setting, and how these design teams operationalized change over time.

Building on the above ethnographic studies on collaboration, this study employs an ethnographic approach to identify the factors that govern researchers' attitudes and behaviours in collaborative scientific research in one case study. Ethnography gives voice to the deep rich descriptions of researchers' collaborative experiences as they work and interact within their cultural settings.

3.3   Case Study—Canadian Wood Fibre Centre

I employed a qualitative research design to study one federal science-based organization within Natural Resources Canada (NRCan), the department responsible for research and development in forestry, energy, mining/materials, earth sciences, hazards, explosives, the North, and the environment (http://www.nrcan.gc.ca). The Canadian Wood Fibre Centre (CWFC), under the Canadian Forest Service (CFS) within NRCan, is the case under study. The CWFC supports NRCan's vision of "improving the quality of life of Canadians by creating a sustainable resource advantage" (Natural Resources Canada, 2010, p. 10).

3.3.1   Canadian Wood Fibre Centre—Background

NRCan launched the CWFC in April 2006. The CWFC is a virtual centre, and is one of CFS' research centres. It has approximately 55 employees located across CFS regional offices, including the Atlantic Forestry Centre, Great Lakes Forestry Centre, Laurentian Forestry Centre, National Capital Region, Northern Forestry Centre, and Pacific Forestry Centre. Based on NRCan's web site, topical areas include sustainable forest management, forest insects and diseases, boreal forest, impacts of climate change on forests, forest fires, forest industry and innovation, remote sensing, and forest inventory (Natural Resources Canada, 2016a).

The CWFC's vision, mission, values, and objectives are presented in Table 1. The main goal of the CWFC is to "deliver a first-class program that sets new standards for wood fibre research at the national level and that contributes to the realization of the innovation agenda of the forest sector in Canada" (Canadian Wood Fibre Centre, 2010, p.16).

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Table 1 CWFC—Vision, Mission, Values, and Objectives

Vision—Canada's wood fibre is sustainably managed to give the forest sector a strong competitive advantage in a global marketplace.

Mission—To create innovative knowledge to expand the economic opportunities for the forest sector to benefit from Canadian wood fibre.

Values
1. The CWFC will aggressively seek opportunities to increase economic benefits in both the short and long term while also promoting forest sustainability.
2. The value of the CWFC will be measured as much by the relationships it fosters as by the research solutions it generates. It will strive for excellence, innovation, creativity, inclusiveness and impact in both.
3. The CWFC will develop strong linkages to other research providers so that its response to clients' needs is comprehensive.

Objectives
1. Undertake a national forest-level research program focused on value chain optimization;
2. Promote uptake and application of CWFC knowledge products by the Canadian forest sector; and
3. Continue to integrate and contribute to FPInnovations' programs.

Source: *Canadian Wood Fibre Centre (2010, p.2).*

As part of its mandate, the CWFC provides FPInnovations, its main industry partner, with forest-level upstream research services that start with the growing (e.g., formation of seedlings) and end with the harvesting of mature trees (Canadian Wood Fibre Centre, 2013). The CWFC

receives approximately $5 Million annually of C-based funding through the Forest Innovation Program with a goal to cultivate "upstream" solutions to the challenges identified by the Canadian forest industries (Natural Resources Canada, 2016b). Upstream research looks at wood fibre supply, and refers to "forest-level research activities such as fibre characterization, quality assessment, and forest inventory" (Canadian Wood Fibre Centre, 2013, p. 1). An example of upstream research is the development and use of enhanced forest-based inventory tools and techniques designed to plot land and vegetation with precision. Software tools and inventory techniques (e.g., ground-based, airborne and satellite remote sensing technologies such as LIDAR) are used to measure tree characteristics, forests, forest stands, and landscapes (Canadian Wood Fibre Centre, 2013).

The CWFC receives its strategic research roadmap from the FPInnovations National Research Advisory Committee in addition to being guided by NRCan's strategic priorities and anticipated outcomes (Canadian Wood Fibre Centre, 2013). The CWFC works with FPInnovations under the Resource Assessment Program's research portfolio and endorses three primary components of forest and wood fibre research: (1) Resource Characterization; (2) Resource Production; and (3) Resource Optimization (Natural Resources Canada, 2014a). *Resource Characterization* encompasses the following research areas: "semi-automated species identification, inventory resolution improvement, spatial productivity measures and spatial supply forecasts, enhanced forest inventory systems, and inventory tools for stewardship" (Canadian Wood Fibre Centre, 2014, p.1). The CWFC collaborates with the provincial governments, industry, and academia to help leverage resources to generate cost-efficient forest

areas. *Resource Production* incorporates the following research areas: "tools for identifying genetic markers associated with desirable wood traits, somatic embryogenesis systems to produce trees with desirable fibre attributes and uniform quality, and management regimes to supply fibre for existing and emerging product stream" (Canadian Wood Fibre Centre, 2014, p.1). This area of research relies on robust collaborative partnerships between provincial governments and industry to ensure greater uptake and impact of forest-based innovations. *Resource Optimization* includes research areas related to "robust wood fibre attribute yield curves for natural and managed stands; models to evaluate and optimize silviculture systems; decision support tools that optimize harvesting systems and logistics; and forest management models that incorporate experimentally verified methods" (Canadian Wood Fibre Centre, 2014, pp.1-2).

Under these three major components, there are component activities which represent research projects. Budget allocation is based on the component activities. Typical component activities receive funding anywhere from $20,000 to $200,000, and depend on the extent of the research work. However, contribution agreement funds supplement the budget allocations received from the Forest Innovation Program. The funding for each component activity is based on three years, where after two years, researchers need to show their progress or achievements, or show a change of course to update the planning cycle. The component activities are interdisciplinary and multidisciplinary (e.g., forestry economics and forestry biology) and rely on partnerships with the CFS, FPInnovations, municipal/territorial/provincial/federal governments, academia, and other external partners. The component activities are nationally decentralized, and

there are about three to five researchers per component activity (e.g., scientists, forestry specialists, and technicians) who carry out the research.

By 2017, the primary goal of the CWFC is to become the national authority on the characterization of wood fibre in Canada, and will be a main contributor to the Canadian innovation agenda (Canadian Wood Fibre Centre, 2010). The aim is to provide "value chain optimization" through "integrated solutions" that will "enable the right tree to be grown, harvested, transported and manufactured into the right products for the right market at the right price" (Canadian Wood Fibre Centre, 2010, p. 6). This optimization is realized under four main output categories, including tools that include: "inventory systems for spatially quantifying forest structure and resource and related fibre attributes"; correlations made through "techniques and methods to relate fibre attributes to tree, stand, and site characteristics"; production "techniques and methods for managing current and future forests to deliver trees and stands with specific fibre attributes"; and valuation "techniques and methods to optimize management decisions that maximize profit and market competitiveness" (Canadian Wood Fibre Centre, 2010, p.7). The main objective is to maintain diversity and manage variability (Canadian Wood Fibre Centre, 2012).

The CWFC's primary areas of forest and wood fibre research are guided by four principles, namely "partnerships, national scope and regional delivery, collaboration, and impact" (Canadian Wood Fibre Centre, 2010, p. vi). For the CWFC, collaboration plays a fundamental role in achieving the desired outcomes for value chain optimization of the forest sector. The Centre's researchers primarily maintain their collaborations with researchers from the

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greater CFS and FPInnovations (main industry partner), and also develop partnerships with researchers from the territorial, provincial and federal governments, industry, and academia for advancing scientific innovations in the forest sector.

The CWFC management model recognizes the role of collective leadership and teamwork in achieving its goals and objectives for strengthening the forest sector (Canadian Wood Fibre Centre, 2010). Several years ago, the CWFC established a *CWFC Management Team Charter* which outlines the success criteria for advancing its mission through the employment of team-oriented service standards and codes of conduct. The CWFC managers use the team charter to create and sustain the conditions for enabling success through an integrated management approach. The CWFC has also striven to create a dynamic culture through the annual employee science forums to foster greater employee engagement and collective leadership in setting the direction and priorities of the organization (Canadian Wood Fibre Centre, 2010). Moreover, the CWFC has employed a learning organization community of practice (LOCoP) approach to enable an inclusive corporate culture, and to establish more collaborative and integrated working relationships across government, industry, and academia (Way & Dale, 2013). In addition, knowledge exchange is fundamental to the CWFC, where the upstream research results are shared with organizations across the forest sector. Knowledge exchange is also conducted through the Knowledge Exchange Group of FPInnovations, with the goal to share and apply best practices in upstream research (Canadian Wood Fibre Centre, 2010).

The CWFC has a component activity (research project) planning tool called ProMIS to ensure compliance with the CFS program management requirements. ProMIS is an interactive

template into which component leaders (i.e., researchers) input their proposed component activities. A paper-based ProMIS system guides researchers in demonstrating and explaining the anticipated component activities. The paper-based ProMIS template includes several pertinent criteria, including component activity title, start and end dates, team membership and a list of partners and collaborators, proposed outputs, alignment to research priorities that fall under Resource Characterization, Resource Production, and Resource Optimization, milestones, end-user/client need for component activity, statement of benefits, alignment to Resource Assessment Program principles, and breakdown of the budget. Once completed, researchers are required to talk to their regional coordinators about their proposed component activity before entering it into the actual ProMIS online system for final approval and budget allocation. The ProMIS tool helps managers to better determine whether the component activity meets all of the requirements before giving final approval.

The success of the component activities are judged against similar criteria delineated in the ProMIS tool. Each component activity within the overarching Resource Assessment Project is reviewed for its progress and also incorporates any additional research components. The criteria used include the relevance of the component activity (e.g., links to a Resource Assessment gap, addresses FPInnovations' strategic objectives, or is intended to move science forward). Other criteria include partnerships (particularly with FPInnovations and provincial collaborators), potential leveraging (cash or in-kind), and potential impacts (return on investment in dollars). Each component activity leader is required to provide progress updates for each deliverable. Component activity leaders are also asked to report their success stories, including

any publications and knowledge exchanges between organizations. Successes are also judged by performance measurement indicators at the Forest Innovation Program level, and at the Treasury Board level departmental Program Activity Architecture which defines the outcomes of the program.

The CWFC wants to become the national authority on Canada's wood fibre resources, including the innovations that are carried out for Canadians and around the world. The CWFC is primarily interested in addressing industry needs and forest sector priorities (Canadian Wood Fibre Centre, 2010). The aim is for the CWFC to achieve the desired impacts that will advance forestry science and address the national priorities challenging the forest sector. The ultimate outcome is to advance the competitiveness of the Canadian forest sector.

3.3.2   Transformation of the Forest Sector—Canadian Wood Fibre Centre and FPInnovations Partnership

In this study, the context of transformational change falls under two inter-related perspectives: (1) transformation of the forest sector; and (2) transformation of the federal government. These two transformational change contexts make up the transformational period in this study which looks at some of the impacts stemming from the organizational changes occurring in the forest sector and federal government.

The transformation of the Canadian forest sector is in response to the need for greater sustainability and competitiveness in advancing the forest industry (Canadian Council of Forest Ministers, 2015). Between 2003 and 2009, the Canadian forest sector lost approximately 130,000 jobs and closed 455 mills due to traditional forestry business practices and forest products

becoming uneconomical and unsustainable in advancing the forest sector (Natural Resources

Canada, 2016c). The aim of the transformation is to develop more "novel products, processes,

business models, markets and applications" that are necessary for the renewal of the forest sector

(Canadian Council of Forest Ministers, 2015, p. 2). Transformative technologies have been at the

forefront of revolutionizing the forest sector. The drivers behind these transformative

technologies include: greater competition within the forest sector; impacts of climate change on

the forest sector; continued sustainable land use; lack of non-renewable fossil fuels; and the

increasing need for environmentally-friendly products (Natural Resources Canada, 2016d). The

value stemming from the production of innovative forest products (e.g., new bi-products and

bioenergy) is the creation of greater sustainability of the forest sector.

In 2003, the Canadian Forest Innovation Council put forward a strategy and framework to

establish a public-private forest research organization that would transform innovation in the

forestry sector (Canadian Council of Forest Ministers, 2015). This effort led to the creation of

FPInnovations in 2006-2007, an organization that would bring together government, industry,

and academia to help advance innovation in the forestry sector. FPInnovations is a national, non-

profit research institute for forestry products. It is a relatively new organization created from the

merger of Forintek Canada Corp, the Forest Engineering Research Institute of Canada (FERIC),

and the Pulp and Paper Research Institute of Canada (Paprican). Forintek provided advanced

technological solutions for wood products. FERIC represented the lead research institute

responsible for forestry operations related to the harvesting and transportation of wood. Paprican

led forestry sector research in developing innovative, economical, and sustainable solutions in pulp and paper.

As a not-for-profit organization, FPInnovations "specializes in the creation of [innovative] scientific solutions in support of the Canadian forest sector's global competitiveness and responds to the priority needs of its industry members and government partners" (FPInnovations, 2016). FPInnovations focuses on downstream research (i.e., research related to product development through manufacturing and marketing), and research and technology transfer. It is the largest public-private forest products research institute in the world (Natural Resources Canada, 2014a). It has about 525 employees, with its main research and development (R&D) laboratories located in Montreal, Quebec City, and Vancouver. FPInnovations has over 400 members across Canada, and has partnerships with government, industry, and academia (FPInnovations, 2013). FPInnovations' vision is "A world where products from sustainable forests contribute to every aspect of daily life" (FPInnovations, 2016). FPInnovations' mission is:

> Powered by creative people and world-class research, FPInnovations fuels the growth and prosperity of the forest sector by:
> - Nurturing our people and scientific excellence within a diverse workplace;
> - Developing solutions to enhance competitiveness and sustainability;
> - Creating and seizing opportunities beyond traditional markets; and
> - Accelerating innovation and enabling partnerships among industry, governments and academia. (FPInnovations, 2016)
>
> FPInnovations also upholds the following core values:
>
> - People: We believe people are our most important asset.

- Safety: We ensure safe work environment and practices that protect the health and well-being of the individual.
- Integrity: We are honest, trustworthy and respectful in all that we do.
- Innovation: We foster innovation and strive for excellence in all that we undertake.
- Sustainability: We care about the environment. We work to achieve sustainable solutions.
- Collaboration: We value teamwork and collaboration in all aspects of our business. (FPInnovations, 2016)

FPInnovations has four flagship programs: "Value Chain Optimization, Building and Living Solutions, Next Generation Pulps and Papers, and Bioenergy, Chemicals and Advanced Bioproducts" (FPInnovations, 2016). It works with an annual operating budget worth approximately $90 million, and develops innovative approaches to capitalize on "forest fibre, forest operations, wood products, pulp and paper, bio-products, bio-materials, bio-chemicals, and bio-energy" (FPInnovations, 2016). Its main federal government partner is the CWFC, and together, both organizations have united the upstream and downstream research components to optimize the full value chain for the forest sector. The Executive Director of the CWFC provides strategic direction to the Centre and also sits on the leadership teams for both the CFS and FPInnovations (including the Resource Assessment Program). Transparency, trust, open communication, and commitment are guiding principles that enable effective governance between the two organizations.

Natural Resources Canada (2014b) envisions that the partnership between the CWFC and FPInnovations will foster greater economic gain of Canada's forest resources through a more

coordinated and transformation-oriented approach to leveraging research and innovation across the full forest value chain. The full forest value chain "is a concept that links forest-level management to product innovation and markets in order to maximize the value of the available fibre" (Canadian Wood Fibre Centre, 2013, p. 1). For example, a recent review of four of its projects highlighted the tangible and anticipated benefits stemming from the outcomes of these projects: enhanced forest inventory systems, multi-varietal forestry and somatic embryogenesis, hardwood optimization, and purpose grown fibre (Canadian Wood Fibre Centre, 2012). These four projects should generate $29.3 Million within the 2008-2022 time frame (Canadian Wood Fibre Centre, 2012).

3.3.3 Transformation of the Federal Government

Blueprint 2020 is a federal government, transformational initiative aimed at modernizing the federal Public Service (Government of Canada, 2013). The principal goal of this federal government initiative is to transform the Public Service into a world-class government institution. It has three anticipated outcomes, including the following: (1) become a lean and agile Public Service that possesses the right set of skills and tools to better serve Canada and Canadians; (2) promote a Public Service that is open and collaborative in its problem-solving and decision-making capabilities; and (3) foster a culture that endorses innovation, transformation, and continuous renewal. Public Service transformation requires a common vision and roadmap for enabling a culture of change. Transformational change within the federal government has led to changes in organizational business strategies and policy development, the restructuring of programs and capabilities, the reorganization of employees, and changes in business processes,

structures, and governance (Robinson & Griffiths, 2005). For example, recent organizational changes in the federal government have introduced new administrative policies, directives, procedures, and guidelines (e.g., travel directives, procurement systems, and information management systems and technologies, including government-wide shared information services) to enable greater efficiencies in productivity and programming. Also, the implications of joint infrastructures in housing departmental information (e.g., big data) are re-examining how government workers integrate and share information within an open science environment (e.g., *Blueprint 2020*, *Destination 2020*, and GCDOCS).

Finally, organizational downsizing and changes in personnel and job roles are also part of the transformation. The Deficit Reduction Action Plan (DRAP) is a driver to transforming the Public Sector. The federal government first announced the DRAP in the federal 2012 Budget with the aim to bring down the deficit and create a leaner Public Service. A leaner Public Service would achieve greater cost-savings and efficiencies in delivering services to Canadians. The DRAP contributed to Public Service reductions, with an estimated 19,200 job cuts in the 2012 federal budget (*The Globe and Mail*, March 29, 2012). All of these factors may have had a direct or indirect impact on researchers' attitudes and behaviours as they engaged in intra-organizational and inter-organizational collaboration.

3.3.4   Organizational Changes Experienced by CWFC

The main organizational changes experienced by the CWFC stem from the development of the Centre in 2006. Based on its new vision, mission, objectives, and values, CWFC managers

tried to create an organizational culture founded on four main principles: partnerships, national scope and regional delivery, collaboration, and impact. The partnership with FPInnovations paved the way for collaboration opportunities that would advance innovation in the forestry sector. This new partnership (i.e., the uniting of upstream and downstream research) would promote greater collaboration between the organizations in order to advance innovation in the forest sector. Employees at both organizations had to learn about each other's organizational cultures, business practices and cycles, publication standards, administrative procedures, and end-users/clients. Since 2006, managers from both organizations have been trying to promote a collective leadership approach to forestry innovation through upstream and downstream research.

The DRAP was introduced in the 2011-2012 timeframe and was regarded as one of the key drivers for transforming the Public Service (Privy Council Office, 2012). The intent was to reduce direct spending by 5 to 10% and position for Public Sector renewal (Privy Council Office, 2012). This would involve the need to downsize the Public Service and to focus on Public Service renewal and transformation (Privy Council Office, 2012). As other federal departments and agencies, NRCan lived through the DRAP period to ensure greater cost-savings and efficiencies in the Public Service.

Other organizational changes were also occurring in the federal government. For example, travel restrictions have made it more difficult (e.g., reduced travel expenditures, approvals, and advanced planning) for researchers to travel and meet their peers at conferences, symposia, and other forums. NRCan's Report on *Annual Expenditures for Travel, Hospitality*

and Conferences outlined that "compared to fiscal year 2011-2012, 2012-2013 departmental expenditures by public servants decreased by $2.291 million mainly due to NRCan reducing travel expenditures as a result of Budget 2012 Saving Measures and of reduced program funding" (Natural Resources Canada, 2016e). This reduction in travel expenditures was upheld to "prioritize and scrutinize travel requests to ensure value for money" which "resulted in reducing the number of participants and exploring alternative ways of meeting with stakeholders and colleagues such as the use of tele/video conferencing" (Natural Resources Canada, 2016e). In the earlier years of the CWFC, employee science forums were instrumental for bringing people together to get to know each other and to explore new projects based on national priorities for advancing forestry innovation. Since the new directive to limit travel expenditures, the employee science forums were stopped because of their annual cost to bring employees together.

During this time period, other governmental changes were also unfolding, including: a new procurement system, information systems and the introduction of a new document and records management system (i.e., GCDOCS), and a human resources system, all that required individual employees to take on administrative tasks themselves. These changes were introduced to enable greater efficiencies and cost-saving measures for NRCan and the federal government as a whole. Mandatory training of these systems along with other training initiatives (e.g., training on values and ethics) all came down in a short time period which impacted the time needed to conduct research.

3.4   Sampling Strategy

A purposive criterion sampling technique guided my sample selection. In the first stage, I targeted a sample of eight collaborative research projects (known as component activities) that had both internal and external team members. This was an interesting strategy to employ because it made sense to examine team members who worked on collaborative research projects. Based on a list of projects provided by the Regional Coordinators within the CWFC, I chose two collaborative projects from each region until eight projects were secured. These projects had both internal and external team membership. This selection process provided me with access to participants who were engaged in collaborative projects, both intra-organizationally and inter-organizationally (main criterion). The second stage involved the selection of participants from each of the targeted collaborative projects. Upon the selection of eight projects, I sent out invitational letters (Appendix B) to all of the CWFC researchers on the project teams asking them to participate in this study.

I also asked CWFC managers to partake in the interview process. I sent invitational letters to managers to obtain their views about collaboration in scientific research within the Centre, across CFS, with FPInnovations, and with other external organizations. I interviewed managers from FPInnovations to obtain their views on collaboration within FPInnovations, and with the CWFC, CFS, and external organizations. Demographic data on the participants included gender, age, education, first official language, years of Public Service working experience (for CWFC only), field of research, number of years in field of research, current job function, and number of years in current job function.

3.5   Data Collection Methods

The primary data collection methods I employed in this study included individual ethnographic interviews, a focus group, and a couple of sessions observing senior management meetings. I used memos, notes, published documents, and reports to capture any information that contributed to the cultures of the organizations.

3.5.1   Ethnographic Interviews

In all, I conducted 25 ethnographic interviews for this study, including thirteen interviews with CWFC researchers, eight interviews with CWFC managers, three interviews with managers at FPInnovations, and one interview with a CFS senior manager. My initial goal was to recruit three researchers from a total of eight projects to take part in the study. In the end, only thirteen researchers were available for the individual ethnographic interviews.

Initially, I found that a semi-structured approach to interviewing enabled a more flexible flow of questioning. Appendix C presents the main open-ended questions that were used to guide my interview process with the researchers, along with several probing questions. I used the ethnographic interview questions to examine several areas: researchers' perceptions of collaboration; their experiences of working on collaborative projects within the CWFC, and collaboration experiences with other government departments/ agencies/organizations, industry and academia; the impacts of the transformational change period on collaboration; the role of senior management in enabling collaboration; and the participants' recommendations to improve collaboration. These questions provided me with rich descriptive answers on the topics under discussion, and allowed me greater exploration of the factors affecting collaboration. My

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interview questions were developed and refined based on input received from my first fieldwork

observations with CWFC managers, further discussions with CWFC managers, input from two

members of my supervisory team, and additional input based on previous studies on

collaboration in scientific research. The interviews I held with the first manager and researcher

helped me to determine if the questions needed further refinement. I only slightly revised the

interview questions because they drew out rich and useful responses.

I scheduled interviews in a private location to maintain participants' anonymity and

confidentiality. To minimize travel costs, I employed telephone interviews and video

teleconference (e.g., Tandberg) for those participants who resided outside of the National Capital

Region (Ottawa/Gatineau). Appendix D outlines a telephone or video teleconference

contact/informed consent form employed for those individuals who were contacted by telephone

for the ethnographic interviews. I also interviewed CWFC managers for the study, and the

meetings took place either in person, by telephone, or by Tandberg. Eight managers agreed to

take part in the study. Managers provided their perceptions of creating a culture of collaboration

through management and leadership practices. Appendix E outlines the CWFC managers'

interview guide. Three managers from FPInnovations also took part in this study, and my

interviews with them took place either in person or by telephone. The industry managers gave

their perceptions of creating a culture of collaboration with the CWFC/CFS. Appendix F outlines

the interview guide for FPInnovations' managers. Before commencing the interviews, each

participant listened to an overview of the scope of the project. Each interview was audio-

recorded with the permission of the participant, and lasted approximately 60 to 90 minutes.

3.5.2   Focus Group

Nine CWFC managers took part in one focus group. The focus group helped me to establish some of the main elements impacting collaboration, and also gauged perceptions on the future of science and technology in the federal government. The advantages of employing a focus group provided me with several opportunities to explore attitudes and feelings toward particular issues in a group setting at one point in time; to share insights within a group setting and foster group dynamics; and to enable the meaningful language, definitions, and concepts to emerge throughout the group discussions.

A trained facilitator led the focus group session with CWFC managers in an NRCan boardroom in Ottawa. This distancing of myself as a researcher gave me a chance to observe and listen to the discussions throughout the focus group session, and to pay greater attention to the group dynamics, verbal and nonverbal cues, and any other aspects that could have influenced the results of the focus group. With permission from the participants, a digital recorder was used to tape the focus group session.

Appendix G outlines the questions that were employed in the focus group with the CWFC managers. Within a two-hour period, participants were asked about their perceptions of collaboration within the CWFC, with the CFS, with FPInnovations, and with external partners. The questions were aimed to elicit the following information: the enablers and barriers to collaboration; motivations to collaborate; experiences of successful and unsuccessful collaborations; critical success factors to enable effective collaboration; impact of

transformational period on collaboration; and recommendations to facilitate future

collaborations.

3.5.3   Fieldwork Observations

I attended two strategic planning events that were led by the former senior Executive

Director of the CWFC: a strategic retreat with CWFC managers; and a CFS strategic workshop

with senior managers across the entire CFS. These two events were not part of the initial

research proposal; however, these events provided me with an excellent opportunity to listen to

the critical issues impacting the CWFC, the CFS, and the greater forest sector. These two

strategic events also enabled me to observe the group dynamics between the CWFC managers,

and the inter-relationships between the senior leaders of CFS, and provided additional insights

into the culture of collaboration.

For the CWFC strategic retreat, I attended a two-day strategic retreat workshop to gain

better awareness of the issues impacting CWFC managers. This workshop was held at a hotel in

Renfrew, Ontario, from 23-24 April, 2014. The managers were concerned with the current state

of the Centre and the need to strategize on building the CWFC of the future. Among the

important topics discussed, CWFC managers felt that maintaining an organizational culture of

collaboration represented the most salient factor, along with developing sustainable relationships

to help advance the forest sector.

For the CFS strategic managers' workshop, I listened to the issues impacting the CFS and

the discussions on implementing an integrated systems approach to better address national

priorities impacting the forest sector. I was invited to attend the *CFS Extended Management Team* meeting which was held on 10 March, 2015 in Ottawa, Ontario. Its objective was to elicit feedback from managers on how to position the CFS for the immediate future. Managers were primarily concerned with CFS' change management agenda, which included discussions about enabling greater impact, better operating efficiencies, more effective leadership, and a collective culture that would enable better science and policy integration.

Part of the fieldwork observations also included visiting a couple of sites to conduct interviews with managers across different regional locations. This gave me a better appreciation of the CWFC environment and its organizational culture.

3.6   Quality, Rigor, and Trustworthiness of the Data

Triangulation is a methodology that ensures greater quality, consistency, credibility, and trustworthiness of the data (Creswell, 2007; Hammersley & Atkinson, 1995). In this study, triangulation of the data consisted of multiple data sources that provided greater meaning and interpretation of the findings. These data sources included ethnographic interviews with 13 CWFC researchers, eight CWFC managers, interviews with three industry managers, a focus group with nine CWFC managers, a personal interview with one senior manager at CFS, fieldwork observations, site visits, and the review of CWFC, CFS, and FPInnovations documents, including organizational/departmental strategies, publications, and research papers. Data records included notes, memos, and about 700 pages of interview transcripts.

Member-checking with a couple of managers also helped me to gauge the accuracy of the data and interpretations. Member-checking is a technique used to determine if the main themes in the study are authentic and reflective of the participants taking part in the study (Creswell, 2007). I held discussions with a few participants to establish greater assurance of the accuracy of the findings and the interpretations during the data analysis and discussion phases.

3.7 Qualitative Data Management and Analysis

The management of qualitative data takes into consideration how the data is processed after the data collection phase. It incorporates the transformation of interviews and field notes into a comprehensive system of categories and codes (Nachmias & Nachmias, 1987). This process helps to determine the different taxonomies that best represent the phenomena under study. I used thematic content analysis to outline the main themes representing the participants in the study. The following sections delineate the steps that were taken in analyzing the qualitative data for the ethnographic interviews and focus group.

3.7.1 STEP 1: Data Management—Becoming Familiar with the Data

Data management involved transcribing the interviews and focus group, and organizing the data to enable a standardized approach for analyzing the data (Bloomberg & Volpe, 2012; Denzin & Lincoln, 2005). I transcribed verbatim each interview and the focus group into Microsoft Word. This involved listening to the interviews and focus group recordings at slow speed to enable fast typing of the transcripts, and then listening to the interviews and focus group

recordings at a regular speed to clean up anything that may have been missed in the first step. This method allowed me to become more familiar with what was said in each of the recordings.

I examined the interviews and focus group for the responses to the questions. I reread the text several times to ensure that I captured the intended meaning (Strauss & Corbin, 1998). I used the Track Changes under the Review feature in Microsoft Word to highlight the initial codes for each transcript. I wrote memos to better understand the context. This process also helped me to situate the interrelationships of the codes, categories, themes, and patterns as they emerged throughout the data collection, interpretation, and analytical processes. I generated about 700 pages of transcripts that needed to be coded and categorized accordingly.

3.7.2   STEP 2: Coding and Categorizing the Data

I devised a codebook and coding rules to help organize the data within a standardized and structured process (Patton, 2002). This codebook outlined the codes and the meaning of the codes that best represented the data. This enabled me to capture the salient coded categories on the right hand side of the text. To avoid researcher bias, I used an inductive approach to develop the categories for each question. At this stage, I developed emergent categories that best represented the interview and focus group data, and refrained from fitting the data into the initial seven factors on effective collaboration outlined earlier. This inductive approach helped me to define the themes and sub-themes that emerged from the transcripts. I created an Excel spreadsheet for each question which contained the coded descriptors (categories) based on the responses in the recordings. I tabulated frequencies to help draw out the emerging themes and patterns stemming from the data. These frequencies yielded thematic categories and were based

on how participants responded to each question. Namey, Guest, Thairu, and Johnson (2008) recommend that counting the frequencies of emerging thematic categories by each participant is a better indicator of prevalent themes than merely counting the number of times specific words or themes come up in a text.

The Excel spreadsheets provided me with a visual overview of the main coded responses (i.e., categories) for each question for both the interviews and focus group questions. For the ethnographic interviews, I created tables for each question that helped me to look at the similarities and differences between the managers and researchers for the same interview questions. I tagged key categories that dealt with the factors that may influence behaviours and attitudes in collaborative research projects accordingly.

Once I completed coding the interviews and the focus group, I synthesized the coded categories in Microsoft Word. This synthesis helped me to better explain the responses to each question for both the ethnographic interviews and focus group. I developed main categories to explain the codes that fell under a grouped set of codes with similar meanings. I also developed sub-categories to refine the initial categories. I used salient quotations to represent the participants' voices which helped to support the interpretation of the findings.

Intra-rater reliability allowed me to finalize the codes and ensured that my assessments and judgments were consistent over time in interpreting the transcript data (Bloomberg & Volpe, 2012). I went back to the existing data several times over a period of five months to ensure that I applied consistent codes to particular data and defined each code accordingly in the codebook.

However, I modified the categories as I started to develop greater insights into how the participants viewed the whole area of collaboration research.

3.7.3   STEP 3: Analyzing the Data

I employed thematic content analysis to synthesize the rich descriptions into the main themes of the study. I developed the individual themes by employing an iterative process of reading and rereading the transcripts. I populated the thematic categories in the tables for each interview question which represented the themes to the responses outlined in the Excel spreadsheets. I examined the common views in the tables if one-third or more of the participants held similar perceptions. This process enabled me to compare the thematic categories between the researchers and managers, drawing on categories that were either important for the researchers, important for the managers, or important for both. The less common views were also included in the main text of the dissertation.

For the individual ethnographic interviews, I coded each question, and summarized, analyzed, and compared each question for both the researchers and managers. This process allowed me to identify the major themes that emerged for each question, and to further examine the similarities and differences for the researchers and managers in response to the interview questions. The focus group data was also analyzed using specific thematic categories. Using the data from both the ethnographic interviews and focus group, a careful examination of the list of categories yielded a list of the main themes that best answered the research questions. In analyzing the content, I examined the stories that represented researchers' and managers' perceptions of how researchers work on collaborative project teams. Researchers' and managers'

perceptions of organizational culture generated both intrinsic and extrinsic characteristics (e.g., vision, norms, goals and values; structures and processes; language and communication; interpersonal relationships; and thoughts, feelings, and stories), and internal team processes that contributed to the successful outputs and outcomes of the collaboration.

3.7.4   STEP 4: Interpreting the Findings
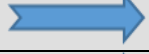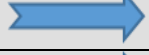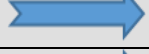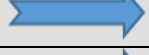
I present the major study findings linked to the literature on collaboration in scientific research, particularly the characteristics that influence effective collaboration for researchers. I also discuss emergent analytic categories and help situate the context of the case study more holistically. The interrelationships between the themes are examined and linked to social interdependence, social systems, and organizational change theories. My interpretations of the findings helped me to outline new insights into collaboration in scientific research, including a new model on effective collaboration. A discussion about these new insights outlines the future implications of effective collaboration during periods of organizational change. Finally, I put forward recommendations to help the CWFC/CFS and FPInnovations develop better intra-organizational and inter-organizational collaborations.

3.8   Inputs

Table 2 outlines the research timeline. The timeline denotes the major milestones for completing the research tasks. The initial research proposal was approved in November 2013; however, the case study was only formally secured in March 2014.

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Table 2 Research Schedule

TASKS	START DATE		END DATE
Proposal Approval (RRU)	Nov-13		Nov-13
Proposal Approval (CWFC)	Mar-14		Mar-14
Recruitment (Researchers & Managers)	Apr-14		Apr-15
Conduct Interviews (Managers)	Jun-14		Jun-15
Conduct Focus Group (Managers)	Sep-14		Sep-14
Conduct Interviews (Industry Managers)	Sep-14		Oct-14
Conduct Interviews (Researchers)	Dec-14		May-15
Transcribe Interviews	Jul-14		Jul-15
Data Analysis	Sep-14		Dec-15
Draft Dissertation Report	Nov-13		Jan-17
Final Dissertation Report	Jan-17		May-17

3.9   Ethics

The theoretical and applied dimensions of ethics in research mandate social scientists to

respect and protect the well-being and rights of all research participants. To ensure proper ethical

standards and principles, I assured each participant that all measures had been considered to

ensure researcher integrity and trustworthiness. Informed consent, confidentiality, and anonymity

were guaranteed for all participants under study, including that no harm or any form of

exploitation would come to any of the participants. I informed participants of the nature of the

project, and the purpose of the ethnographic interviews and focus group as data collection

methods. As outlined in Appendix H, an Informed Consent form was distributed to all of the study participants. I read the background information of the study to each participant, and gave a thorough review of their involvement in the study. Each participant voluntarily consented to taking part in the study prior to being interviewed or recorded for both the ethnographic interviews and focus group.

Moreover, I submitted the Royal Roads University Request for Ethical Review application form to the Royal Roads University Research Ethics Board for approval. The Research Ethics Board at Royal Roads University approved the application for ethical review on 7 November, 2013. NRCan/CWFC gave formal approval in March, 2014 to conduct this study.

3.10   Summary

The approach and methodology employed in this study followed a qualitative research design to examine researchers' and managers' perceptions of intra-organizational and inter-organizational collaboration. The intent of this case study was to determine the factors that influence effective collaboration, and the implications of organizational change on the processes, products, and outcomes that result from successful collaborations. I used an ethnographical focus to examine the inputs, internal team processes, outputs, and outcomes that contribute to successful collaborations. An ethnographic approach provided deep rich descriptions of researchers' collaborative experiences and managers' perceptions of collaboration, and the impacts of organizational change on collaboration.

In this study, the context of transformational change refers to the transformation of the forest sector and the transformation of the federal government. Twenty-six participants took part

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in this qualitative study, including 13 researchers and 13 managers. The sample of thirteen

CWFC researchers was based on collaborative research projects that had both internal and

external team members. Managers from the CWFC/CFS and FPInnovations were also

interviewed to gauge their perceptions on collaboration. Fieldwork observations and

organizational documents provided additional insights into the cultures of the CWFC, CFS, and

FPInnovations. I used thematic content analysis to establish the main themes that represented

collaboration and effective collaboration practices. Ethical standards and principles were applied

to ensure that all measures for the conduct of the study incorporated principles related to

researcher integrity and trustworthiness. The findings are presented in the following chapter and

provide rich descriptions of collaboration that help to answer the research questions.

CHAPTER FOUR: FINDINGS

4.1   Introduction

The purpose of this study was to examine the factors that influence researchers' attitudes and behaviours to collaborate in scientific research projects during a period of transformational change in the Canadian federal government. These factors are based on the thematic categories stemming from the CWFC researchers' and managers' perceptions on collaboration in scientific research, and the perceptions of their main industry partner, FPInnovations. Below, I provide a description of the sample I used based on the different data methods employed in the study, along with a description of the general characteristics of the collaborative research projects under study.

4.2   Description of the Sample

In total, 26 participants took part in this qualitative study: 13 researchers and 13 managers. The 13 researchers worked on projects under the CWFC. Nine managers came from the CWFC, three managers came from FPInnovations (main industry partner), and one manager came from CFS. Although the sample size is small, the intent was to obtain rich descriptions of the case under study to enrich our understanding of scientific research collaborations. As Patton (2002) states: "The validity, meaningfulness, and insights generated from qualitative inquiry have more to do with the information-richness of the cases selected and the observational/analytical capabilities of the researcher than with sample size" (p.245).

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Participants were interviewed from June 2014 to June 2015. The interviews were conducted at the CWFC facility in Ottawa, either in person, by telephone, or by Tandberg (video teleconferencing system). The focus group was conducted in one of the central NRCan buildings located in Ottawa.

For the ethnographic individual interviews, 13 researchers and eight managers who work with the CWFC took part in the study. The average age for the researchers was about 45 years. There were 11 male and two female researchers who took part in the study. The average years of education was equivalent to a Master's degree, and ranged from obtaining a technical or Bachelors degree up to a PhD. The researchers included technicians, specialists, and scientists who had worked an average of 17 years in the Public Service. The researcher participants had worked an average of 19 years in their particular research fields, with an average of 11 years in their current jobs. English was their predominant language. Although the majority of researchers had been involved in collaborative research projects within the CWFC/CFS, there were several researchers who had experience with leading projects. Moreover, the majority of participants also had experience working with researchers at FPInnovations.

Under the CWFC, there were eight male managers who took part in the ethnographic interviews. The average age for the managers was approximately 45 years. The average years of education was equivalent to a Master's degree. These managers had worked an average of 18 years in the Public Service. They had worked about 21 years in their particular fields, with an average of five years in their current jobs. English was the predominant official language. The same managers, including an additional female participant, took part in a focus group. This focus

group session was held on 17 September, 2014 and was combined with a three-day strategic management workshop. A trained facilitator conducted the focus group for two hours and concentrated on eight main questions on perceptions of collaboration.

In addition, three male managers from FPInnovations took part in the study. The average age for the FPInnovations managers was about 60 years. The average years of education was equivalent to a Master's degree. These participants included managers who worked an average of 20 years in their research fields, with about 3.5 years in their current jobs. French was their predominant language. They were given a different set of questions to gauge their perspectives on the future outlook and relationship between the CWFC/CFS, within FPInnovations, and with academia and external partners. The findings for these participants are presented after the initial comparison of the results between the CWFC researchers and managers and the focus group with CWFC managers. One additional male manager from NRCan was interviewed to obtain a background perspective on the CWFC and CFS, and to provide information on the current state and future context of the CWFC.

4.3   Characteristics of Collaborative Research Projects

Within the CWFC, the collaborative research projects are aligned under the CFS Project Portfolio 2014-15. The governance of the Portfolio dictates what projects will be allocated resources within the CWFC. Each project undertaken by the CWFC researchers is aligned to the higher departmental strategic objectives outlined under the CFS. All of the CWFC project team members are housed in CFS research centres across Canada.

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  The collaborative research projects in this study fall under the three principal areas of research (i.e., Resource Characterization, Resource Production, and Resource Optimization). The collaborative research projects are generally described as having small- to medium-sized project teams, with about three to five team members per project (e.g., scientists, specialists, and technicians). The duration of the research projects averages three years. The research projects are interdisciplinary and multidisciplinary in nature, and require leveraging the skills of researchers who work in government, industry and academia. The budget allocation for the research projects ranges from $20,000 to $200,000, depending on the scope of the project. The majority of projects are decentralized because researchers from the CWFC need to work with CFS, regional, provincial, territorial, and federal government organizations, industry partners (particularly, FPInnovations), and academia. These collaborative projects address research of national importance and require innovative solutions. Partnerships with researchers from territorial, provincial, and federal governments, industry, and academia maximize the outputs and impacts aimed at innovating the forest sector. The typical outputs of CWFC research projects may include "inventory systems and tools, correlations techniques and methods, fibre production techniques and methods, and valuation techniques and methods" (Canadian Wood Fibre Centre, 2012, p. 15).

  The majority of researchers were familiar with each other's projects. Many researchers had known each other because many have worked in the greater CFS prior to the establishment of the CWFC. The researchers generally described their project teams as being team- and goal-

oriented. They also highlighted the importance of sharing information between team members. Many of these attributes are discussed under the main themes below.

4.4 FINDINGS

The findings section is divided into a comparison of CWFC researchers' and managers' perceptions of collaboration in scientific research based on ethnographic interview findings, CWFC managers' perceptions of collaboration based on focus group findings, and industry managers' perceptions of collaboration based on individual interview findings.

The main findings for the CWFC researchers and managers are presented in a series of tables. Each table contains the main thematic categories for both researchers and managers for each question. The total number of respondents and percentages were used to provide a clear representation of the participants' responses to the questions. The thematic categories that were congruent for both researchers and managers are highlighted in a lighter shade of grey to demonstrate commonalities in responses between the researchers and managers. I have used quotations to represent the participants' main responses to each of the interview questions. These quotations indicated the participants' voices based on their experiences of collaboration in scientific research.

4.5 PART 1: Comparison of CWFC Researchers' and Managers' Perceptions of Collaboration in Scientific Research—Ethnographic Interview Findings

A comparison of the thematic categories for both researchers' and managers' perceptions of collaboration in scientific research is outlined below. The comparison is based on the

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ethnographic interview questions that I had asked of the 13 researchers and eight managers working under the CWFC. These comparisons helped me to identify the salient factors that were common to both researchers and managers, and to look for any elements that were dissimilar between the two groups. The researchers were also asked additional questions regarding their collaborative projects. The main thematic categories that emerged from these collaborative research project-related questions are summarized in this portion of the analysis.

4.5.1   Perceptions of the Word "Collaboration" in a Research Context

Participants were asked: *What does the word collaboration mean to you in a research context?* Table 3 outlines the main thematic categories that best describe their responses. Researchers and managers described the word collaboration under five general themes. These themes include the following: 1) working together as a collective; 2) sharing a common vision, mission, goals, and objectives; 3) sharing communications and interactions; 4) leveraging complementary knowledge, skills, and abilities; and 5) funding research. The interesting finding is that both researchers and managers generally perceived collaboration as having similar characteristics.

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Table 3 Perceptions of the Word "Collaboration" in a Research Context

THEMATIC CATEGORIES						
RESEARCHERS	**(N=13)**		**MANAGERS**	**(N=8)**		
	N	**%**		**N**	**%**	
WORK TOGETHER AS A COLLECTIVE *(Integration, Synergy, and Collective)*	10	77	WORK TOGETHER AS A COLLECTIVE *(Integration, Synergy, and Collective)*	6	75	
SHARED VISION, MISSION, GOALS & OBJECTIVES *(Shared Vision)*	9	69	SHARED VISION, MISSION, GOALS & OBJECTIVES *(Shared Vision)*	6	75	
SHARED COMMUNICATIONS	7	54	KNOWLEDGE, SKILLS & ABILITIES	5	63	
KNOWLEDGE, SKILLS & ABILITIES	6	46	RESOURCES *(Funding)*	5	63	
RESOURCES *(Funding)*	3	23	SHARED COMMUNICATIONS	4	50	

Working Together as a Collective: Three-quarters of the researchers and managers stated that "working together as a collective" is a major characteristic associated with collaboration. Integration and synergy within a collective team environment is based on the understanding that the whole of a team is greater than the sum of the individual contributions made by researchers in a collaborative project. In other words, the whole is greater than the sum of its parts. Team members support one another to complete the tasks at hand, and appreciate how they each contribute to the successful completion of a shared goal. One researcher stated the following: "Working together as a team…I see people working, helping each other, supporting each other, not being critical of each other to get the work done."

One manager stated that working together requires the need to maximize the outputs and outcomes of a collaboration:

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In reality, we're working in silos. We're just adding the activities from a, b, and c

individuals and putting rapidly together and end up with something that is equal to the

sum of the parts. A collaboration, my ideal of collaboration, is try to maximize

interactions and maximize something that 1 + 1 gives more than 2.

Another manager described collaboration as a "coalition of the willing", in which each

team member is driven by achieving successful outcomes toward the common goal or objective:

"In order to have effective collaboration,…everyone has to see the value of that joint work;…and

get a benefit that arises from that as well."

Similarly, one researcher stated that collaboration requires strong support from each team

member to fulfill the project objectives. However, each team member needs to see or derive

some benefit from engaging in the collaboration:

I think of a group of people that are fully engaged in a project and they're each

contributing. I guess most importantly, the research or collaboration is a win-win for all

of the participants. You want to achieve something that is of mutual benefit to each of

the collaborators.

Sharing a Common Vision, Mission, Goals, and Objectives: A little over two-thirds of

the researchers and three-quarters of the managers stated that collaboration requires team

members to establish a shared vision with common goals and objectives. A shared vision

contributes to the team members' unified understanding of the intended outputs, outcomes, and

possible impacts of a collaboration. A shared vision also includes a sense of integration in which

researchers share ideas freely and concentrate on achieving the project objectives. This shared

vision is based on a shared sense of mission that requires researchers to work together to find solutions that contribute to the competitiveness of the forest sector. Both researchers and managers described this characteristic within the following contexts:

> Working together and I guess in unison to meet one identified target, or one identified goal. *(Researcher)*

> If it's truly collaborative, those goals would clearly strengthen the achievement towards the common goal. I guess an indicator would be if you were to ask any of the actors in a collaborative system, "What's the common goal you're working on?", you'd hear pretty much the same thing, maybe in their own words. But it would be no mistaking that these people were part of a collaborative and had a real working understanding of that common goal. *(Manager)*

In addition to the researchers' need to adopt and understand this shared vision, clients and stakeholders also need to agree on the common goal of the research project, the project's intended outputs, the anticipated outcomes, and the potential impacts on the forest sector.

Sharing Communications and Interactions: Half of the researchers and managers expressed that shared communications and interactions are important elements in collaborative research projects. Building ideas together can only happen through open communications. Shared interests lead to shared ideas; and by working within an open forum, researchers are able to build on each others' ideas for the collective good. One manager stated,

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Collaboration requires a dialogue amongst the actors or the players, the research actors; so that at a minimum, they've come to a full understanding of the goal that they have in common. There's some kind of exchange that has to go on so that there is a level of interdependency that requires an exchange of some critical element needed to perform the research.

The researchers and managers felt strongly about the need to have face-to-face communications. Face-to-face communications helps to establish a greater sense of rapport, and helps to build stronger trust within the team environment. Researchers also described the need to have a close relationship among team members, and greater interaction, openness, and sharing of data. For example, a few participants stated the following:

The other spectrum is working closely with other researchers, sharing data, struggling with methods of analysis and interpretation, having a fairly close research relationship. *(Researcher)*

They're each contributing, communicating, they're having regular meetings where everybody has an opportunity for input, and they're all kept to-date on where the project is going. Everybody understands where the project is going. There's honest communication. *(Researcher)*

Leveraging Researchers' Knowledge, Skills, and Abilities: Close to half of the researchers and two-thirds of the managers interviewed stated that it is important for the researchers to possess the right knowledge, skills, and abilities in order to accomplish successful projects. Both researchers and managers felt that the leveraging of knowledge, skills, and

abilities creates a trusting environment in which each team member contributes to the

overarching goals of the research project. For example, participants relayed the following

testimonials:

> It's working alongside with colleagues from the same research centre. But it's also on a
>
> wider scale. We have colleagues nationally from the different forestry centres across
>
> Canada of the CFS. But it's also with external colleagues, we're collaborators. This is the
>
> people from FPInnovations, from the provinces, from the universities; and we all need to
>
> work together especially in large projects like we work on because there's very specific
>
> expertise between the people. And we just are complementary to each other. So we need
>
> to collaborate for these purposes. *(Researcher)*

> With collaboration, there is also a very clear recognition of the strengths that each of the
>
> partners bring to a group, where they actually have a meaningful contribution to that said
>
> activity. *(Manager)*

Funding Research: Two-thirds of the managers and one-quarter of the researchers stated

that funding is a major characteristic associated with collaboration. The managers felt that

financial contributions need to be aligned with building research capacity so that the resources

are used in an optimal fashion to achieve project objectives.

4.5.2   Perceptions of Collaboration within the CWFC

Participants were asked: *How would you describe collaboration in scientific research*

within CWFC? Participants were also asked if there were any incentives (i.e., motivations) and

disincentives (i.e., lack of motivation) to collaborate within the CWFC, including any

impediments (i.e., challenges/barriers) that prevented researchers from collaborating with one

another. Table 4 reveals that perceptions of collaboration within the CWFC were similar for both

researchers and managers.

Collaboration was described as working together in a collective, working in a culture that

promotes collaboration, cultivating solid working relationships, owning common goals, and

communicating in a shared and open forum to advance ideas and solutions. One quarter of the

researchers also stated that having the right knowledge, skills, and abilities are essential elements

for enabling more effective collaboration. However, one-quarter of the researchers stated that

there is a lack of collaboration within the CWFC.

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Table 4 Perceptions of Collaboration within the CWFC

THEMATIC CATEGORIES					
RESEARCHERS	**(N=13)**		**MANAGERS**	**(N=8)**	
	N	**%**		**N**	**%**
DESCRIPTION OF COLLABORATION WITHIN CWFC					
WORK TOGETHER AS A COLLECTIVE	8	62	WORK TOGETHER AS A COLLECTIVE	8	100
COLLABORATIVE CULTURE	7	54	COLLABORATIVE CULTURE	6	75
RELATIONSHIPS & PERSONALITIES	5	38	RELATIONSHIPS & PERSONALITIES	5	63
SHARED VISION, MISSION, GOALS & OBJECTIVES (*Goals & Objectives*)	4	31	SHARED VISION, MISSION, GOALS & OBJECTIVES (*Goals & Objectives*)	4	50
SHARED COMMUNICATIONS	3	23	SHARED COMMUNICATIONS	4	50
KNOWLEDGE, SKILLS & ABILITIES	3	23			
COLLABORATION (*Lack of*)	3	23			
INCENTIVES TO COLLABORATE WITHIN CWFC					
KNOWLEDGE, SKILLS & ABILITIES	6	46	RESOURCES (*Funding*)	6	75
RELATIONSHIPS & PERSONALITIES (*Building Relationships*)	3	23	CULTURAL PERCEPTIONS (*Cultural Identity*)	4	50
RESOURCES (*Funding*)	3	23	RELATIONSHIPS & PERSONALITIES (*Building Relationships*)	4	50
DISINCENTIVES TO COLLABORATE WITHIN CWFC					
NO DISINCENTIVES	8	62	NO DISINCENTIVES	4	50
INABILITY TO COMMUNICATE FACE-TO-FACE	5	38			
IMPEDIMENTS TO COLLABORATE WITHIN CWFC					
PROXIMITY (DISTANCE & TRAVEL)	5	38	BUREAUCRACY (NEW ADMINISTRATIVE PROCEDURES)	6	75
RELATIONSHIPS & PERSONALITIES	4	31	RELATIONSHIPS & PERSONALITIES	4	50
SHARED COMMUNICATIONS	4	31			

Working Together as a Collective: All of the managers and nearly two-thirds of the

researchers described collaboration within the CWFC as researchers working collectively to

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achieve common goals related to a scientific project or national priority. The majority of participants felt that greater synergy is generated when team members focus on a shared vision, mission, or goal. The following quotes are representative of the general perceptions held by the CWFC researchers and managers:

> The collaboration that we have with other centres, with other researchers within FPInnovations, within different universities as well, within different centres of CFS, as well as with researchers within the CWFC, everybody has their expertise and we work together as a group to create one predetermined goal. *(Researcher)*

> Collaboration in the Fibre Centre started collectively. We identified problems, research questions, challenges, through our clients, based on the client input. And as a scientific community, as a Fibre Centre community, beyond the scientist, all of the staff, we tried to get input and develop what that would mean in the Fibre Centre context…what would success look like in those areas, with input right across the organization. *(Manager)*

Working in a Culture that Promotes Collaboration: Three-quarters of the managers and approximately half of the researchers stated that collaboration within the CWFC is mature, organized, and highly promoted within the Centre. Collaboration is based on a shared vision of fostering a culture that builds on researchers' collective strengths and leadership, and not on individual competitiveness. Senior management at the CWFC strongly encourage researchers to collaborate, both intra-organizationally and inter-organizationally. Research proposals are given higher ratings if they demonstrate collaboration with other researchers, partners, or

organizations. A culture of collaboration enables researchers to invest their time and effort in a research community that builds on each other's strengths. Participants stated the following:

> It [Collaboration] began in the beginning with a really strong vision of what the Fibre Centre would do. They spent a lot of time early in the process building a sense of community, and a whole sense of collaboration, rather than the more competitive environment that you often see in science. That was really strongly encouraged from the top and supported from the top. *(Researcher)*

> The work is organized. But if you speak to any of the actors anywhere in the system, they would understand how it's organized, and why it's organized, and how they fit. I stress that because if it were simply a management conceived organizational structure, I don't think you would really have collaboration going on. *(Manager)*

Conversely, about one-quarter of the researchers expressed the notion that there is a lack of collaboration within the CWFC. One researcher stated that the closeness between researchers has dissipated ever since the employees were not able to get together anymore at the annual employee science forums. Another researcher attributed this lack of collaboration to a lack of information regarding other research projects; while another researcher felt that personalities and egos interfered with collaboration, thereby creating a competitive environment amongst researchers.

Cultivating Solid Working Relationships: Nearly two-thirds of the managers and a little over one-third of the researchers stated that collaboration within the CWFC is based on solid working relationships, where researchers need to take the time to get to know each other

before engaging in actual research projects. Researchers also expressed the importance of having the freedom to choose which researchers they like to work with. Cultivating relationships is essential for enabling collaborations to be effective.

Moreover, the participants expressed the important role that the former employee science forums played in building effective working relationships. These science forums provided a venue for researchers to come together face-to-face and get to know each other, and to further develop strategic research projects. One manager illustrated the following point:

We have built the relationships, the personal relationships, at least minimally by either taking a…coffee, laughing and making jokes. And I see clearly … if we don't invest or try to put an urge on that...it won't work. …I would say...[the] foundation is a good personal relationship. Doesn't mean that you're going to be friends, but you need to get in touch and take time to do that before going on[to] business. Just don't start with business from scratch.

Moreover, personalities also impact collaboration, particularly when egos start to clash among researchers. One researcher stated that collaboration is sporadic and is based on individual personalities:

Egos and personalities seem to get in the way; and it's really based on the individuals you're dealing with. Some people have what I call their pet rocks, or their pet projects. If you stray into what they perceive as their project area, then, they may not necessarily want you to be playing in the same sandbox with them. There's a bit of competition.

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Whereas, it would be so much easier if you were able to put away the ego and work

together, and maybe carve off different pieces of the work.

One manager stated that collective leadership helps to enable more organic collaborations

within the CWFC.

Owning Common Goals and Objectives: One-half of the managers and nearly one-

third of the researchers stated that within the CWFC, researchers need to work with a common

set of goals and objectives that clearly outline what the project is intended to accomplish.

Managers emphasized that researchers need to appreciate the relevance of aligning their projects

with national priorities and objectives of the forest sector.

Communicating in a Shared and Open Forum: According to half of the managers and

about one-quarter of the researchers, communications is an important characteristic within the

CWFC, where the culture is based on openness and transparency. For the first three years, the

CWFC developed an employee science forum initiative to enable researchers to get together and

to discuss research goals, objectives, and opportunities to work within CFS and with external

partners (e.g., FPInnovations). The incentives for working together were contingent on creating a

climate of open communications between colleagues. Examples from the participants include:

We used to have these [employee science] forums that we would get together face-to-

face. There were lots of times where we could talk to folks in informal sessions…that

was very helpful...you get to know them, you got to understand the kind of work that

they were doing, the kind of person that they were, the kinds of things you might want to

follow up with them later. *(Researcher)*

> Often we need to talk to each other, to make sure that we agree on the project and to be able to agree on the outcomes, the deliverables…be sure we have a common understanding of the project. *(Researcher)*

> Having regular meetings together. People who are within each individual centre, within each region, that's easier, because we are always in the same building pretty much. But we can get together more easily and interact in person. However, we have ways to collaborate through technology: through Tandbergs, through other teleconference and video conference. So regular meetings, working on projects together, writing papers, developing presentations, pretty much sharing ideas. *(Manager)*

INCENTIVES TO COLLABORATE WITHIN THE CWFC

There were several main incentives to collaborate within the CWFC. Managers primarily saw funding as the best incentive to collaborate as well as possessing a sense of cultural identity and building relationships. Researchers stated that leveraging knowledge, skills, and abilities across the CWFC was the biggest incentive to collaborate.

Receiving Adequate Funding: Three-quarters of the managers stated that since the inception of the CWFC, the Centre has been well-positioned to receive adequate funding for carrying out scientific research. C-Base funding (e.g., funding that is allocated for specific initiatives/projects) is intended for collaborative engagements with industry, academia, and other government organizations. By having a more structured collaborative system, the CWFC is able to fund projects that are based on national priorities and external engagements. One manager stated that the CWFC funds collaborative projects based on the relevance of the research: "When

we look at the actual project to rate it, the number one, who's asking for it? Is this just a nice research project? Is it a perceived need or is it a real need that you can actually validate?"

A couple of researchers stated that funding represented an important incentive to collaborate. An example illustrates this point:

> We are financially well-off within the CFS. We have the best funding of our fellow researchers in our respective labs. We're envied from that perspective. We have a lot of resources many times more money than we as individuals could possibly spend. So you really need to collaborate with people in order to spend those resources. And then, if you are on the other end of the stick, where you don't have enough resources, it's important to collaborate with the people that do have the resources so you can get the work done at a very basic level.

Possessing a Sense of Cultural Identity: The managers also expressed that researchers have a cultural identity where they relate more with the CWFC as opposed to the greater CFS. Having the knowledge and understanding of how the CWFC is organized and structured, and how it partners with a main industry player (i.e., FPInnovations), helps to create a culture that needs to contribute to the competitiveness of the forest sector. This cultural identity has generated a sense of community and recognition in an organization that contributes to the innovation and advancement of the forest sector. As one manager stated,

> We have a particular identity that defines why we exist. We're all CFS employees; but yet, we very much identify ourselves as being with the CWFC. And I believe that there's a big incentive to collaborate…to be organized and to fit into a well-defined structure

that organizes our efforts because in-so-doing, we kind of strengthen our identity and reinforce our purpose.

Leveraging Knowledge, Skills, and Abilities: Nearly one-half of the researchers also noted that knowledge, skills, and abilities were important incentives when pooling together expertise and sharing the expertise with researchers across the CWFC.

Building Interpersonal Relationships: One-half of the managers and about one-quarter of the researchers stated that good interpersonal relationships among researchers creates an incentive to work together. Relationships are based on finding people with the right attitude, expertise, and willingness to work together. One manager stated, "Once you identify that need, once you identify ok yes, this is something that we do, if we have the expertise, then you develop those collaborations and pick the right people to do the project."

<div align="center">DISINCENTIVES TO COLLABORATE WITHIN THE CWFC</div>

Nearly two-thirds of the researchers and one-half of the managers stated that there were no real disincentives to collaborate within the CWFC. The majority of participants were very emphatic that the CWFC creates an environment where collaboration is highly promoted and communicated to researchers. However, a little over one-third of the researchers expressed that there are challenges to collaboration because researchers are not always able to meet face-to-face to discuss their projects. Also, one researcher stated that it may be perceived that researchers who collaborate take on a secondary role which may not give them the same recognition as a researcher who is a project manager or who has taken a leadership role. One manager also stated that the PhD culture does not value teamwork as much as individual recognition. Another

manager stated that it takes time and trust to build relationships in collaborations, and this necessary extra time can be a disincentive for some researchers. Another manager stated that when researchers work within a team environment, they tend to lose control over the direction of the research.

<div align="center">IMPEDIMENTS TO COLLABORATE WITHIN THE CWFC</div>

Impediments to collaboration within the CWFC were represented under three main themes: battling new bureaucratic administrative procedures; conflicting personalities, relationships, and expertise; and lack of face-to-face interactions.

Battling the New Bureaucracy: Three-quarters of the managers stated that bureaucracy has become a major impediment to conducting collaboration within the CWFC. Like other governmental departments and agencies within the past five years, the CWFC has had to undergo changes to its administrative processes and procedures for carrying out its travel, procurement, human resources management, etc. The current federal government has provided training to individuals to carry out their own administration associated with travel, for example. Changes in travel procedures and that these procedures need to be attended to by individual researchers has created a major impediment for researchers who need to concentrate on their science. Spending the majority of their time working on administrative procedures has taken researchers away from concentrating on their scientific roles and responsibilities.

Building Relationships and Dealing with Personalities: One-half of the managers and nearly one-third of the researchers felt that people's personalities have an impact on the building

of collaborative relationships within the Centre. Researchers and managers felt that the right

personalities enable researchers to mitigate conflicts and sustain good working relationships.

Congenial personalities are the cornerstone to any effective collaboration. Oftentimes,

researchers collaborate with people that they know and can trust to get the project completed. For

example, one manager stated that "some people like working with others; others have challenges.

It depends on the individual and their approach to work."

Another manager spoke about the impacts of organizational change on collaboration and

how researchers develop relationships during a time of financial scarcity:

> When you bring in the organizational change or the things that are happening in the
>
> government, I think this is a really good time to start to analyse: What is the change in
>
> behaviour from a shortage of resources, particularly when it comes to finances? How
>
> does our behaviour change in a time of scarcity of resources? Is there incentive for
>
> people to start pooling or is there incentive to start putting their elbows up? It will be
>
> interesting to observe the behaviour as budgets are challenged and how the money for
>
> research is very difficult to obtain. What are people's choices? Do they tend to go
>
> leverage off each other or…try to out compete others?

Proximity and its Impact on Face-to-Face Interactions: Just over one-third of the

researchers expressed that proximity and the inability to travel to see researchers face-to-face

posed additional impediments to collaboration. This factor was closely linked to building

relationships with researchers across the CWFC. Participants stated,

I think the biggest challenge is communication. I think the Fibre Centre benefited very

much early on in its establishment by having face-to-face sessions and getting together

and building relationships…and having workshops and talking about your science.

(Researcher)

There were several employee forums…That's the point in time which I best understood

the Fibre Centre as an entity and what it wanted to accomplish…I feel as time has gone

by, there has been a significant effort put on having national Tandbergs…Personally, I

find it really difficult to communicate with those types of technology. *(Researcher)*

Just government policy about federal Public Service travelling. The first question is: Why

can't you do this virtually? And I think once you build the project and you build

relationships, you can do things virtually because you understand the person you're

dealing with and you can pick up on physical cues because so much of our

communication is physical and not just verbal. But to be able to build those

relationships…you have to be physically in the same place. *(Researcher)*

4.5.3   Perceptions of Collaboration across the CFS

Participants were asked: *How would you describe collaboration in scientific research across the CFS?* Table 5 outlines participants' overarching responses to the question.

Perceptions of collaboration across the CFS included aligning common objectives, fostering a collaborative culture, cultivating a team environment, and tapping into expertise, skills, and partnerships.

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Table 5 Perceptions of Collaboration across CFS

THEMATIC CATEGORIES					
RESEARCHERS	**(N=13)**		**MANAGERS**	**(N=8)**	
	N	**%**		**N**	**%**
DESCRIPTION OF COLLABORATION ACROSS CFS					
COLLABORATIVE CULTURE *(Impact on Relationship)*	8	62	SHARED VISION, MISSION, GOALS & OBJECTIVES *(Objectives)*	6	75
WORK TOGETHER AS A COLLECTIVE *(Teamwork)*	7	54	COLLABORATIVE CULTURE *(Impact on Relationship)*	5	63
KNOWLEDGE, SKILLS & ABILITIES	6	46	KNOWLEDGE, SKILLS & ABILITIES	4	50
RESOURCES *(Funding)*	4	31	WORK TOGETHER AS A COLLECTIVE *(Teamwork)*	4	50
SHARED COMMUNICATIONS	3	23			
INCENTIVES TO COLLABORATE ACROSS CFS					
KNOWLEDGE, SKILLS & ABILITIES	8	62	KNOWLEDGE, SKILLS & ABILITIES	5	63
RELATIONSHIPS & PERSONALITIES	4	31	WORK TOGETHER AS A COLLECTIVE *(Teamwork, Integration & Trust)*	5	63
WORK TOGETHER AS A COLLECTIVE *(Teamwork, Integration & Trust)*	3	23			
SHARED VISION, MISSION, GOALS & OBJECTIVES *(Objectives & Interests)*	3	23			
DISINCENTIVES TO COLLABORATE ACROSS CFS					
SCARCE RESOURCES *(Funding)*	5	38	SCARCE RESOURCES *(Funding)*	**(N=6)**	
				5	83
NO DISINCENTIVES	5	38	BUREAUCRACY (NEW ADMIN)	2	33
IMPEDIMENTS TO COLLABORATE ACROSS CFS					
RELATIONSHIPS & PERSONALITIES *(Inability to Build Relationships)*	5	38	RELATIONSHIPS & PERSONALITIES *(Inability to Build Relationships)*	**(N=5)**	
				3	60
SHARED COMMUNICATIONS	4	31			
RESOURCES *(Funding & HR)*	3	23			
NO IMPEDIMENTS	3	23			

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Aligning Common Objectives between CWFC and CFS: Three-quarters of the managers described collaboration across the CFS as needing to align common objectives. According to the managers, there is a need to examine more collective ways of addressing national priorities and overarching goals of the forest sector.

Fostering a Collaborative Culture (Impact on Relationships): Nearly two-thirds of the researchers and managers spoke about the relevance of fostering a collaborative culture and how it impacts the relationships between the CWFC and CFS. The governance structure does promote collaboration between the CWFC and CFS, and researchers are strongly encouraged to collaborate across the different regions. A collaborative culture helps to promote a strong identity and service mentality that recognizes the need to serve the Canadian forest sector. One manager described it this way:

> The CFS, going back to the way that we've organized our work, based upon our
>
> governance structure, it does promote collaboration across all parts of the organization.
>
> So our policy works with our researchers. Researchers in one region work with many
>
> researchers in completely different regions of the country. I think there is a very special
>
> culture that we have here within the Canadian Forest Service. We've got a lot of proud
>
> people committed to forestry.

Some of the researchers stated that collaboration across the CFS has improved over time. The CWFC-CFS relationship is becoming stronger and more united in its approach to addressing research projects of national priority. The CWFC is looking at establishing more integrated research proposals with CFS. However, participants stated that there needs to be better

engagement, interaction, and communications with CFS to ensure that both organizations understand each other's goals and objectives. One researcher gave the following example:

> I remember when the Fibre Centre got started. There was lots of questions and the resistance side of CFS…We got lots of funding. We were this new thing. There was a bit of push-back probably to collaboration. They didn't want us to be separated and then tapping into their resources or their programs or their people. But as things changed over the years, and the Fibre Centre kept getting pretty good funding, I think attitudes maybe changed. And it was seen as collaborating [with] CFS, CFS collaborating with the Fibre Centre.

Since the inception of the CWFC, there has been a perception by some of the participants that the CWFC is distinct from the rest of CFS. The observation is that CFS has somewhat forgotten that the CWFC is a part of this greater Forest Service, and that collaboration used to occur between researchers. It was also noted that the relationship between the CWFC and FPInnovations has brought back the applied research side to CFS.

Cultivating a Team Environment: A little over half of the researchers and about half of the managers expressed that fostering a collaborative culture must take into account the importance of working together in a team environment. The CWFC and CFS have a governance structure that fosters greater collaboration between the researchers. The intent is to establish greater integration and collaboration for the competitiveness of the forest sector.

Leveraging Expertise and Skills through Partnerships: Close to half of the researchers and half of the managers stated that effective partnerships between the CWFC and

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CFS are essential for good collaboration. These partnerships are based on researchers who have not only complementary skills; but, they also have good reputations in carrying out their roles effectively.

From an organizational perspective, researchers and managers stated that the incentives to collaborate across CFS are mainly associated with leveraging researchers' expertise and skills, and creating a team-oriented and integrated environment.

Leveraging Researchers' Expertise and Skills across the CFS: Close to two-thirds of the researchers and managers reported that an incentive to collaborate across the CFS is the ability to leverage research capacity, and to attain greater access to data sets, information, and the generation of knowledge. The CWFC acts as the entry point, from government science to industry needs. The Centre has been regarded as the link between the CFS and FPInnovations (the service provider to the forest industry) in accessing knowledge and expertise.

Another manager stated that the collaborations are mainly built on existing relationships and groups of people that have worked together before the inception of the CWFC. These individuals are known for their expertise, skills, and knowledge which makes it difficult for other individuals to join their collaborative research projects. Researchers who have built trusting relationships with one another tend to continue to work together on future projects.

Creating a Team-oriented, Integrated, and Trusted Environment: Nearly two-thirds of the managers and one-quarter of the researchers felt that having a team-oriented and trusted

working environment represented an incentive to collaborate across the CFS. Many researchers have known each other from the greater CFS before the inception of the CWFC. Researchers have come to know each other and trust each other to work on common research problems.

Managers asserted that one incentive to collaborate with CFS has to do with working within an open culture of collaboration, where there's greater integration between the main organizations. For example, an integrated systems approach enables researchers to embrace a collective pride and ownership to achieving the common objectives that impact the competitiveness of the forest sector. This integrated systems approach contributes to the value chain optimization of forest sector innovation. For example, one manager summed it up this way:

The CFS recognizes that we are that extension of them and that they or we, collectively, are strongly advantaged by having the CWFC part of the CFS, because that portal idea is one which increasingly the CFS can exploit to the benefit of the whole forest sector. So, it's taken about seven years; but what apparently is happening now is the way FPInnovations presents its full value chain offering to the forest sector [which] includes a deepening capacity to deliver innovative solutions to the upstream.

Another manager stated that the CWFC and CFS need to work together for the collective survival of the forest service capability within NRCan:

I'm really concerned about the future of CFS with the current budgetary or the transformation of the government in terms of research, and the downsize [of] the government. Being relevant is crucial to survive. If CFS is not capable of showing relevancy to the forest industry, and in that, I include not only the private sector, but I

include strongly the provincial sector, I think there's a high risk of disappearing. That's

one incentive of working together. … And if we can tie ourselves with CFS, the survival

of Fibre Centre is attached to the survival with CFS. And that's an incentive to

collaboration.

<div align="center">DISINCENTIVES TO COLLABORATE ACROSS CFS</div>

One main theme represents a challenge to collaborate across the CFS, namely prioritizing

research based on a scarcity of resources. Interestingly, over one-third of researchers stated that

they did not feel that there were any disincentives to collaborate across CFS.

Prioritizing Research Based on Scarcity of Resources: The vast majority of managers

and just over one-third of researchers stated that there is a need to prioritize research projects

because CFS is given a limited budget to work with. One manager attributed the scarcity of

resources to the need to share funding among the researchers: "The biggest complaint anyone

trying to break in, getting involved in one of these groups that already has scarce resources, x

number of dollars, you have ten people: anyone else comes in, you slice the pie one more time."

<div align="center">IMPEDIMENTS TO COLLABORATE ACROSS CFS</div>

The participants stated that main impediment to collaboration across the CFS was the

inability to build relationships. To a lesser degree, researchers also felt that a lack of shared

communications was also an impediment to collaborating with CFS (e.g., lack of proper

communication tools). Also, about a quarter of the researchers stated that a lack of financial and

human resources has impeded CWFC researchers to collaborate with CFS researchers. In

<div align="center">115</div>

contrast, about a quarter of the researchers stated that there were no impediments to collaborate across the CFS.

4.5.4   Perceptions of Collaboration with FPInnovations

Participants were asked: *How would you describe collaboration in scientific research with FPInnovations?* The sub-questions examined incentives and disincentives to collaborate with FPInnovations, including any impediments that prevented researchers from collaborating with one another. Table 6 outlines the main thematic categories that represent participants' perceptions of collaboration with researchers at FPInnovations.

The majority of the managers and researchers primarily described collaboration with FPInnovations as "culturally challenging." Researchers were more concerned with the need to pay for FPInnovations' services. Managers, on the other hand, stated that both organizations need to find better ways to work together to fulfill the continuum between the upstream and downstream research. Managers described the relationship with FPInnovations as needing to be more integrated through the whole value chain process to advance the competitiveness of the forest sector. Managers also discussed FPInnovations' different business model and practices, in which there are different project timeliness (e.g., short-term research) which impact how collaborations are carried out between the two organizations.

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Table 6 Perceptions of Collaboration with FPInnovations

THEMATIC CATEGORIES						
RESEARCHERS	**(N=13)**		**MANAGERS**	**(N=8)**		
	N	**%**		**N**	**%**	
DESCRIPTION OF COLLABORATION WITH FPINNOVATIONS						
PAY FOR SERVICES	10	77	VALUE CHAIN INTEGRATION	6	75	
COLLABORATIVE CULTURE *(Challenging)*	7	54	COLLABORATIVE CULTURE *(Challenging)*	6	75	
			BUSINESS MODEL AND PRACTICES *(Different)*	4	50	
INCENTIVES TO COLLABORATE WITH FPINNOVATIONS						
CULTURE (GOVERNANCE PROMOTES COLLABORATION)	6	46	VALUE CHAIN INTEGRATION	(N=7)		
				5	71	
KNOWLEDGE, SKILLS & ABILITIES	4	31	CULTURE (GOVERNANCE PROMOTES COLLABORATION)	5	43	
VALUE CHAIN INTEGRATION	3	23				
DISINCENTIVES TO COLLABORATE WITH FPINNOVATIONS						
PAY FOR SERVICES	7	54	BUSINESS MODEL AND PRACTICES	(N=7)		
				5	71	
NOT KNOWING RESEARCHERS	4	31	NOT KNOWING RESEARCHERS	3	43	
IMPEDIMENTS TO COLLABORATE WITH FPINNOVATIONS						
PAY FOR SERVICES	6	46	PAY FOR SERVICES	(N=6)		
				4	67	
			SCIENTIFIC STANDARDS	3	50	

Challenging Collaborative Culture: Three-quarters of the managers and over half of the researchers stated that the CWFC and FPInnovations have very different corporate cultures, which in turn, make collaborations very challenging between the organizations. There are several good examples where collaborations between CWFC and FPInnovations have been able to deliver on projects that satisfy the needs of the forest sector and end-users. However, the CWFC

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is more geared toward long-term research which is represented through peer-reviewed scientific research and publications. Publishing peer-reviewed papers is important for RES [Research Group] promotional criteria, and recognition in the scientific community. FPInnovations, on the other hand, is more concerned with carrying out member-based, short-term applied research. According to several researchers, FPInnovations acts more like a consultant because it responds directly to industry members' needs. This dichotomy creates a conflicting research structure and culture that impacts the ability of the two organizations to collaborate effectively. Participants stated the following:

> They [FPInnovations] are more operations research, more responding directly to industry needs on small projects and technical projects; where we are a science-oriented research organization that our research has to be fully replicated, peer-reviewed, and the whole nine yards. It's a different frame of thought. And our funding models are different. [FPInnovations is] invested by forest companies, and they have to bill their time. And we have the luxury of not having to do that. I think the research structures conflict with each other. *(Researcher)*
>
> Different culture. The culture of the CFS is more academic…So peer-reviewed, published, recognized, [and] acknowledged in the scientific community. That's important to CFS researchers. It's important criteria in the RES promotion side…On the FPInnovations' side, there is a component of that and there are a number of scientists that are very well-known, and published; but the thrust is more towards application in a relatively near-term and on financial remuneration. So they get paid for what they do by

their members, and they need to be responsive to member demands…short-term

problem, trouble-shooting. So bringing the players together and addressing those

different kinds of voltages on the research is a challenge. *(Manager)*

Some researchers described the relationship between the two organizations as being

inauthentic because researchers feel obligated to collaborate with FPInnovations if they are to be

successful in attaining funding for their research proposals. A couple of researchers stated that if

FPInnovations receives public money then the research should be in the public domain.

Although the collaborative relationship between the two organizations has been

challenging, there were three researchers who expressed positive feelings about the collaborative

relationship:

With the individuals that I have been dealing with, it's been quite good. They're prepared

to bring resources to the table if we could bring resources to the table (bodies or dollars).

They've been really good to work with.

It's been very good…They've been very willing to help me…It's been very positive.

Optimizing Full Value Chain: Three-quarters of the managers stated that finding ways

to work together is an important factor for the CWFC and FPInnovations. Creating partnerships

across the value chain enables better optimization of the full spectrum of forestry research. The

partnership between the CWFC and FPInnovations is intended to be synergy-based and

collective-driven to meet the demands of the end-users. "From the tree to the market" is the

metaphor that explains the full value chain of the forest sector: the partnership between upstream

and downstream research fosters collective products, solutions, and decisions for the forest

sector. In so doing, FPInnovations, along with CWFC and CFS, receives recognition for contributing to the national innovation system.

Paying for Services Rendered: About three-quarters of the researchers focused strongly on the need to pay for FPInnovations' services. Several researchers noted that collaboration with FPInnovations is not true collaboration because it is based on the need to pay for services. FPInnovations incorporates a cost-recovery business model, in which its researchers have a standard charging practice based on billable hours for expertise or services rendered.

Working with Different Business Models: The business model and processes within FPInnovations are different from the business model and processes within CWFC/CFS. FPInnovations works on short-term objectives for research projects with limited timelines. According to one manager, FPInnovations takes on a project-oriented approach while CFS takes on a program-oriented approach. So, building projects together is not seamless.

INCENTIVES TO COLLABORATE WITH FPINNOVATIONS

There are two main themes that represent the incentives to collaborate with FPInnovations: working together along the full value chain, and mandated collaboration with FPInnovations.

Working Together Along an Integrated Value Chain: About three-quarters of the managers and one-quarter of the researchers stated that a main incentive to collaborate with FPInnovations is to optimize the full value chain of the forest sector. A fully-optimized value chain perspective helps to situate Canada as an innovative and competitive contributor to the

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forest sector. Researchers are able to look at the full spectrum of the forest sector. Together, these two organizations produce a stronger outcome through the integration of upstream and downstream research. Participants gave the following examples:

> They [FPInnovations] are our link to … the downstream products, the downstream
> market for the forestry sector. They are our link to the value chain optimization. They are
> closely in tune with the forest industry, and what the forest industry needs. *(Researcher)*
> Looking at the entire so-called value chain, I would say, that's a big incentive for us to
> work together…I think the two upstream, downstream parts, they inform each other, and
> there's an important feedback loop in there. *(Manager)*
>
> **Mandated Collaboration with FPInnovations:** Nearly half of the researchers and

managers stated that CWFC managers place a strong emphasis on collaborating with FPInnovations through their governance structure. Some researchers and managers have coined it "mandatory" or "strongly encouraged" to collaborate with researchers from FPInnovations. Funding has been contingent on whether CWFC researchers state that they will collaborate with researchers from FPInnovations. Both researchers and managers revealed that proposals which include FPInnovations are looked upon very favourably by CWFC managers, and are more inclined to get funded.

Although most researchers and managers saw collaboration with FPInnovations as a good opportunity, one researcher felt that other than being told to collaborate, there really was not any incentive to collaborate.

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The question about disincentives to collaborate with FPInnovations generated three particular themes: different business models and practices, pay for services, and knowing researchers across the organization.

Working with Different Business Models and Practices: According to nearly three-quarters of the managers, the main disincentive to collaborating with FPInnovations revolves around the different business models and practices used by FPInnovations and the CWFC. Managers have stated that these two internal planning processes need to be better synchronized. These business models are mandated and culturally driven and have impacts on the interdependency of the two organizations working on upstream and downstream research. As one manager relayed,

> The disincentives are different cultures, different administrative systems, [and] different financial systems. You've got to make them all talk to each other in one form or another…As long as you are able to generate that mutual respect between the different players, and generate a sense of belonging, 'ya we're a part of you and you're a part of us,' a sense of interdependency.

Paying for Services Rendered: A little over one-half of the researchers stated that paying FPInnovations for their services can be a challenge or a disincentive, and can negatively impact collaboration between FPInnovations and CWFC. Researchers felt that there would be a greater incentive to collaborate with FPInnovations' researchers if there was no fee attached to every service. One researcher expressed the following:

They want me to pay for all the services that they offer. Just because of the way they're structured in terms of having to cover their wages, all of their costs, it sometimes is very difficult to incorporate them into projects because of how much it does cost.

Not Knowing Researchers: For the researchers and managers, CWFC researchers are not very familiar with researchers working at FPInnovations. This unfamiliarity sometimes prevents researchers from working more collaboratively.

IMPEDIMENTS TO COLLABORATE WITH FPINNOVATIONS

Close to half of the researchers and two-thirds of the managers stated that paying service fees to FPInnovations can create barriers to future collaborations. Moreover, managers stated that the scientific standards (e.g., peer-reviewed reports) and intellectual property (IP) in publishing research reports can impede researchers from collaborating with FPInnovations. Researchers with the CWFC/CFS produce scientific reports that need to be peer-reviewed; yet FPInnovations generally produces reports that respond to the members' needs. Also, research reports produced by CWFC researchers are shared in the public domain; yet, research reports produced by FPInnovations are mainly shared with the member companies.

4.5.5   Perceptions of Successful Collaborations

Participants were asked: *Based on your experience, how would you define successful collaboration?* Table 7 outlines the main categorical themes emerging from this question.

Researchers and managers primarily defined successful collaborations in relation to internal team processes and tangible outputs. For example, the researchers and managers

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described several internal team processes that contribute to successful collaborations: having a sense of collective ownership and commitment to completing the tasks successfully; being smarter together by leveraging skills and knowledge to advance the scientific outputs and outcomes; building relationships for future collaborations; concentrating on a common vision with goals and priorities (e.g., collaborative planning) to achieve the end goal; and communicating throughout the collaborations to ensure that the team goals are met. These processes contribute to the success of collaborations.

Table 7 Perceptions of Successful Collaborations

THEMATIC CATEGORIES					
RESEARCHERS	**(N=13)**		**MANAGERS**	**(N=8)**	
	N	**%**		**N**	**%**
COLLABORATION IMPACT *(Impact of Collaboration and its Application)*	8	62	COLLECTIVE OWNERSHIP & COMMITMENT	7	88
OPEN COMMUNICATIONS	7	54	SMARTER TOGETHER	6	75
COLLECTIVE OWNERSHIP & COMMITMENT	6	46	COLLABORATION IMPACT *(Impact of Collaboration and its Application)*	5	63
SHARED VISION, MISSION, GOALS & OBJECTIVES *(Vision, Goals & Priorities)*	6	46	BUILDING RELATIONSHIPS & LEADERSHIP	4	50
SMARTER TOGETHER	5	38	RESOURCES *(Funding)*	4	50
BUILDING RELATIONSHIPS & LEADERSHIP	4	31	SHARED VISION, MISSION, GOALS & OBJECTIVES *(Vision, Goals & Priorities)*	3	38
RELATIONSHIPS & PERSONALITIES *(Trust)*	4	31			
INTELLECTUAL PROPERTY (IP)	3	23			

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Participants also described successful collaborations in relation to completed tangible outputs. Tangible outputs were primarily driven by the realization that the team contributed to the application or adoption of products, tools, or decision-making processes. Successful collaborations were also attributed to shared publications and intellectual property, funding for new projects, and shared knowledge. The researchers stated that the outputs need to impact the end-user. Researchers also stated that shared IP is an important outcome of a collaboration and demonstrates further success (e.g., writing papers together and publications with joint authorship, and giving co-presentations). Managers also stated that getting additional funding for research projects is another characteristic stemming from successful collaborations. One researcher stated that getting recognition among your peers or team represented a successful collaboration.

Collective Ownership and Commitment: Close to all of the managers and half of the researchers felt that collective ownership and commitment play an essential role in fostering successful collaborations. Participants stated that working together encompasses the ability to deliver more than working alone through collaborative planning, sharing of tasks, or collectively developing a good concept than if researchers are working independently. By working together, researchers are working jointly with other researchers and a network of partners in which there is a greater sense of collective ownership of the research project among the team members. Participants stated the following examples:

I don't mind sharing to the point that collectively we come up with a good concept. And you want to build a research program around it. *(Researcher)*

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> Somebody looks back and says, 'We did that?' And one time out of ten, they will say, 'that was your idea'. But nine times out of ten, they will say, 'That was a great idea we had!' They own it…And organizationally, how do you replicate that, to get people to take ownership, in the individual sense of pride and in the collective sense of pride? For me, that's one of the big drivers. *(Manager)*

Smarter Together: Three-quarters of the managers and over one-third of the researchers stressed that leveraging complementary knowledge, expertise, and skills helps to establish successful collaborations. Participants noted that a successful collaboration is contingent on having the right players at the table to deliver the science. For example, one researcher stated, "You learn something. We pooled our knowledge…and came up with something that probably we would have never done on our own. We're much smarter together than we are separately."

Impact of Collaboration and its Application: Nearly two-thirds of the researchers and managers stated that the impact of the collaboration and its application delineate a successful collaboration. For example, the knowledge derived from a research project contributes to new knowledge in a scientific field or domain. This knowledge is then applied by an end-user who derives benefit from a new and advanced application. The collaboration is continuous; and greater investment is made by working with the key players and partners of a given collaborative research project to continue to achieve outputs and potential outcomes. Participants gave the following examples:

> Everybody…really wants their work to be used and to make it useful. That's what collaboration does when you bring in people from other fields. *(Researcher)*

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> A successful collaboration results in all parties being enthusiastic about the work being done. All parties get to learn something new or be part of something that is newer….I think successful collaboration, once a project is done, would lend support to the notion of that collaboration continuing. If there's a desire for that collaboration to continue, that to me is a statement that it was successful. *(Researcher)*

> Knowledge from a research project is matured and brought to an application for a specific client or user. It gets to that whole point, particularly from the CWFC, when you can take something from a foundational research to application and adoption, is success to me. *(Manager)*

Building Lasting Relationships and Leadership: Half of the managers and about one-third of the researchers stated that building lasting relationships and leadership are characteristics that define successful collaborations. Relationships that are successful in a collaboration usually result in long-term relationships. A few researchers and managers added that good leadership enables these relationships to be more successful. Success becomes more evident as these relationships continue to grow exponentially over time. One manager stated,

> Success is where there are continuous adoptions of the previous tasks, deliverables, [and] collaborations into new actions. The evolution of the collaboration, preliminary collaboration expanding, that we end up with a very nice network of collaborators and network of partners, national network of partners, so they're ongoing.

Holding a Common Vision with Goals and Priorities: Nearly half of the researchers and over one-third of the managers stated that team members who hold a common vision, goals

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and organizational priorities are more focused on successfully completing their project goals. As one researcher stated, "That's where the success lies. A group working together for the same goal...everybody [is] bringing a vital part to the table: it is [a] very successful collaboration."

Open Communication: A little over half of the researchers indicated that team members who have open communication across the project team are more successful in their collaborations. Building on each other's ideas enables better decision-making. Researchers gave the following examples:

There was ongoing conversation, where people would contribute something…it was a real conversation. It wasn't a debate…It ended up with a real synthesis of our collective knowledge and experience. Where sometimes those things can end up if it's more of a debate, there's a winner or a loser, you end up getting one person's point of view. In this case, we didn't actually, the whole is greater than the sum of the parts.

Regular and effective communication... honest communication…an openness and sharing of ideas and data.

Trust: Nearly one-third of the researchers stated that trust is an important attribute for any successful collaboration. Researchers felt that you have to be willing to share your ideas with the rest of the project team and pay attention to the collective endeavour. Researchers stated,

And sometimes, if you're afraid that somebody is going to steal your idea and tell it as their own, you're not going to be a good collaborator. Everybody's hiding too much in their hand. Our good collaborations, we have free exchange of ideas.

There has to be trust.

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4.5.6   Perceptions of Unsuccessful Collaborations

Participants were asked: *Based on your experience, how would you define unsuccessful collaboration?* Table 8 outlines the main thematic categories that best depict the participants' perceptions of unsuccessful collaborations.

Table 8 Perceptions of Unsuccessful Collaborations

THEMATIC CATEGORIES					
RESEARCHERS	**(N=13)**		**MANAGERS**	**(N=8)**	
	N	**%**		**N**	**%**
LACK OF COLLECTIVE OWNERSHIP	6	46	LACK OF COLLECTIVE OWNERSHIP	5	63
RELATIONSHIPS & PERSONALITIES *(Conflicting Personalities)*	6	46	RELATIONSHIPS & PERSONALITIES *(Conflicting Personalities)*	4	50
COMMUNICATIONS *(Lack of Shared Communications and Trust)*	5	38			

Lack of Collective Ownership: Close to two-thirds of the managers and nearly one-half of the researchers stated that unsuccessful collaborations are based on a lack of collective ownership of the projects' goals. This lack of project ownership leads to failed efforts. There is little participation by team members and minimal attempts to integrate and coordinate the research. There is also a lack of trust in the group, and no unified commitment, interdependence, and cohesion. Researchers' collaborative attempts are intended for individual gain as opposed to benefiting the collective group. For example, participants stated,

When the collaboration is in name only for the benefit of one of the collaborators, there's limited engagement. Collaboration supports the objectives of an individual, single

organization rather than a group. There is a lack of trust. The collaborators work

independently. There's limited interaction, limited sharing; people are not willing to

share their knowledge and data for the common good. *(Researcher)*

Unsuccessful collaboration is where people are willing to sit in a group but there's no

group ownership over the issue. There's no group action; and ultimately, the execution,

the yardstick is never moved. It's an ongoing coffee chat about interesting work. You

don't actually see it progress. *(Manager)*

Conflicting Personalities: Approximately half of the researchers and managers indicated

that conflicting personalities can contribute to unsuccessful collaborations. Researchers' egos and

motivations may affect collaborations and how researchers interact on a project team.

Participants also noted that researchers are sometimes forced to work together without investing

in the relationship beforehand. This lack of getting to know the project team members may result

in poor synergy within the collaboration. One researcher gave the following example:

Someone wanted to be the boss. They had a point of view, and they were going to make

sure the research went in the direction they thought best…And eventually you lose

interest, you lose trust, you become unengaged because it doesn't seem to matter what

you say, [and] you're going to be overruled or ignored. It is very unsatisfying.

Lack of Shared Communications *(including Trust)***:** A little over one-third of the

researchers stated that a lack of sharing information is another attribute of unsuccessful

collaborations. Some researchers find it difficult to trust other researchers when it comes to

sharing ideas and concepts. One researcher stated, "Lack of communication…It all comes back

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to the trust and the willing[ness] to accept other people's thoughts. What I tend to see is that people don't trust each other and don't communicate everything."

4.5.7 Perceptions of the Benefits of Successful Collaborations

Participants were asked: *Based on your experience, what are the benefits of successful collaborations in scientific research?* Table 9 outlines three main thematic categories that represent the benefits of successful collaborations: working together as a collective (teamwork), experiencing bigger impacts as a result of successful collaborations, and accessing additional resources to continue the collaborations. Managers also expressed the importance of building relationships, while researchers centred more on sharing knowledge, skills, and abilities.

Table 9 Perceptions of the Benefits of Successful Collaborations

THEMATIC CATEGORIES					
RESEARCHERS	**(N=13)**		**MANAGERS**	**(N=8)**	
	N	**%**		**N**	**%**
IMPACT *(Bigger Impact)*	11	85	TEAMWORK	7	88
RESOURCES *(Access Additional Resources)*	7	54	IMPACT *(Bigger Impact)*	6	75
TEAMWORK	5	38	RELATIONSHIP BUILDING	3	38
KNOWLEDGE, SKILLS & ABILITIES	4	31			

Teamwork: The vast majority of managers and a little over one-third of the researchers stated that working together in a collective produces better outputs and outcomes. Participants stated that collective contributions carry more weight than summing up the parts that contribute to the whole of a research project. Managers stated that it is too difficult to address complex

problems individually. It is only through a collective group of team members that ideas flow easily when researchers address scientific problems. Participants expressed the following thoughts:

> I guess we do smarter science for starters. I mentioned the fact that there's the whole being greater than the sum of the parts. We actually end up doing better work because we are able to synthesize our knowledge and experience together. When you are on a good collaborative team, you really try to transcend yourself that way. *(Researcher)*
>
> I think that we cannot address serious large problems alone. Nothing in the past was done by a single person. Even the light bulb. Thomas Edison had invented the light bulb, but he had a lab with around 100 people working for him looking at different aspects. So every large stuff is a construction of human minds, multiple human minds. So, that's for me the reason for collaboration. *(Manager)*

Conflicting perspectives in a teamwork setting was reported by one researcher to be an important aspect of collaboration. For example, this researcher stated, "I can't imagine not taking other people's results into account because conflicting results are important."

Bigger Impacts: Another major benefit of having successful collaborations is the actual impact of the collaboration. Nearly all of the researchers and three-quarters of the managers stated that a successful collaboration contributes to a bigger outcome (e.g., fill a knowledge gap, change a policy or standard, or fulfill an end-user's need). In a time of limited funding, scarce resources go much further in a collaboration. Examples of participants' perceptions include the following:

Impacts to the greater forest community. A large impact. A change in policy or industry

standards. A change in public perception. Sometimes it helps to open up other funding

pots or shed light on new ideas. *(Researcher)*

The maturity of the research to fill a knowledge gap or user need. So that's the

benefit…there's a policy question that we have better information. So I look at it from

better information, better science equals better decisions…From a researcher's

perspective, the benefits of collaboration again would go back to the return on my effort

is greater than doing an individual…So the benefit for the researcher is that we get

bigger impacts. The profile is higher when you are working with a bigger group.

(Manager)

Access Additional Resources: A little over half of the researchers expressed the

importance of building additional resources in order to share research ideas.

4.5.8   Perceptions of Consequences of Unsuccessful Collaborations

Participants were asked: *Based on your experience, what are the consequences of*

unsuccessful collaborations in scientific research? Table 10 outlines the main thematic

categories that address the consequences of unsuccessful collaborations: failed efforts, poor use

of resources, lack of desire to collaborate again with the same people, lack of personal

satisfaction, and the inability to build relationships, and distrust.

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Table 10 Perceptions of Consequences of Unsuccessful Collaborations

THEMATIC CATEGORIES					
RESEARCHERS	**(N=13)**		**MANAGERS**	**(N=8)**	
	N	**%**		**N**	**%**
COLLABORATION IMPACT *(Negative Impact of Collaboration and its Application)*	7	54	FAILED EFFORTS	7	88
FAILED EFFORTS	6	46	POOR USE OF RESOURCES	6	75
RELATIONSHIPS & PERSONALITIES *(Inability to Build Relationships, & Distrust)*	6	46	COLLABORATION IMPACT *(Negative Impact on Future Collaboration and its Application)*	3	38
POOR USE OF RESOURCES	5	38	SATISFACTION *(Lack of Personal Satisfaction)*	3	38
SATISFACTION *(Lack of Personal Satisfaction)*	4	31			

Failed Efforts: Close to all of the managers and nearly one-half of the researchers stated that the inability to reach the intended outcomes of the science, a failure to launch the science where the research or policy question went unanswered, or the product was not adopted by the end-user were all consequences of unsuccessful collaborations. For example, one manager stated the following major consequence: "The research products will not be adopted…You might have research that is rigorous and peer-reviewed…but because there has not been a sufficient measure of collaboration, that research will remain bound in the pages of a research journal."

Poor Use of Resources: Three-quarters of the managers and a little over one-third of the researchers felt that another consequence is the poor use of resources (i.e., loss in time and money, and higher costs). According to the participants, organizations cannot afford to conduct irrelevant science. Therefore, it becomes important to use the resources more effectively to

ensure that the expertise, money, and time allotted to tasks are conducted in a proficient manner. One manager stated the following: "…because we are a part of public science…we are dealing with public resources. I think that we do have a responsibility to make sure those resources are being used efficiently and effectively."

Lack of Desire to Collaborate Again: A little over half of the researchers and one-third of the managers stated that another consequence of an unsuccessful collaboration is the lack of desire to collaborate on future research projects with the same people. Participants stated that researchers who go through a bad experience tend not to collaborate with the same researchers on future projects. For example, one manager relayed the following: "The consequences are….it's being black balled from certain partnerships that it taints the relationship between the partners, the collaborators, and the future activities and action[s] are hampered."

Lack of Personal Satisfaction: Participants stated that another consequence of an unsuccessful collaboration is a lack of personal satisfaction. Nearly one-third of the managers and researchers felt that there is a loss in personal satisfaction if the collaboration is unsuccessful in the end. This lack of personal satisfaction can be attributed to getting bad reputations or not understanding why the collaboration failed in the first place. Participants gave the following examples:

> I guess from an organizational perspective, it gets a bad reputation, both from an organizational and individual perspective. If you're involved in a poor collaboration, it gives a bad reputation, bad feelings. It decreases morale and demotivates people because nobody wants to be involved in a bad collaboration. *(Researcher)*

If we don't succeed together, we're going to ask a lot of questions on *Why*? And I don't

think that we are good at doing post-mortems on *Why did we fail?…*collectively I would

say. People are going on each of their side and making their own post-mortems. And I

think we might have misconceptions or misjudge[ments on] what's happened. *(Manager)*

Inability to Build Relationships: Close to one-half of the researchers also stated that

another consequence is the inability to build relationships for future projects. Bad experiences in

collaborations have led to a distrust of researchers. One researcher expressed the following:

It could be sometimes where one partner will try to do something that it wasn't assigned

to do, and almost steal the work or the credit themselves. So, that can really poison the

whole project, the whole relationship for a long time.

4.5.9   Researchers' Perceptions of Collaborative Research Projects

Researchers were presented with a series of questions to gauge their perceptions of their

collaborative research projects. These questions examined researchers' perceptions concerning

motivations for getting involved in the collaborative projects, project elements that were

successful and unsuccessful, team members' abilities to accomplish project goals, team

members' assigned roles and responsibilities, interpersonal relationships, and shared

communications.

4.5.9.1   Motivation to Collaborate on Research Projects

Research participants were asked: *What motivated you to get involved in this*

collaborative project? Researchers primarily described three main motivators for getting

involved in their collaborative research projects: leveraging knowledge, expertise, and learning opportunities; having greater impacts through wider networks and initiatives; and viewing these projects as being part of one's job.

Leveraging Knowledge, Expertise, and Learning Opportunities: Close to half of the researchers stated that leveraging knowledge, expertise, and learning opportunities were important motivators for working on their collaborative research projects. Researchers stated that they were able to look at a bigger research problem with other researchers who had the knowledge and expertise to carry out the project.

Having Greater Impact Through Wider Networks: Close to one-third of the researchers stated that having a greater impact through wider networks and research initiatives represented another motivator for researchers to get involved in collaborative research projects. One researcher stated, "It was just a matter of finding other partners across the province that were interested in doing similar type of work. So we built the collaborative network."

It's Really Part of My Job: Close to one-third of the researchers stated that they were just doing their everyday job by engaging in these collaborative projects.

4.5.9.2 Successful and Unsuccessful Elements of Collaborative Projects

Research participants were asked: *Please describe what elements of the collaborative project were successful?* Researchers primarily described their projects as being successful. Several elements were attributed to their success: leveraging knowledge, expertise, and

partnerships; leveraging funds and resources; sharing communications; and demonstrating relevance to industry and other government departments.

Leveraging Knowledge, Expertise, and Partnerships: Just over three-quarters of the researchers stated that one successful result of working on their collaborative project was the ability to leverage one's knowledge, expertise, and partnerships. Researchers felt that leveraging their own knowledge and expertise provided greater depth to their science domains. Establishing greater partnerships also helped to create networks of people that engage in future collaborations with the participants.

Leveraging Funds and Other Resources: Just over one-third of the researchers stated that another successful element of working on collaborative projects is the ability to leverage funds and other resources such as in-kind contributions.

Sharing Communications: Over one-third of the researchers stated that having the ability to share data and information with the project team members also represented a successful element. The use of meetings, teleconferencing, emails, and telephone calls to team members has created a culture that fosters open dialogue among researchers. For example, one researcher relayed the following: "The communications between organizations. The communications with ourselves was definitely successful….Public communications have been very successful."

Impacting Industry and Other Government Departments: Close to one-third of the researchers stated that the ability to impact industry, government, and Canadians was also a successful element of collaborative projects. For example, one researcher stated, "Impact with

industry; impact with other government, provincial government sector: we made large in-roads with them."

Interestingly, there were no major themes that emerged from the participants when they were asked: *Please describe what elements of the collaborative project were unsuccessful?* Just over two-thirds of the researchers stated that there were no unsuccessful elements attributed to their research projects. However, two researchers stated that they ran out of funding; one researcher expressed concern about what the future holds for the technology; and another researcher expressed unease over technology-uptake by the end-user.

4.5.9.3   Perceptions of Being Successful in Accomplishing Project Goals

Participants were asked: *How successful were you in accomplishing the goals of your project?* All of the researchers felt that they were successful in accomplishing their project goals. Responses ranged from 'accomplished project goals' to being 'very successful.'

4.5.9.4   Team Members' Roles and Responsibilities

Researchers were asked: *How would you describe team member roles and responsibilities in the project?* In general, participants stated that it is important to define team members' roles and responsibilities at the beginning of the collaboration. Participants also stated that supportive team members enable the successful completion of goals.

Defining Team Member Roles and Responsibilities: Close to two-thirds of the researchers stated that as a team comes together to work on a collaborative project, it is essential to clearly define the roles and responsibilities for each team member, with some flexibility. One

researcher stated the following: "Right from the beginning. And everybody stuck to their roles…There's always discussion on the roles and how we are progressing. But there's never a limiting factor…We're given the freedom to develop it in certain ways."

Supporting Team Members: Just over one-third of the researchers stated that having supportive team members who work in a collective enables the team to successfully carry out its tasks and goals. For example, one researcher gave the following perspective: "It's a consortium of peers if we collectively decide how to do things. Things are done as a group rather than being mandated. It's partly because I'm a firm believer in the fact that no one is smart enough to make all the right decisions."

4.5.9.5 Interpersonal Relationships

Researchers were asked: *How would you describe the interpersonal relationships within your collaborative project?* Participants stated that team members need to have good working relationships and need to be interdependent in completing their tasks.

Good Working Relationships and Interdependency: Close to all of the researchers felt that it is important to have good working relationships with team members in any collaborative project. Many of the relationships are based on friendships: team members take the time to get to know each other before starting the collaboration. Participants also stated that there is a need to look at the research collectively (e.g., team-oriented), and how each team member relies on others to complete the project goals. Researchers gave the following examples:

I guess the fact that we are also to some extent friends; it's not just strictly collegial or work. Interested in what goes on in each person's life. Start with a meeting with a chat in how things are going in people's personal lives. It certainly helps to build a sense of engagement with your group…if you care about the people that you work with, you care about what the group does collectively, and not just concerned about your own thing. This is a team behind all of this. This isn't my research. This is the team's research.

However, one researcher stated that liking a team member is not as important as being able to accord respect to the individual.

4.5.9.6   Shared Communications

Researchers were asked: *Please describe how information was communicated (or shared) in your collaborative project?* Researchers primarily stated that communications involved sharing information with all team members to ensure that everyone understood all aspects of the project (e.g., project goals, developments, outputs, and impacts). To a lesser degree, team meetings were also important; however, participants emphasized the importance of sharing information in general and being able to have face-to-face communications.

Sharing Information with Team Members: Close to all of the researchers felt that keeping the lines of communication open enabled team members to have good working relationships. Social interdependence among team members ensured that each member had an appreciation of what needed to be communicated as well as the interpretation of the

communications. Researchers shared data and information by telephone, emails, meetings, presentations, Web applications (e.g., Skype or Tandberg), and file-sharing.

Another researcher stated that researchers need to take a more proactive approach to communicating with others to enable better working relationships on future projects. A little over one-half of the researchers stated that face-to-face interactions allowed researchers to look at the problem space more collectively by interacting very fluidly in their discussions and conversations. Body language also facilitated greater reciprocity of conversational exchanges.

4.5.10   Perceptions of Managers Enabling Collaboration in Scientific Research

Participants were asked: *In your opinion, how have senior managers tried to enable collaboration in scientific research within the CWFC, across CFS, with FPInnovations, and with external partners?* Table 11 outlines the major themes across the different organizations. For example, the main themes for the CWFC included: incentivizing researchers to work together; fostering better communications and interactions through the employee science forums; and building relationships. Over one-third of the researchers also felt that managers enabled collaboration within the CWFC by communicating a shared vision.

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Table 11 Perceptions of Managers Enabling Collaboration in Scientific Research

THEMATIC CATEGORIES					
RESEARCHERS	**(N=13)**		**MANAGERS**	**(N=8)**	
	N	**%**		**N**	**%**
MANAGERS ENABLED COLLABORATION WITHIN CWFC					
SHARED COMMUNICATIONS *(Employee Science Forum)*	9	69	INCENTIVIZE RESEARCHERS TO WORK TOGETHER	7	88
INCENTIVIZE RESEARCHERS TO WORK TOGETHER	6	46	SHARED COMMUNICATIONS *(Employee Science Forum)*	4	50
SHARED VISION, MISSION, GOALS & OBJECTIVES	5	38	RELATIONSHIPS & PERSONALITIES	4	50
RELATIONSHIPS & PERSONALITIES	4	31			
MANAGERS ENABLED COLLABORATION ACROSS CFS					
SHARED VISION, MISSION, GOALS & OBJECTIVES *(Integrated Systems Approach)*	7	54	CULTURE (GOVERNANCE PROMOTES COLLABORATION)	7	88
CULTURE (GOVERNANCE PROMOTES COLLABORATION)	5	38			
RELATIONSHIPS & PERSONALITIES	3	23			
DON'T KNOW	3	23			
MANAGERS ENABLED COLLABORATION WITH FPINNOVATIONS					
WORK TOGETHER AS A COLLECTIVE *(Increase Integration)*	9	69	WORK TOGETHER AS A COLLECTIVE *(Increase Integration)*	8	100
WORK IN PROGRESS	4	31	WORK IN PROGRESS	6	75
CULTURE (GOVERNANCE PROMOTES COLLABORATION) *(Mandatory)*	4	31	SHARED COMMUNICATIONS *(Meetings)*	4	50
SHARED COMMUNICATIONS *(Meetings)*	3	23			
PAY FOR SERVICES	3	23			
MANAGERS ENABLED COLLABORATION WITH EXTERNAL PARTNERS					
NETWORKS *(Build Networks)*	6	46	NETWORKS *(Build Networks)*	6	75
RESOURCES *(Leverage External Monies)*	4	31	RESOURCES *(Leverage External Monies)*	3	38

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Incentivizing Researchers to Work Together: Close to all of the managers and half of the researchers felt that managers provided incentives for researchers to work together. Managers provided virtual tools (e.g., Tandberg) to create linkages with researchers across the forest sector. Moreover, CWFC managers stated several times that research proposals were given adequate funding if they demonstrated collaboration with partners.

Fostering Better Communications and Interactions: Over two-thirds of the researchers and one-half of the managers stated that the CWFC managers enabled collaboration within the Centre by creating the annual employee science forum. The forum provided a platform where employees across the organization got together for a span of three days to regroup as an organization. The three days were built around presentations from senior managers who centred on the objectives and priorities of the CWFC, brainstorming sessions on future projects, and relationship-building to enable future collaborations by getting to know people across the organization. Researchers and managers from FPInnovations were also in attendance to help build better research partnerships across both organizations. Participants stated that these employee science forums were the most effective source of communications and interactions that enabled effective collaborations, both internally and with FPInnovations. For example, a few researchers conveyed the following:

> The single most important thing we did as a group was to have regular science employee
>
> forums…But those face-to-face meetings, where you talk about the work you're doing,
>
> the directions for the future, everything we needed to do to make our work better, we

would try and fit into a couple of days of face-to-face meetings. And then the real value

in that was that you get to know your colleagues as people. And since we were scattered

all over, and in each individual centre, there would be one person with [a] particular kind

of expertise. There, you might have a counterpart in several of the other centres; but until

you got to know them personally, you wouldn't necessarily think of working with them.

And those face-to-face really got to the point where I could call somebody out there and

talk to them, even now. There's a relationship there. So that was really an effective way

of building collaboration within the Fibre Centre was those initial face-to-face meetings.

Building Relationships: Half of the managers and nearly one-third of the researchers

revealed that senior managers encouraged researchers to build relationships, both internally and

with external partners, to enable collaboration between the research communities. For example,

one researcher stated, "They tell us they want us to do that [collaborate]. It is really up to the

individual researcher. We have some researchers that don't collaborate. And a manager can't

really force that. It's really up to the individual to build these relationships."

MANAGERS ENABLING COLLABORATION ACROSS CFS

Two main themes emerged to best explain how managers enabled collaboration across

the CFS. First, managers created a culture where governance promotes collaboration. Second,

researchers were more inclined to say that managers enabled collaboration across the CFS by

unifying researchers in common objectives (e.g., integrated systems approach in carrying out

research projects). Also, close to one-quarter of the researchers stated that building relationships

across the CFS enabled collaboration. However, one-quarter of the researchers were not sure how management enabled collaboration across CFS.

Creating a Culture of Governance that Promotes Collaboration: Almost all of the managers and a little over one-third of the researchers stated that senior managers enabled collaboration across the CFS by promoting a governance structure that fosters greater collaboration among researchers. Researchers within the CWFC had known CFS researchers and have worked with them for many years prior to the formation of the CWFC. The CWFC and CFS managers have developed a more integrated program by funding projects that demonstrate collaboration with internal and external partners. A couple of researchers stated that collaboration was not encouraged naturally across the CFS in the past years. One researcher noted that collaboration across the CFS is improving and is becoming more encouraged among researchers.

Unifying Researchers through Common Objectives: A little over one-half of the researchers stated that the CWFC managers enabled collaboration with the CFS by examining common objectives through an integrated systems approach. Strengthening collaborative ties across the CFS is essential to building the national forest program.

MANAGERS ENABLING COLLABORATION WITH FPINNOVATIONS

Three major themes best explain how senior managers enabled collaboration with FPInnovations. First, researchers and managers stated that the CWFC managers enabled collaboration by increasing the integration between the CWFC and FPInnovations. Second, managers more so than researchers, saw this integration as a work-in-progress. Third, increasing

communications between the two organizations helped to better understand each other's programs and how to build greater synergy between them. Close to one-third of the researchers felt that it was mandatory to collaborate with FPInnovations. One-quarter of the researchers spoke about the need to pay for FPInnovations' services.

Working Together to Enhance Integration: All of the managers and a little over two-thirds of the researchers stated that the CWFC managers have enabled collaboration by increasing integration with researchers across the different divisions in FPInnovations. This increased integration encompasses the need to embed collaborative initiatives and projects within research proposals. The desired outcome enables more collaborations with FPInnovations. For example, participants stated,

> They have certainly tried to link us better, to have a better understanding of
> FPInnovations [through presentations, emails, and meetings]. *(Researcher)*
> Develop relationships. Develop and encourage our scientists to talk. We talk positively
> about the benefits of the relationship, where we can develop good collaborative science.
> *(Manager)*

Relationship is a Work in Progress: Three-quarters of the managers and one-third of the researchers stated that the relationship between the CWFC and FPInnovations is a work-in-progress. The Director of Integration within the CWFC is responsible for building better integration and relationships with FPInnovations by discussing opportunities for collaboration that contribute to the optimization of the forest sector. However, researchers and managers stated that there still is a need to develop a common program and a common way of doing things

between the two organizations (e.g., aligned business model). For example, one manager relayed the following: "One example is training that we took together. For example, FPInnovations several years ago had a new approach to formulating research problems…That's the NABC [Needs, Approach, Benefits and Competition]…value [proposition]."

Enhancing Communications between the CWFC and FPInnovations: One-half of the managers and a quarter of the researchers stated that senior managers have encouraged communications with FPInnovations through meetings with the senior management team, consultations with the program advisory committee which includes industry representatives, provincial governments, and academia, and participation at the employee science forums.

MANAGERS ENABLING COLLABORATION WITH EXTERNAL PARTNERS

Senior managers enabled collaboration with external partners by building networks and by leveraging external monies.

Building Networks: Three-quarters of the managers and nearly one-half of the researchers disclosed that building networks refers to working collaboratively with academia on basic, applied, and operational research. This relationship helps to build a "community of knowledge" through the connected network of researchers in government (including NSERC), universities, industry, and the provinces. Relationships between the CWFC and external partners are based on good relationships that have worked in the past. However, there are differences (e.g., different values) between the parties that could affect the collaborative working relationships in the future.

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Leveraging External Monies: A more muted theme looked at leveraging money from external partners. A little over one-third of the managers and one-third of the researchers stated that senior managers have enabled collaboration with external partners by leveraging external monies (e.g., large NSERC networks, and non-governmental organizations).

4.5.11   Perceptions of Transformational Change on Collaborations

Participants were asked: *The federal government is undergoing a period of transformation. In your experience, how has this transformation influenced research collaboration, if at all?* Table 12 outlines the main thematic categories.

Table 12 Perceptions of Transformational Change on Collaborations

THEMATIC CATEGORIES						
RESEARCHERS	**(N=13)**		**MANAGERS**		**(N=8)**	
	N	**%**			**N**	**%**
PRODUCTIVITY *(Decreased Science Productivity)*	6	46	BUREAUCRACY (NEW ADMINISTRATIVE PROCEDURES)		6	75
TRAVEL *(More Difficult)*	6	46	PRODUCTIVITY *(Decreased Science Productivity)*		5	63
BUREAUCRACY (NEW ADMINISTRATIVE PROCEDURES)	4	31	RESOURCES *(Scarce)*		3	38
RESOURCES *(Scarce Resources)*	4	31				
SHARED COMMUNICATIONS	3	23				
RELATIONSHIPS & PERSONALITIES *(Inability to Build Relationships)*	3	23				
COLLABORATIVE CULTURE *(Increased Collaboration)*	3	23				

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Four themes mainly explain how the participants perceived the transformational period in the federal government influencing research collaborations: impact of bureaucracy (e.g., new administrative processes); decreased productivity in scientific research; scarce resources; and the inability to travel and interact with other researchers. To a lesser degree, researchers stated that a lack of communication or information sharing, and limited relationship-building also negatively influenced collaboration during this period of transformational change. Interestingly, nearly one-quarter of the researchers stated that the overall transformation period increased collaboration because of financial and travel constraints.

New Bureaucratic Processes Impacting Science: Three-quarters of the managers and close to one-third of the researchers stated that new bureaucratic rules, regulations, and processes have impacted researchers. Although the transformation of the forest sector has been very beneficial in promoting innovations in forestry research, there have been significant bureaucratic organizational changes that have impacted researchers and the way they carry out their research. Organizational change has been responsible for changes in the day-to-day business and administrative processes. The organizational changes in the federal government are based on more centralized and cost-efficient processes and tools. Participants stated the following:

> It's the whole increase in that rules and regulations and all these new systems in place to make government more efficient. I think in the long term, it will help government to be more efficient. But in the short term, it's just an enormous administrative burden certainly for the scientists. I'm talking about the new travel system, the new finance system, and the rules and regulations for travel. *(Researcher)*

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The period of transformational change, if we're talking about transformation to attitudes and people's perceptions, I think for the most part, that's beneficial. But if we are to talk about transformation to the process where there's more oversight, where there's more and more layers of bureaucracy, that kind of transformation is not going to be beneficial and positive for government and research. *(Manager)*

Decrease in Scientific Research Productivity: Nearly two-thirds of the managers and one-half of the researchers disclosed that there is a decrease in the production of scientific research as a result of the new administrative and bureaucratic processes governing the day-to-day business operations in the CWFC. For example, researchers have had to learn new processes and procedures for travel and procurement, which have impacted scientific productivity. Both researchers and managers expressed great concern over administrative processes impacting researchers' time to work on research projects. Participants stated,

Publication rate has slowed down. You could easily spend three-quarters of your week doing [administrative work]…nothing to do with research. *(Researcher)*

Our researchers are starting to have concerns over the amount of time that they're taken away from their research projects to do tasks that they were not … they have not done in the past in terms of the day-to-day operational [administration]. *(Manager)*

Scarce Resources: About one-third of the managers and researchers stated that scarce resources (both human and financial) contributed to the need to augment funding and expertise through collaborative efforts. For example, one researcher stated that the financial pressures in the CWFC/CFS may have held back researchers in their career progression: "If they know that

there's no money, they aren't going to be progressing in their careers, they may not invest

themselves as much as they would otherwise. So there's a motivational aspect that has been

difficult because of the transformational change."

Travel Becomes More Difficult: Nearly one-half of the researchers also stated that the

transformational period made travel more difficult. This has led to limited interactions and

communications with other researchers, potential clients, and researchers at conferences. The

inability to travel due to travel restrictions has impacted researchers' abilities to collaborate more

effectively. Participants felt that travel is key for researchers because they feel the need to

interact with people at conferences/symposia, technical meetings and international panels,

workshops, and discussion groups. Examples from the researcher participants include:

> [The governmental changes are] making travel more difficult. It can be an impediment if
>
> one wants to go to a conference or a workshop or go for a meeting. All of these things
>
> have a fair bit of approval required and advance planning…But in some cases, it
>
> probably impedes the potential for collaboration.
>
> The thing that had the biggest impact would be probably travel restrictions. It does make
>
> it harder to get out and meet people. You don't just start a collaboration by picking up a
>
> phone and making a cold call. That rarely ever works. You want to build that
>
> relationship.

Interestingly, one-quarter of the researchers stated that collaboration has increased as a

result of the transformation of the forest sector. With limited core funding and expertise, there is

a definite need to collaborate across the governments, industry and academia.

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4.5.12   Perceptions of Enabling Collaboration during Transformational Change

Participants were asked: *In this period of transformation, please describe what factors would enable researchers to collaborate more effectively within CWFC, across CFS, with FPInnovations, and with external partners?* Table 13 outlines the factors that would enable better collaboration within the CWFC, across CFS, with FPInnovations, and external partners.

Table 13 Perceptions of Enabling Collaboration during Transformational Change

THEMATIC CATEGORIES						
RESEARCHERS	**(N=13)**		**MANAGERS**	**(N=8)**		
	N	**%**		**N**	**%**	
ENABLING COLLABORATION WITHIN CWFC DURING TRANSFORMATIONAL CHANGE						
FACE-TO-FACE COMMUNICATIONS	7	54	FACE-TO-FACE COMMUNICATIONS	7	88	
RELATIONSHIP BUILDING	4	31	RELATIONSHIP BUILDING	4	50	
RESOURCES *(Funding)*	3	23	COLLABORATIVE OBJECTIVES WITH NATIONAL APPLICATION	4	50	
			REMOVE BUREAUCRATIC BURDEN	3	38	
ENABLING COLLABORATION ACROSS CFS DURING TRANSFORMATIONAL CHANGE						
CHANGE CULTURE OF COMMUNICATIONS	7	54	GREATER SYNERGY ON COMMON PROBLEMS	7	88	
REMOVE BUREAUCRATIC BURDEN	3	23	CHANGE CULTURE OF COMMUNICATIONS	4	50	
ENABLING COLLABORATION WITH FPINNOVATIONS DURING TRANSFORMATIONAL CHANGE						
WAYS TO WORK TOGETHER	11	85	WAYS TO WORK TOGETHER	8	100	
SHARED COMMUNICATIONS	5	38	SYNERGY ON COMMON PROBLEMS	6	75	
ENABLING COLLABORATION WITH EXTERNAL PARTNERS DURING TRANSFORMATIONAL CHANGE						
RESOURCES *(Increase)*	4	31	IDENTIFY POLICY QUESTIONS	5	63	
RELATIONSHIP BUILDING	4	31	RESOURCES *(Increase)*	3	38	
SHARED VISION & GOALS	3	23				

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Three major themes emerged to best explain what factors would enable researchers to collaborate more effectively within the CWFC: increase face-to-face communications, build relationships, and engage in collaborative objectives with national application. Managers also stated that an enabling factor would be to remove the bureaucratic burden from the researchers' day-to-day activities to allow them to have more time to engage in their science. Researchers, on the other hand, thought that an increase in funding would enable greater collaboration.

Increase Face-to-Face Communications: Researchers and managers stated that the overarching factor that would enable better collaboration within the CWFC is the need to enhance face-to face communications. Nearly all of the managers and a little over half of the researchers stated that researchers need to come together face-to-face to get to know each other and to build more effective relationships through these interactions. Face-to-face interactions are more conducive to learning and enhance communications among researchers. These interactions help researchers to develop closer bonds to sustain long-term relationships. Managers and researchers felt that collaborative initiatives, like the annual employee science forums, enabled researchers to get together face-to-face and develop stronger bonds. The relationships established during these forums helped to foster greater trust among researchers and allowed them to have a better rapport with researchers who worked in different regions across Canada. Researchers and managers stated the following:

Where possible, give staff opportunity to have face-to-face communication when it's necessary. Like if you're building a new collaboration, I think it's important for some

people to get together to help gel the ideas. To invest in face-to-face interaction, where

necessary. *(Researcher)*

We have the ability to have face-to-face events, face-to-face activities [employee science

forums]. That's the one thing about having a virtual centre. If you're scattered across the

country and you're all working on similar issues, and you don't have an opportunity to

get together on a regular basis, you lose that culture to a certain degree. That openness,

that one-on-one, that personal piece that is really important for collaborations, and you

need to have that ability to communicate, to have a conversation that isn't only about the

project, the program. But moreover, what is the person like, what do you do, what are

your interests? You need to have that. *(Manager)*

Participants stated that meeting virtually is another way to communicate to enable

collaboration although it is not as effective as face-to-face communication. The current virtual

communication tools are not always conducive to having effective meetings. Participants felt that

if virtual communication tools need to be used, these tools need to be more helpful than the

current tools.

Build Relationships: One-half of the managers and nearly one-third of the researchers

disclosed that building relationships enables more effective collaboration within the CWFC. The

investment in relationships helps to further refine collaboration opportunities in research.

Engage in Collaborative Objectives with National Application: Half of the managers

interviewed felt that it is important to look at collaborative objectives that have national

application. This approach would create better integration and interaction among researchers

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intra-organizationally and inter-organizationally as they work collectively on national research projects. As one manager stated, "If we could agree on a problem that is larger scale, larger in impact, and more national application, then it would be easier in working in a collaboration."

Two themes emerged to best explain what factors would enable researchers to collaborate more effectively across the CFS: create greater synergy to work on common problems; and change the culture of communications between the two organizations.

Greater Synergy on Common Problems: Almost all of the managers specified that the CWFC and CFS need to create greater synergy through an integrated systems approach. Several managers stated that there is a need for greater integration of goals, in which the research problems are motivating for both sides. One manager stated that there is a need to change the culture to enable greater trust in the sharing of information, even at the data collection phase, to better support collaboration between the CWFC and CFS.

Change Culture of Communications: About half of the researchers and managers stated that enhanced knowledge exchange enables better collaboration between the CWFC and CFS. According to the participants, creating a culture of openness and information-sharing creates better synergies between the two organizations. For example, participants stated,

> For CFS, that whole investing in face-to-face interaction is even more important than in the Fibre Centre where people already have established relationships...If we're going to focus on something specific like a project, I think that those that are wanting to

collaborate on that particular problem or that project, certainly at the initial stages, we

would need to get together. *(Researcher)*

Within the CFS, we have this initiative called the integrated systems approach. Where

the issue is that we have a set of complex problems…and various researchers are looking

at a piece of the problem…And they've collected the information and they've got data,

but there is very limited openness to share that information until it gets to a point of

publication where now it's in the open…I guess the question then becomes is there a way

to influence culture change which tends to be more open with the sharing of information

as it's collected? And it's that faith, it's that trust…Collaboration is around that openness

and sharing. *(Manager)*

ENABLING COLLABORATION WITH FPINNOVATIONS DURING TRANSFORMATIONAL CHANGE

Two themes emerged in response to what factors would enable researchers to collaborate

more effectively with FPInnovations: identify specific ways of working together; and foster

greater synergy by addressing common problems.

Identify Specific Ways of Working Together: All of the managers and almost all of the

researchers stated that identifying better ways of working together would enable better

collaboration with FPInnovations. By identifying common objectives, both organizations can

maximize collaborative opportunities and further contribute to the competitiveness of the forest

sector. Participants articulated their ideas in the following ways:

Reassess Funding Process: Allocating funds differently within FPInnovations. A lot of

money that FPInnovations gets is from the CFS. Or making more funds available to us

within the Fibre Centre to be more effectively able to collaborate with FPInnovations. Or encourage or incent FPInnovations to give us some preferential rates for some of the services that they offer. Sometimes, we just can't afford to work with them. *(Researcher)*

Enhance Communications and Interactions: I guess right now within the Fibre Centre and CFS, we use the same information technologies on the system to support communication. FPInnovations is outside that. They wouldn't use the same GCDOCS. If we start communicating well internally through these systems, sharing of documents, FPInnovations is outside that; so, we have to figure out a different system collaborating with them. *(Researcher)*

Synchronize Business Planning Cycle: More collaborative planning. I think in a sense that's one of the bigger stumbling blocks. We work on different planning cycles. So when we're trying to figure out what we're doing, FPInnovations has already got next year figured out…We're not doing a very good job of sitting there together. Here's a research question that we're both interested in. How do we actually do it together? *(Researcher)*

Align Short-Term and Long-Term Research: They got to get around this short-term research focus. They are really trying to pit two different types of researchers together, and that doesn't necessarily work. We have an accountability to the public for spending public dollars. It's got to be in the public domain. It's got to be peer-reviewed. They have quite the opposite. They're work is not in the public domain…And they don't have to peer-review. *(Researcher)*

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Link Basic and Applied Research: The big factors would be our external collaborators because the mutual stakeholder[s] for FPInnovations and ourselves [are] forest industry and provincial governments…We need that third party, external partner, that will facilitate the need to have participation both from the very applied FPInnovations perspective as well as the focused and developmental research perspective of the CFS. *(Manager)*

ENABLING COLLABORATION WITH EXTERNAL PARTNERS DURING TRANSFORMATIONAL CHANGE

Two main themes emerged for the participants: identify research policy questions, and increase resources.

Identify Research Policy Questions: Nearly two-thirds of the managers stated that there is a need to identify what the research policy questions are and how relevant these questions are to government, industry, as well as the public. There is a need to have more open dialogue with the key stakeholders to validate the forestry issues impacting the forest sector and economy.

Increase Resources: To a lesser degree, approximately one-third of the researchers and managers stated that both sides need to bring players to the table and validate the commitment of resources against the real scientific priorities and issues.

4.5.13   Perceptions of Constraints in Collaboration during Transformational Change

Participants were asked: *In this period of transformation, please describe what factors would constrain researchers to collaborate more effectively within CWFC, across CFS, with*

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FPInnovations, and with external partners? Table 14 outlines three primary themes that would constrain collaboration within the CWFC, specifically new bureaucratic processes, inability to travel, and lack of funding. To a lesser degree, managers also stated staffing reductions and lack of succession planning, while researchers stated a lack of shared communications.

Table 14 Perceptions of Constraints in Collaboration during Transformational Change

THEMATIC CATEGORIES					
RESEARCHERS	**(N=13)**		**MANAGERS**	**(N=8)**	
	N	**%**		**N**	**%**
CONSTRAINING COLLABORATION WITHIN CWFC					
TRAVEL *(Inability to Travel)*	8	62	NEW ADMINISTRATIVE PROCEDURES	5	63
NEW ADMINISTRATIVE PROCEDURES	4	31	RESOURCES *(Lack of Funding)*	4	50
SHARED COMMUNICATIONS *(Lack of)*	3	23	SUCCESSION PLANNING *(Staffing Reductions and Succession Planning)*	3	38
CONSTRAINING COLLABORATION ACROSS CFS					
NEW ADMINISTRATIVE PROCEDURES	4	31	LACK OF COMMON OR URGENT MOTIVATING PROBLEMS	4	50
RESOURCES *(Lack of Funding)*	3	23			
CONSTRAINING COLLABORATION WITH FPINNOVATIONS					
INABILITY TO INTERACT	4	31	LACK OF COMMON OR URGENT MOTIVATING PROBLEMS	4	57
RESOURCES *(Lack of Funding)*	3	23			
BUSINESS MODEL	3	23			
CONSTRAINING COLLABORATION WITH EXTERNAL PARTNERS					
RESOURCES	5	38	RESOURCES	(N=5)	
				4	80
INTELLECTUAL PROPERTY	3	23			

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CONSTRAINTS IN COLLABORATION WITHIN CWFC

New Administrative Hurdles: Nearly two-thirds of the managers and one-third of the researchers stated that the new administrative processes continue to constrain collaboration.

Inability to Travel: Researchers were mostly troubled by the inability to travel to meet with colleagues, attend conferences, and conduct fieldwork. Nearly two-thirds of the researchers were concerned that they would not have the ability to interact face-to-face with colleagues.

Lack of Funding: For one-half of the managers, staff reductions have led to reduced resources. One manager stated: "Transformation is causing us to get a little more regionally protective and a little bit more possessive as it relates to resources, both human and cash resources."

CONSTRAINTS IN COLLABORATION ACROSS CFS

The main constraint to collaboration across CFS during a period of transformational change is based on not having a common or joint problem that would require greater skills and participation across the CFS. One-half of the managers stated that a lack of a common or urgent motivating problem is a major constraint to collaboration. A joint problem would create the synergies for working together and would motivate researchers to cross-pollinate across the CFS. To a lesser degree, researchers felt that the new administrative procedures and a lack of funding are additional constraints to collaboration.

<div style="text-align:center">CONSTRAINTS IN COLLABORATION WITH FPINNOVATIONS</div>

Similarly, the managers relayed that the main constraint to collaboration across FPInnovations is not having a common or joint problem to work on together. Over one-half of the managers stated that a lack of a common or urgent research problem continues to constrain collaboration between the organizations. To a lesser degree, researchers also felt that the inability to interact with other researchers, a lack of funding, and the current business model would continue to constrain collaboration with FPInnovations.

<div style="text-align:center">CONSTRAINTS IN COLLABORATION WITH EXTERNAL PARTNERS</div>

The biggest constraint to collaboration with external partners, particularly for the managers, is the lack of resources (both financial and human resources).

4.5.14 Perceptions of Improving Collaboration Performance

Participants were asked: *If you were given an opportunity to improve collaboration in scientific research within CWFC, CFS, FPInnovations and external partners, what would be [up to] three of the most important elements that would increase collaboration performance?* Table 15 outlines the main thematic categories stemming from this question.

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Table 15 Perceptions of Improving Collaboration Performance

THEMATIC CATEGORIES					
RESEARCHERS	**(N=13)**		**MANAGERS**	**(N=8)**	
	N	**%**		**N**	**%**
IMPROVING COLLABORATION PERFORMANCE WITHIN CWFC					
CULTURE OF COMMUNICATIONS	9	69	CULTURE OF COMMUNICATIONS	7	88
SYNERGY TO WORK ON JOINT PROBLEMS	5	38	SYNERGY TO WORK ON JOINT PROBLEMS	4	50
RIGHT EXPERTISE/SKILLS	5	38	RIGHT EXPERTISE/SKILLS	3	38
RELATIONSHIPS & TRUST	4	31	RELATIONSHIPS & TRUST	3	38
RESOURCES *(Distribution of Funding)*	3	23			
IMPROVING COLLABORATION PERFORMANCE ACROSS CFS					
CULTURE OF COMMUNICATIONS	8	62	SYNERGY TO WORK ON JOINT PROBLEMS	5	63
SYNERGY TO WORK ON JOINT PROBLEMS	4	31	CULTURE OF COMMUNICATIONS	4	50
RIGHT EXPERTISE/SKILLS	4	31	RIGHT EXPERTISE/SKILLS	4	50
RELATIONSHIPS & TRUST	3	23			
IMPROVING COLLABORATION PERFORMANCE WITH FPINNOVATIONS					
CULTURE OF COMMUNICATIONS	6	46	SYNERGY TO WORK ON JOINT PROBLEMS	7	88
SYNERGY TO WORK ON JOINT PROBLEMS	5	38	CULTURE OF COMMUNICATIONS	6	75
BUSINESS MODEL & PRACTICE	5	38			
DECREASE FUNDING RESTRICTIONS	4	31			
IMPROVING COLLABORATION PERFORMANCE WITH EXTERNAL PARTNERS					
CULTURE OF COMMUNICATIONS	7	54	CULTURE OF COMMUNICATIONS	**(N=6)**	
				4	67
SECTOR PRIORITIES	3	23	SECTOR PRIORITIES	3	50

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IMPROVING COLLABORATION PERFORMANCE WITHIN CWFC

In defining the way ahead for improving collaboration performance within the CWFC, both managers and researchers were very similar in their overall responses. Four themes were highlighted: create a culture of communications; foster greater synergy to work on common problems; link researchers with the right expertise/skills; and build interpersonal relationships to establish greater trust.

Create a Culture of Communications: Almost all of the managers and over two-thirds of the researchers stated that the CWFC has to create a culture of communications in order to increase collaboration performance. Building a culture of communications requires a culture change. One manager stated that developing an "ideas lab" would be beneficial in getting researchers to come together in a space where they could offer ideas in an open environment and allow researchers to build on those ideas without the fear of losing their innovative concepts. This culture would be based on researchers actively contributing to the development of ideas. As ideas circulate, the collaboration develops organically across the organization.

Moreover, communications refers to increased face-to-face meetings in which the interactions between people are developed over time. Participants stated that there is a greater need to have researchers meet face-to-face to help build more sustainable relationships, similar to the way the former employee science forums had enabled greater opportunities to meet people. For example, one researcher stated: "I would bring back the Fibre Centre annual meeting [employee science forum]. I would encourage networking opportunities…through workshops."

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Foster Greater Synergy to Work on Common Problems: One-half of the managers and over one-third of the researchers stated that there is a need to foster greater synergy among the researchers within the CWFC so they may continue to work on common problems of national importance. As one manager stated, "The benefit is for the collective as opposed to the individual…It's just a different thought process…So, as opposed to going from an individual impact and appreciation to more of a collaborative group impact and appreciation."

Link Researchers with the Right Expertise/Skills: A little over one-third of the managers and researchers stated that there is a need to link researchers together so that they may leverage each other's knowledge and expertise to fulfill the goals and outcomes of their research projects.

Build Interpersonal Relationships: About one-third of the managers and researchers stated that building interpersonal relationships within the organization gives researchers a feeling of belongingness. This sense of organizational belonging originates in senior management where the objective is to nurture and respect all researchers.

IMPROVING COLLABORATION PERFORMANCE ACROSS CFS

Three main themes emerged from the participants' responses as to how collaboration performance can be improved across the CFS: foster greater synergy to work on common problems, enhance communications, and link researchers with the right expertise/skills. A few researchers noted the importance of building trust. These themes are very similar to the participants' responses for improving collaboration performance within the CWFC.

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Foster Greater Synergy to Work on Common Problems: Nearly two-thirds of the managers and one-third of the researchers stated that there is a need to foster greater synergy between the CWFC and CFS by working on common problems of national importance.

Enhance Communications: About two-thirds of the researchers and half of the managers stated that through more effective communications and networking, researchers are able to improve their collaborative performance across the CFS. Open communication fosters more effective collaborations across the CFS, and is essential to breaking down silos across the research community. For example, one manager stated:

> We need to think of ways to work better collaboratively, virtually, and more connected as we are going through complex problems. We need to have complex solutions. With complex solutions, means we need to collaborate and bring each of our skills to the table.

Link Researchers with Right Expertise/Skills: One-half of the managers and about one-third of the researchers stated that linking researchers with the right expertise/skills would leverage skills across the CFS.

IMPROVING COLLABORATION PERFORMANCE WITH FPINNOVATIONS

Two major themes emerged from the participants' responses as to how collaboration performance can be improved with FPInnovations: create greater synergy to work on common problems, and enhance communications between researchers so that they may advance the science. A few researchers also noted the need to reassess the FPInnovations business model and to decrease funding restrictions.

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Foster Greater Synergy to Work on Common Problems: Interestingly, nearly all of the managers and over one-third of the researchers recommended the need to create greater synergy between researchers so that they may work on common problems. Working on common problems takes into consideration the need to re-examine the FPInnovations business planning side (i.e., the business model and process). This process would involve an increased integration of key players at the development phase and the need to produce common outputs based on national objectives. To do so would also entail linking basic and applied research. One manager stated,

> As the relationship grows, and continues to evolve, and gets to a point where everybody looks in and says these two organizations are mutually dependent on each other…So then figure out how to collaborate because you're in it together. Right now, we're not fully committed to being knitted together. How can we strengthen that and get us to a point…where one without the other, you don't get anything?

Enhance Communications Between the Researchers: Improved communications would help to increase collaboration performance with FPInnovations. Three-quarters of the managers and nearly one-half of the researchers stated that there is a need to enhance communications to promote research. Ways to accomplish greater interaction between the researchers could include seminars, workshops, *Lunch and Learn* activities, and other information exchanges.

IMPROVING COLLABORATION PERFORMANCE WITH EXTERNAL PARTNERS

Two major themes emerged from the participants' responses as to how collaboration performance can be improved between the CWFC and external partners: enhance multi-level communications inter-organizationally, and promote a collective vision and shared priorities.

Enhance Inter-organizational Communications: About two-thirds of the managers and over one-half of the researchers stated that enhancing communications with external partners would include greater openness of information and knowledge. They believe that face-to-face discussions are required to examine science needs and priorities. Employee exchanges between organizations are fundamental to fostering a collective vision and identifying national priorities with key stakeholders and partners.

Establish Collective Vision and Shared Priorities of Forest Sector: One-half of the managers and one-quarter of the researchers disclosed that establishing a collective vision and shared priorities of the forestry industry would advance the competitiveness and optimization of the forest sector.

4.5.15   Summary of Ethnographic Interviews with CWFC Participants

The interviews with the CWFC researchers and managers yielded several important findings. These participants stated that the CWFC has an *organizational culture* that strongly promotes collaboration, both intra-organizationally and inter-organizationally. Although some researchers stated that there is a lack of collaboration in the CWFC, the majority of the CWFC participants felt that the *governance* structure fosters an integrated *collaborative culture* that

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relies on researchers' *collective leadership* and strengths to optimize the full value chain of the forest sector. This organizational culture is based on having a *collective vision* and *shared leadership*, a culture where researchers agree on the intended outputs and anticipated outcomes of their research projects. A shared vision is also characterized by the need to create a sense of *integration* in which researchers share ideas freely and concentrate on achieving *common project objectives*. For example, both CWFC researchers and managers stated that collaboration with organizations (e.g., FPInnovations, CFS, and external partners) requires a shared vision of the problem to ensure the intended quality and impact of the end-product. A shared vision also embodies greater *synergy* among the researchers. For example, the CWFC managers stated that by *working together* within an integrated systems approach, researchers essentially take a collective view to examine common national priorities with key partners/collaborators. This integrated systems approach helps to cultivate solid working relationships with collaborative partners across the CFS, FPInnovations, territorial, provincial and federal governments, academia, and other industry partners.

The CWFC researchers and managers primarily defined effective collaboration in relation to organizational and internal team processes that impact the quality of their outputs and outcomes. The main processes that define the way in which teams function include the following: *sharing a common vision*; *fostering collective leadership*; *working together to enable greater team integration and synergy*; *sharing communications through face-to-face interactions* (e.g., employee science forums); *learning through leveraging scientific knowledge and expertise*; *nurturing interpersonal relationships*; and *exercising team leadership*. The participants also

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stated that a collaborative culture needs to have *values* that enable greater integration (e.g., *mutual respect and trust*). These internal team processes are essential for developing a shared product, one for which each person's contribution enhances the team's performance and the overall success of the project.

The CWFC participants generally felt that *positive impacts* resulting from collaborations (e.g., knowledge applied by an end-user to advance a process or system) represented the biggest sign of collaboration success. The *desire to collaborate again* with the same researchers on future projects also characterizes effective collaboration. Researchers stated that having the right team composition and personalities enables them to work in a synergistic environment where each team member contributes to the successful achievement of the outputs and anticipated outcomes. Also, the vast majority of participants highlighted that *face-to-face communications* helps to establish stronger connections and trust within the project team and contributes to successful team performance, the willingness to work together again, and overall satisfaction. The participants noted that failure to reach the intended outputs and outcomes results in lost productivity, loss of time and money, additional costs, lack of personal and team satisfaction, and the lack of desire to collaborate again with the same researchers. Successful collaborations were also described as being comprised of researchers who clearly understand their *roles*, and know how each person can contribute to the advancement of team productivity and team performance. The participants highlighted that researchers need to take *collective ownership* of the project and be *committed* to its accomplishment and success.

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Collaboration across the CFS was also viewed positively; however, participants stated that *a culture of integrated teams needs to be cultivated* to better address common research problems (e.g., integrated systems approach). The CWFC managers were adamant about *aligning common objectives* between the organizations and examining more *collective ways* to address national priorities and overarching goals of the forest sector. Participants stated that building *stronger relationships* across the CFS helps to tap into the different *expertise* and partnerships, and ensures proper communication tools to enable greater *synergy* between researchers.

As a main industry partner to the CWFC/CFS, FPInnovations plays a fundamental role in the optimization of wood fibre innovation. FPInnovations primarily responds to the needs of industry members, and provides cost-recovery research services on applied short-term research projects. The CWFC, on the other hand, provides long-term research that is peer-reviewed for scientific publications. The differences in mandates and organizational practices create challenges between the organizations. The CWFC participants felt that there is a need to reassess the funding process between the CWFC and FPInnovations, *enhance communications and interactions*, synchronize business planning cycles, align short-term and long-term research, and link basic and applied research. The participants also recommended the need for *better integration* between the organizations to *solidify relationships* and to create secondment opportunities between the organizations. As a result, participants recommended the need to create more *common approaches*, *collaborative environments*, and *principles of engagement*. Although the CWFC-FPInnovations partnership has resulted in numerous successful collaborations, the interdependency of the programs relies on a better alignment of cultural

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elements, priorities, systems, and business processes to enable greater integration between the organizations. These factors augment team performance and collaboration practices.

The transformational change of the forest sector has been regarded as generally positive. The majority of participants expressed the importance of their impacts on the forest sector, and felt that their end-products have been well received by the end-users. However, a few of the organizational changes stemming from the federal government were not viewed as positively. Researchers addressed challenges with learning new administrative processes, decreased productivity in scientific research, scarce resources, and the inability to travel to leverage scientific knowledge and establish more integrated working relationships. These challenges need to be revisited with regard to the implications of organizational change on scientific productivity and relationship-building. Participants stated that improvements to collaboration would entail integrated programming, more face-to-face communications with research experts, and enhanced relationship-building to better address common objectives with national application.

The majority of participants felt that better integration practices with other external partners and academia would require the establishment of common goals, clearly defined outcomes, the transfer of knowledge to industry, and complementary expertise. The participants also felt there is a greater need to work on national objectives and common problems with CFS, FPInnovations, other government departments, industry and academia, and to further change the culture of communications between the organizations. Such sharing would enable greater collaboration and would create a more holistic approach to finding solutions and innovations in forestry research.

4.6 PART II: CWFC Managers' Perceptions of Collaboration in Scientific Research—Focus Group Findings

The CWFC managers took part in a focus group and discussed their perceptions of collaboration in scientific research within the CWFC, across the CFS, with FPInnovations, and with external organizations. The responses to the questions yielded several important themes that represent the CWFC managers' perceptions of collaboration.

4.6.1 Characteristics of Collaboration in Scientific Research

The CWFC managers were asked: *When you think of collaboration in scientific research, what characteristics come to mind?* The main thematic categories that emerged include a common issue or goal that fosters a mutual benefit, trust, shared communications and information, and leveraged complementary expertise and financial resources.

Common Issue or Goal that Fosters a Mutual Benefit: According to the CWFC managers, one of the main characteristics of collaboration is the need to address a common goal. Collaboration in scientific research is viewed as "pushing boundaries for mutual benefit." The collaborators may come from different organizations; however, the people work within a collective to advance the projects' goals. As one manager stated, "The realization is that you cannot do it alone." The collaboration leads to a shared product that is leveraged by all team members.

Trust: The CWFC managers stated that trust is another important characteristic of collaboration in which there is a willingness to share information freely as opposed to withholding information relevant to the collaboration. Attributing credit to people is also

important in maintaining trust. Participants stated that it always comes down to trusting

relationships in fostering collaboration.

Sharing Information through Open Communications: The CWFC managers revealed

that sharing necessary information enables greater agreement as to how the information is

communicated and interpreted. However, one manager stated, "If there's a rule in your

organization that forces you to collaborate, would that have the same kind of flavour and results

than if you actually realized as a person that you need to?"

Leveraging Complementary Expertise and Funding: The CWFC managers disclosed

that leveraging complementary expertise is essential in collaboration, in which team members

share their knowledge, skills, perspectives, and experiences in realizing the project goals. In

leveraging such expertise, these participants stated that team members need to be willing to listen

to each other's perspectives.

4.6.2   Personal Attributes that Define a Good Research Collaborator

The CWFC managers were asked: *Based on your experience, what are the personal*

attributes that make up a good collaborator in scientific research? Participants stated that good

collaborators work in a collective, exhibit emotional intelligence (i.e., adaptable, open-minded,

truthful, open to criticism, self-confident, risk-takers, and humble), and are able to communicate

effectively to different audiences about their science.

Work in a Collective: There is a synergistic relationship between people that creates

greater energy and passion for science. People's collective efforts enable scientific excellence.

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Science must be fun, and there is a need to learn from others. Having suitable personalities enables good collaboration (e.g., respect and willingness to work together). One CWFC manager stated, "The biggest detriment is conflicting personalities…It really comes down to respect and willingness to work together. As managers, we spend 80% of our time dealing with personalities."

  Exhibit Emotional Intelligence: A couple of CWFC managers stated that emotional intelligence derives from being open-minded, truthful about personal research limitations, and able to withstand strong criticism. There must also be a willingness and enthusiasm to learn with humility and intelligence.

  Effective Communicators: The CWFC managers also revealed that researchers must be good communicators. Researchers are very passionate about their science, and they need to be able to communicate effectively to different audiences about their work.

4.6.3 Culture of Collaboration

  The focus group participants were asked: *How would you describe the culture of collaboration in scientific research within the CWFC, across the CFS, with FPInnovations, and with external partners?* Within the CWFC, the managers described the culture of collaboration as being open, transparent, and fair. Leadership plays an important role in enabling a collaborative culture. One manager stated, "If you're asking about collaboration in the Fibre Centre, it's exceptional between the cross-linkages with our own staff." Another manager stated that the CWFC worked hard at developing a culture of collaboration. A third manager stated that

collaboration is depicted as a tool within the toolbox; it can be implemented any time. However, it does not have to be employed all of the time.

The CWFC managers had mixed perceptions about the culture of collaboration across the CFS. A couple of managers stated that CFS has a relatively healthy collaborative culture. According to one manager, there has been an increase in collaborations over the last two years. Another manager stated that there has been a lot of effort into promoting collaboration across the CFS, particularly as it relates to science, policy, and analysis. However, one manager stated that collaboration has been inconsistent across the CFS. This may be attributed to different perceptions of collaboration across the diverse regions. Another manager felt that there is not sufficient sharing of information among colleagues. This manager stated, "We work in close proximity with colleagues, but we don't know what they do. I think it's relatively poor."

The CWFC managers described collaboration with FPInnovations as being "ad-hoc", "pragmatic" and "goal-oriented." These managers were not certain if it could be called real collaboration because FPInnovations' researchers are charging fees for their services. The managers agreed that if there is incongruence in the way collaboration is depicted between the two organizations, there needs to be a more common understanding of collaboration.

A few CWFC managers described collaboration with external partners as being "healthy" and "vibrant." Opportunities with universities could be very fruitful; however, sometimes there is an element of competition that exists with the universities. This may be attributed to a scarcity of resources. One manager stated, "There's definitely a history within CFS and more so with FPInnovations [about] the feeling of competition with the universities, especially in days of

scarce resources." Another manager stated that collaboration occurs if there is funding coming from the government. However, this manager expressed some cynicism by saying, "We're good at collaborating because we have money. It draws people. But if we didn't have money, and we weren't paying for people to work with us, what would the level of collaboration be?"

4.6.4   Big Drivers of Change Affecting Collaboration in Scientific Research

The focus group participants were asked: *The federal government is going through a period of transformational change. Based on your experience, what are some of the big drivers of change that are affecting collaboration in scientific research?* The two major themes include open science and economics of efficiencies.

Open Science: According to the CWFC managers, the biggest driver of change is *open science* in the federal government. The speed of change is contributing to how research is carried out across the scientific communities. *Blueprint 2020* outlines the need for a whole-of-government approach where open science fosters more integrated ways of working together. However, one manager stated that controlled messaging by the government takes the enthusiasm away from the researchers and contradicts open-sharing of information. Companies like Google primarily foster environments that are based on openness and different collaboration models. The federal government has an opportunity to learn from these companies' collaborative business processes and cultures. The trend is to change cultures to enable greater sharing of information.

Economics of Efficiencies: Another driver of change looks at the "economics of efficiencies." One CWFC manager asked, "Are they real efficiencies or false efficiencies?" The

concern is that the goal is to save money; however, are we being efficient as a result of these cost-saving measures? Another manager added that centralizing processes may contribute to greater efficiencies; however, there is a loss of ownership and accountability that results from this centralization. A third manager stated that the approval process (i.e., approval process for travel) has created a system that is not based on trusting professionals to make the right decisions. A lack of trust and respect for science becomes the ultimate driver of change.

4.6.5   Approaches to Organizational Change to Enable Effective Collaboration

The focus group participants were asked: *During this period of transformational change, what approaches to organizational change need to be considered to enable effective collaboration in scientific research within the Canadian forest sector?* Two major themes emerged: re-establish collaborative structures for scientific networks/consortia; and re-examine the new bureaucratic processes that are impacting the time spent on conducting science.

Re-establish Networks/Consortia: Several CWFC managers stated that there is a need to re-establish the structures/processes that bring together a network or consortia of actors from universities, industry, and provincial governments. The lack of structure is most evident at the regional levels, and it has had an impact on collaboration among those actors. Moreover, there is a need for more information exchange mechanisms that enable staff to freely move and grow among the organizations. Such mechanisms would also address the gaps in skills and expertise to enable more effective collaboration across the networks/consortia. Leadership also plays a role in fostering better collaborative planning in research.

Address New Bureaucratic Burden: Many CWFC managers noted that the new bureaucratic structures have had a negative impact on how science is conducted at the federal level. For example, travel restrictions have had serious implications on collaboration, both internally and externally. According to one manager, it is important to reduce the impediments that affect researchers' innovative creativity and enthusiasm for science. The new bureaucratic factors have had an impact on decision-making at lower levels. According to this manager, "the organizational change to enable collaboration could be to restore decision-making at a lower level because some of the discretion has been pulled up higher."

4.6.6   Integrated Working Relationships

Participants were asked: *You're given the opportunity to design Canada's forest sector for the year 2025. What are the elements that would enable more integrated working relationships within the CWFC, across the CFS, with FPInnovations, and with external partners?*

Within the CWFC, participants stated that effective visionary leadership is one element to administering the scientific research program. One manager stated that there needs to be a new, robust, and agile framework for administrating science-based research. This agile framework needs to incorporate leadership and diverse expertise to carry out science more effectively. For example, an R&D workforce needs to be balanced with the right number of researchers, analytical specialists, and technologists. There is also a need to hire more administrative staff and free up some of the research staff. For example, one of the three research domains, *Characterization*, is a good model for demonstrating how a group of people with the required

expertise are able to effectively manage a large research domain across Canada (e.g., research on enhanced inventory systems). Researchers working in this domain have developed their own integrated program across the country in tandem with universities and industry. Exchange programs that enable researchers to work across the Centre, within universities, and with industry have the potential to bolster the research program and contribute more effectively to the forest sector. There is an additional requirement to have people with soft skills expertise. This enables greater support and flexibility among people and component activities. A better technological system also fosters more effective communications and interactions over long distances.

Participants stated that the CFS needs to evolve into what the CWFC is today. One manager stated that this entails "the elimination of barriers to sharing intellectual resources." The new management structure would be horizontally-based as opposed to vertically-based.

FPInnovations could be known as the "world-renowned institute for the forest sector." It would possess a common forest sector planning platform with the government and industry to enable more integrated forest sector research strategies. Employees at FPInnovations would be co-located in more regions across Canada and would be involved in real collaborative research.

External partners could include landowners and managers as part of the collaborative research effort for setting priorities and implementing results. There would be less competition among universities and more flexibility of assignments/exchange programs. Professors on sabbaticals would come to work in government; students would work in government; and

government scientists would work in universities. Also, a common plan with the provinces would enable more effective planning, conduct, and implementation of forest sector research.

4.6.7   Characteristics that Embrace Blueprint 2020

Participants were asked: *Blueprint 2020 "envisions a capable and a high-performing Public Service that embraces innovation, transformation, and continuous renewal." Please describe the characteristics that would foster a federal science and technology community that embraces "innovation, transformation, and continuous renewal."*

Restoring the Value of Science: Participants stated that there is a need to "restore the faith and results of science." One manager stated, "We need a government that really sees the value of science." Promoting the value of science requires strong leadership and support. According to another manager, it is also important to give responsibility back to the scientists. In redistributing their science better, researchers feel more empowered in their decision-making capabilities. Restoring the faith and value of science helps to renew the passion for innovation.

Succession Planning: Participants also stated that there is a need to look at succession planning for researchers. According to the managers, the younger staff need to be coached and mentored before the older staff leave for retirement. As one manager stated, "For every three people that retire, we only hire one. It will be a transformation. But it won't be innovation."

Systems-thinking Approach: The CWFC managers stated that taking a systems-thinking approach enables staff to make more effective decisions.

Greater Transparency: The CWFC managers discussed the need to attract greater transparency. One manager stated, "[A] lack of transparency fosters [a] lack of trust, loss of motivation. More transparency leads to greater trust and respect."

Leadership for Identifying Research Priorities: The CWFC managers stated that leaders needs to plan a clear strategy and framework to best identify and prioritize research.

4.6.8   Enduring Values for 2025

Participants were asked: *The Public Service of Canada holds the following enduring values: "Respect for Democracy, Respect for People, Integrity, Stewardship, and Excellence." What would be the main enduring values that would shape the integration of collaborative science with policy and management in the year 2025?*

Values of Respect and Trust: The CWFC managers stated that there needs to be respect for the Public Service, respect for democracy, and respect for people and their contributions. The values of respect and trust encompass freedom, interaction, and personal accountability. These values also involve pushing the boundaries for continuous improvement in the forest sector. One manager stated, "With respect and trust, you have that motivation to push forward."

Value of Diversity: The CWFC managers spoke about the need to believe, practice, and encourage diversity (including diversity in culture and scientific language).

Value of Will to Succeed: The CWFC managers underlined the will to succeed. One manager stated that the will to succeed helps to shape successful collaborations. Having the right attitude integrates the collaboration of science, policy, and management. The will to succeed also

encompasses not being afraid to fail. Failure is part of growth and allows people to learn from their mistakes.

4.6.9   Summary of Focus Group Findings with CWFC Managers

The focus group with the CWFC managers generated several important findings. These managers characterized collaboration in scientific research as a *common issue or goal* that fosters a mutual benefit. In a collaborative team environment, members *trust* each other and *share their communications*. Team members *leverage their expertise and skills* as well as their *financial resources*. Team members are characterized as good collaborators if they *work collectively*, display emotional intelligence (e.g., adaptable, open-minded, truthful, open to criticism, self-confident, risk-takers, and exercise humility), and effectively present the science to different audiences. *Organizational culture* plays a significant role in enabling effective collaboration. These managers described the *culture of collaboration* as being open, transparent, and fair. However, there are government-based drivers of change (e.g., the need for more open science and the economics of efficiencies) that are shifting the landscape of collaboration.

As the CWFC continues to go through transformational changes, the CWFC managers said that there is a need to re-establish collaborative structures for scientific networks/consortia and to re-examine the new bureaucratic processes that are having an impact on the time spent on conducting science. The CWFC managers noted that *integrated relationships require effective visionary leadership* and the *elimination of barriers for sharing intellectual resources*. The CFS needs to evolve to a more dynamic and resourceful organization that leverages partnerships with industry players for greater innovative capacity. FPInnovations needs to look at investing in a

common forest sector planning platform with the government and industry to enable more integrated and innovative forest sector research strategies, processes, tools, and products. External partners need to create wider networks with landowners and managers as part of the collaborative research efforts for setting priorities and implementing research results. Less competition among universities and more flexibility of assignments/exchange programs enable greater integration for more effective planning, development, and implementation of forestry sector research.

Part of the innovation, transformation, and continuous renewal of the federal government needs to be the recognition that the value of science must restore the faith in the results of science. Promoting the value of science requires strong leadership, and a systems-thinking approach to enable greater openness and transparency when identifying and resourcing research priorities. These managers noted that the future years call for more *enduring values* to better shape the integration of collaborative science. These values include *trust, respect* (i.e., respect for the Public Service, respect for democracy, and respect for people and their contributions), *diversity* (e.g., diversity in culture and scientific language), and the *will to succeed collectively*.

4.7 PART III: Industry Perceptions of Collaboration in Scientific Research—Interview Findings

4.7.1 Characteristics of Collaboration in Scientific Research

Senior managers from FPInnovations were interviewed to gauge their perceptions on collaboration in scientific research. These managers were asked: *When you think of collaboration in scientific research, what characteristics come to mind?* The managers stated that having a

common vision, with shared goals, objectives, and values, and having the ability to leverage key resources represented the two main characteristics of collaboration.

Common Vision, Goals, Objectives, and Values: FPInnovations' managers stated that the main characteristic of collaboration is the need to have a common vision, with shared goals, objectives, and values. Researchers collaborate towards a common vision, one in which the common goals define the outcomes of the research. The values define how researchers in the collaboration want to work together to achieve their goals. If researchers work together to cover the full value chain, then silos are broken down, and the researchers align themselves with the common vision and plan. Delivering more value together is essential; however, all parties need to understand the principles of engagement and the expectations for achieving the outputs and anticipated outcomes.

Leveraging Key Resources: Participants stated that leveraging specific resources (i.e., money, human resources, and capabilities that include upstream research) contributes to the optimization of the forest sector value chain.

4.7.2   Culture of Collaboration

Industry managers were asked: *How would you describe the culture of collaboration in scientific research within FPInnovations, with the CWFC, with CFS, and with external partners?*

CULTURE OF COLLABORATION WITHIN FPINNOVATIONS

Within FPInnovations, two major themes emerged. The managers stated that the culture of collaboration is based on members' needs and innovative thinking.

Collaboration in Scientific Research: *Factors that Influence Effective Collaboration during a Period of Transformational Change*

Members' Needs: According to these managers, collaboration is based on members' needs. One manager stated that FPInnovations' culture tries to ensure that members' needs are fulfilled in a timely fashion. This manager described this need as an "obsession" to ensure that the member is satisfied with the end-state. Another manager stated that a member-based collaboration model helps to generate greater collaborative capacity through capabilities found in government (provincial and federal), industry, and academia.

Innovative Thinking: For FPInnovations, innovation optimizes the full value chain for the forest sector. By innovating together, these managers felt that cross-boundary collaboration creates "cross-boundary pollination."

<div align="center">CULTURE OF COLLABORATION WITH CWFC</div>

Three themes addressed FPInnovations' working relationship with the CWFC. First, the culture of collaboration has been challenging. Second, the relationship between the CWFC and FPInnovations helps to deliver the full value chain of the forestry sector. Third, the federal administrative processes have an impact on the timely delivery of products.

Challenging Collaborative Culture: These managers spoke primarily about the differences in culture and mandates. The relationship between FPInnovations and the CWFC was difficult at the beginning because both organizations were experiencing growing pains in learning how to work together. As one manager stated, "How [can] you bring the two cultures together? It's a bit challenging."

Collaboration in Scientific Research: *Factors that Influence Effective Collaboration during a Period of Transformational Change*

Synergistic Relationship to Delivering Full Value Chain: According to FPInnovations' managers, both organizations at the very beginning had difficulty in understanding each other's mandate. Too much emphasis had been placed on downstream research; more emphasis had to be placed on the value of upstream research. One manager stated that the CWFC is part of FPInnovations. There is a need for a more synergistic relationship between the two organizations. Both organizations vary in their approaches and oversight; however, they have a common goal. This manager described the CWFC as a "key conduit" for FPInnovations. According to the industry managers, the culture of collaboration between FPInnovations and the greater CFS is contingent on the strength of their relationship. One manager stated that there is very strong collaboration with CFS. This manager said that the CFS is a firm supporter of FPInnovations; and as a result, the culture of collaboration between the two organizations has been improving over time.

Challenges with Federal Government Administration: The managers described the administrative processes as being difficult, slow, and not delivery-oriented. One manager stated, "On the administrative aspect, it is painful."

CULTURE OF COLLABORATION WITH EXTERNAL PARTNERS/ACADEMIA

The industry managers spoke primarily about their collaborative relationships with academia. Hiring the best graduates from the universities is essential for developing innovative research. Collaborative partnerships with universities have enabled FPInnovations to have oversight responsibilities over the wood fibre network. One manager stated that closer collaborative relationships need to be developed with universities. Another manager stated that

although relationships with universities are important to maintain, academic institutions tend to

go off on tangents which create challenges for researchers to fulfill their specific objectives and

to deliver the products in a timely manner. Working with the colleges tends to be more beneficial

than working with the universities because the colleges share the same goals as FPInnovations in

delivering their products. One manager stated that having direct relationships with associations

and councils (e.g., Forest Products Association of Canada, and Canadian Wood Council) enables

critical knowledge transfer to industry stakeholders. They also play an important "collaborative

role in informing and gaining support from the federal and provincial funders for our

operations." Another manager stated that it is important to work with First Nations Peoples. First

Nations Peoples are developing their own natural resources at the community level, and there is a

fundamental need to continue to respect and learn about their cultures, their peoples, and their

communities.

4.7.3   Elements that Improve Collaboration Performance

Industry managers were asked: *If you were given an opportunity to improve collaboration

in scientific research within FPInnovations, with the CWFC, with CFS, and with external

partners, what would be the three most important elements that would increase collaboration

performance?*

IMPROVE COLLABORATION PERFORMANCE WITHIN FPINNOVATIONS

Create Greater Synergies: The predominant theme articulated by FPInnovations'

managers was the need to increase collaboration performance in FPInnovations by creating

greater synergies within the organization. One manager stated that FPInnovations staff should be

given ample opportunities to get together, as the CWFC researchers had been getting together at the employee science forums. The objective would be to set strategic priorities and planning, and reach out to other teams for additional resources. Research portfolios would be based on cross-cutting projects, and funds would be allocated to collaborative projects teams.

Examine Better Training Approaches to Science Innovation: FPInnovations' managers stated that the staff have taken the Needs, Approach, Benefits and Competition (NABC) training which has given researchers an opportunity to examine the relationship between science and the human. By role playing, the researchers are able to examine different perspectives and determine the best possible outcomes from a project. As a result, it is important to identify the science being employed and the deployment of the science through evidenced-based training and prioritized research.

IMPROVE COLLABORATION PERFORMANCE WITH CWFC

Enable Better Integration: The main factor that would increase collaboration performance with the CWFC would be to create better integration between team players. Better integration would involve co-locating FPInnovations researchers with CWFC researchers. The creation of joint teams represented another suggestion: once a project is established, it should not be regarded as a specific organizational project, but a team or joint project. For mutual projects, resources should be used collectively. One participant also suggested that both organizations should consider secondments or sabbatical exchanges. Part of this effort would involve the establishment of key performance indicators. One manager stated that collaboration should represent a key performance indicator because there is a need to have more collaboration

between the organizations. Greater strides to collaborate between the two organizations occurred at the beginning of the FPInnovations-CWFC partnership. In addition, a transformation framework would create a "common nucleus point" to enable researchers to understand the general goals of the forest sector. The framework would also create a common language for innovation, and would generate a balance between the different providers. This would entail the need to make decisions collectively.

<div align="center">IMPROVE COLLABORATION PERFORMANCE WITH CFS</div>

Enable Better Integration: The main factor that would increase collaboration performance with the CFS revolves around the research program itself. One manager stated that there is a need to understand the CFS program and how it could be accomplished through better integration between team players. Another manager stated that there is a need to standardize business and research project management tools to offset the diverging business practices between the two organizations. This would also require a better arrangement of CFS employees, where these employees would be on loan to FPInnovations. The writing up of white papers would demonstrate better foresight when dealing with similar research topics and strategic areas. This manager stated, "We can collectively create state of the nation white papers. It would be very helpful for both directing research and also justifying research to federal funders and our members as well." More holistic integration among team players would involve a better alignment of CFS stakeholders to enable good governance, common goods, and international agreements. Finally, a common innovation framework would allow better alignment and integration of the research programs.

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The main factors that would increase collaboration performance with external partners include a collective vision, goals, and principles, better methods of working together with industry and universities, and improved sharing of innovation and technology transfer.

Collective Vision: A collective vision requires an understanding of the common goals, principles, and rules of engagement of diverse organizations. Clear accountabilities enable greater clarity of roles to help strengthen research goals.

Better Ways to Work Together: Improved partnering with industry and universities will require better rules of engagement and a common lexicon. For example, one manager stated that "the innovation framework will allow us all to collectively look at the portfolio and identify areas that overlap that could lead to collaboration." This manager also said that membership models could enable better collaboration with industry.

Improved Open Sharing of Innovation: One manager felt that there should be less emphasis on intellectual property issues between FPInnovations and universities; while another manager stated that sharing openly can potentially lead to issues with technology transfer:

> One of the challenges at the moment is that we're trying to share everything across industry stakeholders and that creates barriers for uptake and utilization because obviously the industry members appropriately want to have some advantage of the market for uptake of the technologies from the various providers. At the moment, it's a

struggle because ourselves, NRCan and others often require sharing a co-leveraging and

I think it could be a barrier for uptake.

4.7.4 Integrated Working Relationships

The industry managers were asked: *You're given the opportunity to design Canada's forest sector for the year 2025, what are the elements that would enable more integrated working relationships?*

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MORE INTEGRATED WORKING RELATIONSHIPS WITHIN FPINNOVATIONS

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Within FPInnovations, there were three main needs that emerged from the interviews: to concentrate on world-leading collaborative innovations; to create more integrated collaborative partnerships; and to implement more robust hiring strategies.

Concentrate on World-Leading Collaborative Innovations: A few managers stated that there is a need to look at more robust models of innovation. Adopting best practices for innovation will enhance their impact.

Create More Integrated Partnerships: These managers stated that FPInnovations needs to create more integrated partnerships across the forest sector and other sectors to complement the forestry industry. Developing new partnerships are essential to the innovation of the forestry sector as the global marketplace continues to change. Moreover, the development of cross-functional teams with other markets and sectors (e.g., biochemical, bioenergy, or biofuels) would foster greater innovation in the forestry sector. More intimate partnerships along the research value chain contributes to greater innovation. One manager stated, "[It's important to have an]

intimate relationship at the front end, the ideation stage where we're looking at proof-of-concept. I think that's a close relationship between FPInnovations and universities because that's where the innovation sparks come from." Such a relationship would entail more formal collaboration models between universities and FPInnovations, and industry, to help stimulate innovation.

Implement More Robust Hiring Strategies: These managers stated that hiring the right people contributes to world-leading collaborative innovations. Implementing effective hiring strategies contributes to more successful integrated working relationships. One manager stated that hiring strategies need to focus on people who are passionate about their research, think outside the box, and exercise humility by putting the organizational needs before their individual needs.

<div align="center">MORE INTEGRATED WORKING RELATIONSHIPS WITH CWFC</div>

There were two main themes that represent the need to create more integrated relationships with the CWFC. There is a need to expand partnerships, and there is a need to foster better information and knowledge exchange between FPInnovations and the CWFC.

Expand Partnerships across the Forestry Sector: The main theme for these managers represented the need for FPInnovations and the CWFC to further expand partnerships across the entire forestry sector. This would involve the following: working with all of the CFS (not just the CWFC); working with other sectors (e.g., chemical, construction, and energy); being more industry focused; and concentrating on "warm body exchanges" (e.g., more cohesive relationships across executive appointments). One manager felt that the relationship between

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FPInnovations and the CWFC is more than a partnership. Being co-located in the same building across various sites enables better integrated relationships. Another manager stated that the benefit of having CWFC as a federally-funded organization is the ability to balance and leverage a government-driven organization against an industry organization. A third manager stated there will be a need to maintain common strategic imperatives that will be co-developed between FPInnovations and the CWFC to improve integration and partnering.

Better Knowledge Exchange: Knowledge exchange with the CWFC requires the transfer of information and knowledge to a spectrum of stakeholders. Virtual collaborations will enable better knowledge exchange in sharing research through co-organized seminar series, newsletters, co-authored white papers, and monthly webinars.

MORE INTEGRATED WORKING RELATIONSHIPS WITH CFS

There were two main themes that represent the need to create more integrated working relationships with the CFS: optimize resources, and work collectively to enhance the science.

Optimize Resources: Optimizing resources across all of the CFS requires secondments and warm body exchanges. One manager stated, "It would be really good to see if the policy makers would second us into the organizations to learn more about the research process; and for some of the senior scientists to go into CFS and work in some of the policy groups so they get to [understand] how policy is created and shapes R&D." Resources need to come together to achieve a common objective from a regional and provincial perspective.

Collaboration in Scientific Research: *Factors that Influence Effective Collaboration during a Period of Transformational Change*

Work Collectively to Enhance the Science: Two managers expressed the need to create more common approaches and alignment of messages, collaborative environments, and principles of engagement (e.g., virtual network of provincial leaders with common approaches, messaging, principles, and opportunities). These changes would involve the implementation of constructive principles, a collective approach in delivering value and innovation, and more integrated partnerships.

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MORE INTEGRATED WORKING RELATIONSHIPS WITH EXTERNAL PARTNERS

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There were two main themes that represent the need to create more integrated working relationships with external partners: better integration practices, and partnering to work more collectively.

Better Integration Practices: Enabling more integrated working relationships with external partners involves better integration practices with universities/colleges and with other external organizations. Common goals, clearly defined outcomes, the transfer of knowledge to industry, and complementary expertise are needed. Creating consortia also promotes more successful collaborations and fosters solid partnerships in delivering the science.

Partnering to Work Collectively: Partnering with international organizations creates greater innovation. The aim is to have common goals and values to enable greater cooperation and collaboration. One manager stated,

> To be honest, much of the issues are around a shared set of values between the various
>
> agencies and having a common goal. We shouldn't be fighting with each other. If we

have a common goal and a common framework, we should be trying to find mechanisms

to work together…if we're able to share some values and common frameworks.

4.7.5   Enduring Values for 2025

Industry managers were asked: *The Public Service of Canada holds the following*

enduring values: Respect for Democracy, Respect for People, Integrity, Stewardship, and

Excellence. What would be the main enduring values for FPInnovations that would build your

capacity to deliver innovative R&D for the Canadian forest industry in the year 2025? The

industry participants stated that the main enduring values for FPInnovations include respect for

people (including integrity), collective capacity to provide greater value and excellence, and

proactive leadership to champion success. Other individual values highlighted centralizing

information technology for better communications, having an open dialogue, and being a trusted

broker, objective facilitator, and efficient evaluator.

Industry participants were also asked: *What would be the main enduring values for*

FPInnovations that would shape the integration of collaborative science with policy and

management in the year 2025? FPInnovations outlined the following values: a collective vision

(e.g., stretch goals, a shared set of values between parties, and evidenced-based decision-making

processes); excellence in science; respect for people; having the right people (e.g., accessible

managers and effective staff); innovation and fun in science; and a formal collaboration

framework that may encourage ways to foster collaboration and further develop sustainable

partnerships.

4.7.6   Summary of Interview Findings with Industry Managers

The ethnographic interviews with managers from FPInnovations produced several important findings. The main characteristic that represented collaboration for the industry managers is the need for team members to hold a *common vision, with shared goals, objectives, and values*. Researchers collaborate towards a common vision, and the common goals define the outputs and anticipated outcomes of the research. The *values* define how researchers in a collaboration work together to achieve their goals and objectives. *Leveraging resources (e.g., money, human resources*, *and capabilities* that include upstream research) is an important consideration at the foundational stage of a collaboration.

Within FPInnovations, the culture of collaboration is based on fulfilling members' needs and innovative thinking to optimize the full value chain of the forest sector. The *culture of collaboration* between FPInnovations and the CWFC is more challenging because of different mandates and business practices and the challenges with the federal government administration. However, the FPInnovations-CWFC relationship is essential to delivering the full value chain for the forestry sector. The *collaborative relationships* with academia will require the development of greater innovations by hiring the best graduates from the universities. Collaborative partnerships with universities have enabled FPInnovations to have oversight responsibilities over the wood fibre network.

Moreover, there is a need to increase collaboration performance with the CWFC and CFS by creating *better integration among team players* (e.g., co-locating FPInnovations researchers with the CWFC researchers, creating joint teams, pooling resources, creating secondments or

sabbatical exchanges between organizations, and establishing key performance indicators). This practice would foster more innovative products and solutions to the end-users. With external partners, the main factors that would increase collaboration performance include a *collective vision, goals and principles*, better methods of *working together* with industry and universities, and *sharing innovations and technology transfer*. To enable better *integrated relationships* in the next ten years, FPInnovations needs to concentrate on world-leading collaborative innovations, create more *integrated collaborative partnerships*, and implement more robust hiring strategies. FPInnovations needs to foster more *integrated partnerships* with the CWFC by expanding partnerships and creating *better information and knowledge exchanges*. With the CFS and external partners, FPInnovations needs to *optimize resources and work collectively* for the advancement of science. The future scientific outlook includes several main elements: a *collective vision* (e.g., stretch goals, shared set of values between parties, and evidenced-based decision-making processes); excellence in science; *respect for people*; *access to the right people* (e.g., accessible managers and effective staff); innovation and fun in science; and a formal collaboration framework that encourages ways to foster collaboration and develop sustainable partnerships. All of these factors help to influence how collaboration is carried out at FPInnovations, and impact the quality of products and their overall outcomes.

4.8   Summary

The main findings of this study are based on a comparison of CWFC researchers' and managers' perceptions of collaboration, CWFC managers' perceptions of collaboration during a focus group session, and FPInnovations' managers' perceptions of collaboration. The

participants' insights, observations, and experiences of intra-organizational and inter-organizational collaboration contribute significantly to answering the research questions in this study. Furthermore, the participants' perceptions augment the literature on research collaborations, including the impacts of organizational change on the quality of collaborations.

CHAPTER FIVE: DISCUSSION AND INTERPRETATIONS

5.1 Introduction

This qualitative study aims to advance knowledge of the factors that influence researchers' attitudes and behaviours regarding collaboration in scientific research projects, particularly during a period of transformational change. Answers to my original research questions can contribute to the literature on teamwork and effective collaboration, and to improving research collaborations in the federal government.

5.2 RESEARCH QUESTION #1: *What factors influence researchers' attitudes and behaviours in scientific research collaborations (i.e., intra-organizationally and inter-organizationally)?*

According to the study participants, collaboration plays a fundamental role in advancing forestry research. The CWFC participants stated that establishing partnerships with industry (particularly with FPInnovations), academia, and all levels of government (federal, provincial, regional, and municipal) is essential in order to develop a research program that has national scope for optimizing the forest sector. The CWFC participants also stated that researchers engage in collaborations because doing so is part of their governance structure and collective leadership aimed at optimizing research outputs and outcomes. The majority of participants stated that the main expectation of research collaborations is to advance forestry science and innovation. The CWFC participants felt that forestry researchers attribute their identity to being part of something bigger, and that effects of their collaborations speak volumes to their clients and end-users. Their research outcomes influence departmental policies and programs, national objectives, and the

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innovation system. For both the CWFC and FPInnovations, participants stated that innovation plays an important role in optimizing the value chain of the forest sector.

Based on the study findings, the factors that influence researchers' attitudes and behaviours in scientific research collaborations include collaborative culture (i.e., shared vision, goals, and objectives, governance, and values of mutual trust and respect), leadership (i.e., visionary, collective, and team leadership), resources (i.e., human and financial resources), team integration and synergy (i.e., shared commitment and team cohesion), shared communications (i.e., face-to-face communications), and interpersonal relationships through social interdependence.

Collaborative Culture: A shared collaborative culture of forestry science and innovation represented the largest theme for the participants in this study, and includes a collective vision, governance, and shared values. Within the CWFC, an integrated collaborative culture is contingent on team members having a shared vision with aligned organizational programs, policies, and strategies. This collaborative culture stems from the generally recognized need to transform the forest sector to enable greater science-based innovations and impacts. Governance helps to foster a collaborative culture. For example, participants felt that both the CWFC and FPInnovations play a role in encouraging researchers to collaborate both intra-organizationally and inter-organizationally. Shared values (e.g., trust and respect) also enable team members to work together more effectively.

Shared Vision, Goals, and Objectives: The majority of the participants stated that a collaborative organizational culture requires that team members share in a vision that builds on

researchers' collective strengths and not on individual competitiveness. This shared vision is based on a "shared sense of urgency," a common mission to work together to develop solutions that will contribute to the competitiveness of the forest sector. The majority of participants stated that a culture of collaboration unifies researchers through a common vision, goals, and objectives. Everyone in the collaboration brings something of great value which makes the collaboration successful. Isabelle and Heslop (2011) found in their study on international scientific collaborations with foreign countries that government senior scientists and science managers equate effective collaboration with having a shared vision. This shared vision is based on clearly defined goals with a solid commitment to the success of the collaboration. In essence, the collaboration is perceived as being mutually beneficial to all the participants. Similarly, the majority of participants in this study noted that researchers need to have a common vision and goals in order to ensure successful team performance and avoid duplicating research efforts.

Governance: Corporate governance is another important factor that generates a collaborative culture. As part of the transformation of the forest sector, the CWFC managers strongly encouraged researchers to collaborate, both intra-organizationally and inter-organizationally. For example, some researchers and managers described collaboration with FPInnovations as "mandatory" or "strongly encouraged." For many CWFC participants, getting funded for research projects is contingent on demonstrating collaboration with FPInnovations and other partners. However, these participants stated that collaboration with FPInnovations can be somewhat challenging. Although there are many instances where collaborations between the CWFC and FPInnovations have led to the development of high-quality products, several CWFC

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researchers felt that getting research funding was contingent on collaborating with

FPInnovations. Also, the majority of participants stated that both the CWFC and FPInnovations

have very different corporate cultures and business models and processes for conducting

research. FPInnovations has short-term research objectives that are member-driven, and the

CWFC works on longer-term research projects for the federal government and Canadians. These

cultural differences impact the team dynamics between the organizations. Huxham (2003) says

that collaboration becomes very challenging when organizations have different agendas and lack

common aims/goals. For example, some researchers in this study said that collaboration with

FPInnovations is not true collaboration because it is based on the need to pay for services

rendered (grounded on FPInnovations' cost-recovery business model). The researchers

acknowledged that there would be greater incentives to collaborate with FPInnovations if there

was not a requirement to pay for every service. The majority of participants stated that there

needs to be better alignment of FPInnovations' business model and processes with the

CWFC/CFS working model. For example, the two organizations could develop a common forest

sector planning platform to enable more integrated forest sector research strategies and

programming and further generate better collaboration practices between the organizations.

Shared Values (Mutual Trust and Respect): Shared values represented another

important factor within a collaborative culture. The majority of the study participants felt that

mutual trust is a core value that enables researchers to share information freely with each other.

Several participants stated that to enable greater trust within a team context, researchers need to

demonstrate a willingness to share ideas and information within an open environment. Team

members do not hold back any information that may be pertinent to the decision-making process. This finding is supported by Salas, Sims, and Burke (2005), who claim that a culture of mutual trust helps to support teamwork processes. Isabelle and Heslop (2011) also discovered that effective collaboration is contingent on trusting relationships.

The participants stated that respect is another important value to maintain between researchers. For example, FPInnovations' managers stated that having mutual respect for people (including integrity) and working in a collective mind-set provide greater value and excellence than not doing so. Diversity in people and in scientific disciplines, and a willingness to succeed are also important in shaping the integration of collaborative science, policy, and management. Proactive leadership (i.e., having the right champion to enable success) is one of the main values for FPInnovations that would further build its capacity to deliver innovative research to the forest sector.

Many participants stated that giving credit to the team effort is an important element in building trust and respect within the team. Everyone realized that all individual team members have contributed their expertise and decision-making capabilities to the progressive outcomes of the collaboration. Participants felt that giving credit to the collective effort helps to create greater trust, respect, and motivation to collaborate with team members.

Leadership: Several participants stated that leadership (i.e., visionary and collective leadership, and team leadership) played a fundamental role in attaining high quality research outputs and outcomes.

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Visionary and Collective Leadership: Visionary leadership helps to build interpersonal relationships so that there is a greater commitment to research objectives and national priorities. Researchers believe in the new transformation of the forest sector and try to establish integrated working relationships with external partners. Leaders inspire a spirit of collaboration by empowering people to fulfill their goals. The majority of CWFC researchers and managers highlighted the exceptional leadership of their former executive director who led the centre for nearly eight years. The participants noted that this executive director employed both visionary and collective leadership styles. Many participants expressed that both visionary and collective leadership have contributed to the successful outcomes of the component activities. Huxham (2003) states that structures, processes, and participants enable effective collaboration because the leadership impacts the outcomes of the collaboration.

Team Leadership: Several researchers in this study also disclosed the importance of team leadership. A project team leader who inspires team members fosters a synergistic environment that enables more effective decision-making and outcomes. This finding is supported by Salas, Burke, and Stagl (2004, p.343) who state that team leadership plays a fundamental role in effective teamwork because it promotes "social problem-solving" through the coordination of goals and team performance outcomes. However, a couple of researchers in this study stated that they had experienced a lack of team leadership in past collaborations which resulted in poor team performance and the unwillingness to work together on future projects.

Complementary Human and Financial Resources: Participants stated that collaboration enables better research capacity because of the teaming up of individuals who

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possess the required expertise. Team composition (e.g., knowledge, skills, expertise, and abilities), based on inter-disciplinary and multi-disciplinary backgrounds that enable teams to work on complex problems, better address national priorities. The majority of participants said that team members must have a good understanding of their roles, responsibilities, and accountabilities. The aim is to establish teams that have the right mix of knowledge, skills, and expertise for researchers to work together on research problems. The "right" combination of researchers creates greater team synergy among the players as they become collectively responsible in fulfilling their project team roles. This finding is supported by Hoevemeyer (1993) who states that positive roles and norms are based on assigning the right team roles so that each member can exploit and contribute his/her individual talents to the collective group. This defining of roles enables greater team commitment, team cohesion, team morale, and team accountability. Larson and LaFasto (1989) note that team players must be competent and possess the right combination of skills to achieve successful team performance.

Many participants noted that collaboration with internal and external researchers requires financial resources. However, participants also said that prioritizing research is key to leveraging resources. Many managers stated that aligning financial contributions to national priorities builds greater research capacity. However, participants noted a few challenges with funding. Several CWFC participants stated that the more people are involved in a collaboration, the more funding needs to be shared with other researchers. Although collaborations with external partners have been mainly "healthy" and "vibrant," research collaborations involving academia have occasionally been competitive. They attribute the competition to a scarcity of resources. A few

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CWFC managers noted that the government is known to provide funding for intra-departmental collaborations, and without funding from the government, these participants wondered what collaboration would look like.

Team Integration and Synergy: The majority of participants expressed the need to create better integration and synergy within a collective team environment. They understood a collective team environment to mean that the whole of a team is greater than the sum of the individual contributions made to a research project. For example, the CWFC participants described collaboration within the Centre as researchers working collectively to achieve a common goal. These participants expressed that more synergy is generated when team members are united through a collective vision, mission, or goal. For the CWFC, collaboration with FPInnovations has been encouraged from the very beginning, but participants stated that there needs to be increased integration between the two organizations.

The perceptions of CWFC researchers and managers revealed that the relationship between the two organizations is still fragmented. The perception is that both organizations still need to develop a common approach to leverage the science through more integrated relationships and programming. This perception was also reflected in the interviews with FPInnovations' managers, who echoed that the relationship between FPInnovations and the CWFC is somewhat challenging because the mandates of these organizations are different. These industry managers felt that better integration between the two organizations would require standardizing business processes and research project management tools to offset the diverging

business practices between the two organizations, or an interchange of employees between CWFC/CFS and FPInnovations.

Team integration and synergy though are contingent on several behavioural traits, namely shared commitment and team cohesion.

Shared Commitment: Shared commitment plays a strong role in team integration. Shared commitment is represented by the dedication of team members to work collectively to achieve the team's goals (Heimeriks, 2002; Katzenbach & Smith, 1993a, 1993b; Larson & LaFasto, 1989). Participants stated that having a strong commitment to the collaboration is fundamental to the success of team performance. Taking collective ownership requires strong commitment to foster successful collaboration. This finding echoes those of several researchers who argue that shared commitment among team members enables team effectiveness (e.g., Heimeriks, 2002; Larson & LaFasto, 1989).

Team Cohesion: Many participants stated that team cohesion contributes to better working relations and synergy among team members. Participants maintained that researchers from the CWFC, CFS, and FPInnovations require better inter-organizational integration and working relationships. Improved working relationships would involve a greater integration of goals: the research problems need to be motivating for both sides. Greater integration with FPInnovations would produce better synergies: basic and applied researchers could work together to study the research problems from the inception stage to the concluding stage of a research project (e.g., Sonnenwald, 2006). Better integration with academia would entail clearer and common goals, knowledge exchange, use of complementary knowledge and skills, and more

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developed consortia to work on joint national priorities and research goals. Creating more common approaches, collaborative environments, and established principles of engagement would enable better integration across all organizations. Conversely, some participants noted that a lack of team integration could potentially lead to a lack of team cohesion and trust among team members.

Shared Communications: The open sharing of ideas through frequent conversational exchanges among team members enables shared situational awareness (Dietrich, Eskerod, Dalcher & Sandhawalia, 2010; Hoegl & Gemuenden, 2001). The majority of participants stated that in collaborative research projects, researchers need to share their knowledge through open communication channels. Participants felt that team productivity is increased in collaborative project teams that exercise good communication practices. Researchers feel more productive if they have open communication and information exchanges with other team researchers, even through virtual environments (e.g., videoconferences and teleconferences). The participants stated that open information exchanges lead to greater trust and enable researchers to engage in more effective decision-making, and ultimately, more effective collaborations. Studies show that that the quality of a collaboration is contingent on the communication that exists among team players (Keyton & Stallworth, 2003). Keyton and Stallworth (2003) show that effectiveness in collaboration is dependent on communication that enables equal participant input and shared decision-making.

Face-to-Face Communications: The majority of participants expressed the need to have more face-to-face communications with researchers across the CWFC, CFS, FPInnovations,

other external partners, and academia. For example, the employee science forums in the earlier years of the CWFC enabled researchers to get together face-to-face to discuss research objectives and national priorities. These face-to-face interactions enabled researchers to form longer-lasting relationships because they had spent time to get to know one another, learn about each others' skills and research areas, and discuss the potential of working together on future projects.

Interpersonal Relationships through Social Interdependence: Social interdependence theory states that social interdependence is reached when individuals promote supportive attitudes and behaviours in order to achieve team goals (Johnson & Johnson, 1995; Luca & Tarricone, 2001; Tarricone & Luca, 2002). Many participants stated that good working relationships usually stem from past collaborations with team members, from which team members develop a sense of trust and learn to rely on each other to meet the project team's objectives and goals. Participants suggested that successful teams were contingent on positive social interdependence, in which individuals promoted cooperative attitudes and behaviours and highlighted mutual interests to achieve project team goals.

There were many examples given by the participants on the importance of relationship-building through social interdependence. However, participants also stated that when researchers are forced to work together and do not have a chance to get to know one another early on, they tend to have difficulties in forming good working relationships. This finding is supported by Keyton and Stallworth (2003) who reveal that effectiveness in collaboration is contingent on member interdependence. Otherwise, conflicting personalities, poor communication, and a lack

of trust may result among team members (Keyton & Stallworth, 2003), all of which can impact the team's performance.

Interpersonal issues can also get in the way of working more collaboratively. Close to half of the researchers highlighted that bad experiences in collaborations have led them to distrust researchers and contributed to failed outputs. For example, many participants felt that personality conflicts in research teams have led to unsuccessful collaborations. Peoples' egos (e.g., individual competitiveness) and individual motivations can have a negative impact on collaborations leading to problems, such as lack of trust, which may disable positive social interdependency among team members.

In summary, the majority of participants stated that a collaborative organizational culture, leadership, resources, team integration and synergy, trust and respect, shared communications, and interpersonal relationships represent some of the main factors that influence researchers' attitudes and behaviours in scientific research collaborations. These factors also influence the quality and quantity of good team outputs and outcomes.

5.3   RESEARCH QUESTION #2: *How do the factors that influence researchers' attitudes and behaviours in scientific research collaborations affect the quality and quantity of team outputs and outcomes?*

Using Hackman's (1987) criteria for team effectiveness, the factors that produce good research outputs and outcomes are illustrated under three components that describe effective collaboration, namely collaborative team performance, team viability, and individual and team satisfaction.

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5.3.1   Collaborative Team Performance

According to Hackman (1987), team performance is contingent on the assessment of how well the team performed in the project. Team performance assessments can be based on the innovativeness of a product, the quantity or quality of a product, the speed of completing the product, or the ability to stay within budget. Team members may ask how successful they were in their team productivity (e.g., completion of team tasks and goals, or team efficiency). Hackman's (1987) premise is that team performance is based on meeting or exceeding end-users' expectations.

In this study, the participants felt that the success of their outputs are attributable to how well the team performed in the collaboration. The vast majority of researchers believed that they had performed well in their collaborative research projects because they felt that they had met or exceeded their clients' expectations. The participants defined successful collaborations in relation to the achievement of tangible outputs and anticipated outcomes, and the organizational and individual factors that enabled them to achieve success. Tangible outputs represented actual products that were produced as a result of the collaboration (e.g., innovative tools, or new decision-making processes). Other tangible outputs included shared publications, new funding for new projects, intellectual property, and presentations with joint authorship. Intangible outputs were expressed as team members being "smarter together" by leveraging skills and knowledge to advance the scientific outputs and outcomes; building relationships for future collaborations; developing a common vision with goals and priorities (e.g., collaborative planning) to achieve

the end goal; and communicating throughout the collaborations to ensure that the team goals were met or exceeded.

The majority of participants stated that a collaboration is successful once an end-user implements the new scientific output to advance a process, technology, policy, etc. Successful collaborations contribute to a bigger end-state (e.g., application of a technology on a wider scale, or a change in policy). Researchers also disclosed that the ability to impact industry, other government departments, and Canadians represented significant outcomes from their collaborative team performance. In other words, collaborations were perceived to be successful if they yielded high-quality outputs and outcomes. The outcomes of these team outputs ranged in scope: knowledge exchange, skills development, application of innovative methods, new tools and technologies, policy development, new provincial or federal guidelines, technology transfer, operational best practices, newfound partnerships and relationships, new programming, follow-on collaborations, contributions to economic impacts, and state-of-the-art decision-making on the assessment, characterization, production, and optimization of wood fibre.

According to the participants, there are several factors that affect the quality and quantity of good research outputs and outcomes.

Collaborative Culture: Organizational culture helps to foster collaborative team performance. According to Sundstrom, De Meuse, and Futrell (1990), team performance is interrelated with organizational culture because it incorporates the shared values and norms that enable team members to work together. For the CWFC and FPInnovations, the transformation of the forest sector generated the conditions and the context for enabling a collaborative

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organizational culture. The majority of participants stated that researchers need to focus on a common vision, goals, and objectives to produce high-quality innovative end-products. Many researcher participants disclosed that their collaborations were successful because team members understood the overarching vision, the intended project outputs, and anticipated outcomes.

Participants also stated that the success of a collaboration is contingent on clear and attainable project goals and objectives. Each team member needs to ensure that they carry out their roles to produce accurate and timely good quality products. A common vision is fostered through shared mental models to help achieve common project goals and objectives, and is enabled through a collaborative organizational culture and shared leadership. Salas, Sims, and Burke (2005) highlight that shared mental models help to achieve collective goals. They say that "teams that share similar mental models communicate more effectively, perform more teamwork behaviors (i.e., backup behaviors), [and] are more willing to work with team members on future projects" (p. 566). These characteristics contribute to the quality of team products and their overall outcomes. As one researcher stated, if researchers do not have an aligned vision or goals, team members have a difficult time being productive.

Governance also played a role for the participants. The participants stated that managers in the CWFC and FPInnovations strongly encourage researchers to collaborate on projects. According to the participants, funding is contingent on demonstrating collaboration between the organizations and with other external partners. Performance is based on tapping into other expertise to carry out the project goals.

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Many participants stated that mutual trust and respect represent values that foster good quality outputs and outcomes. Trusted and respectful working relationships with internal and external researchers foster good collaborative team performance. One of the key team characteristics stemming from Bozeman, Gaughan, Youtie, Slade, and Rimes' (2015) study on effective research collaboration is the attaining of team members' trust. Interpersonal trust and experience are indicative of effective collaborations. Salas, Sims, and Burke (2005) highlight that mutual trust is a coordinating mechanism that enables effective teamwork. Bandow (2001) also notes that trust impacts many team processes and outcomes, including product quality, cycle times, and member contributions (cited in Salas, Sims, & Burke, 2005). Kelly and Schaefer (2014) also state that "trust and respect are the bedrock of collaboration [and are] key to building a commitment to collective goals" (p.6). Kelly and Schaefer (2014) continue: "When people feel disrespected and see their contributions going unrecognized and unvalued, they disengage and look elsewhere for opportunities to contribute" (p. 6).

Leadership: According to the participants, visionary leadership, collective leadership, and team leadership contributed to successful collaborative team performance. Visionary and collective leadership created the working conditions that facilitated researchers in effective collaborations. Visionary leadership contributed to an integrated collaborative environment that enabled the development of valuable research outputs. A focus on collective leadership highlighted for researchers their responsibility and accountability in achieving the research outputs. Team leadership also played a critical role in collective decision-making and goal attainment. Amabile, Patterson Nasco, Mueller, Wojcik, Odomirok, Marsh, and Kramer (2001)

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note that "leader skills in managing team communications appeared to strongly influence the team's functioning" (p.428).

      Human and Financial Resources: The majority of participants stated that getting the right team composition is essential for enabling valuable team productivity. Team composition is based on researchers who come from different scientific fields/disciplines, the size of the team, and the blend of other attributes that researchers bring to the project team. For example, Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) reveal that disciplinary and inter-disciplinary dynamics are important to consider in research collaborations. Differences in scientific approaches and methodologies can impact team performance and productivity. In this study, several participants noted that learning about different disciplines or working with researchers who come from different disciplines requires a better understanding of the way others use scientific languages. Although differences in scientific languages can cause frustrations among researchers, and may impact the team dynamics, the participants in this study noted that leveraging complementary knowledge, expertise, and skills enhances research capacity in the development of concepts, processes, and technologies. Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) note that "different disciplines develop different research skills, which encourage scientific complementarity among research collaborators" (p. 6). Also, the majority of participants in this study felt that leveraging skills among organizations (e.g., CWFC and FPInnovations and the greater CFS) is essential for successful collaborative team performance, particularly when working on joint problems or research problems of national

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importance. Having access to additional human resources (e.g., specialists who work with unique

data sets), funding, and facilities helps to enhance the team's research capacity and performance.

Team Integration and Synergy: The majority of participants outlined that team

integration and synergy enable effective collaborative team performance. Participants stated that

when team members work within an integrated team environment, they build the synergy

required for completing goals and generating good quality outputs. This integrated environment

is based on everyone working within an open research context which involves a complete

breakdown of knowledge silos. The managers and researchers expressed that working together as

a collective enabled researchers to fully carry out their project goals. The majority of participants

also expressed the need for greater commitment and cohesion to achieve project goals. Similarly,

Isabelle and Heslop (2011) found that government senior scientists and science managers

equated effective collaboration with a unified commitment to the collaboration. According to

Katzenbach and Smith (1993b), teams are driven by their commitment to the team when

members share in the responsibilities and accountabilities of the outcomes.

Shared Communications: Collaborative team performance is contingent on effective

communication practices. The participants stated that shared communications fosters greater trust

between researchers, and limits groupthink. The participants felt that fostering good

communications skills among researchers and organizations enabled greater team productivity.

This finding is supported by Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) who

discovered that the quality of communications between researchers is essential to fostering

effective collaboration.

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According to Salas, Sims, and Burke (2005), one of the coordinating mechanisms in enabling effective team performance is closed-loop communication. Closed-loop communication refers to effective communication processes that help team members to improve their collective awareness of the information (e.g., shared mental models). Closed-loop communication facilitates team members' understanding of the tasks, and how each team member contributes to the completion of the project goals. As in this study, closed-loop communication becomes necessary to use when team members are dispersed across organizations and collaborate mainly through virtual technologies. Although the majority of participants in this study need to work in a virtual capacity, high team performance is contingent on how effective members are in sharing their information, perceptions, ideas, and research concepts.

The participants in this study generally expressed a preference to work face-to-face with researchers across the CWFC/CFS, and FPInnovations, and with other external relations (e.g., academia, and provincial/territorial/regional governments). Positive social interdependence is dependent on face-to-face promotive interactions (Johnson, Heimann, & O'Neill, 2000; Pentland, 2012). Many participants felt that these face-to-face interactions establish greater team and trust-building among team members. Face-to-face interactions enable collective performance, responsibility, and accountability to complete team goals. For example, Pentland (2012) uncovered that face-to-face communication is the most valuable method of communication. High-performing teams rely on good communication skills that enable effective interactive team performance (Pentland, 2012).

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Interpersonal Relationships: The majority of participants underlined the need to build good interpersonal relationships between researchers and organizations. These participants stated that researchers are socially interdependent within a collaborative project team, in which relationships are formed and nurtured over time. Participants reiterated that researchers who work in successful collaborations demonstrate an emotional capacity or intelligence that enables them to perform well in a team environment. Some of these characteristics include adaptability, open-mindedness, truthfulness, openness to criticism, self-confidence, risk-taking, and the ability to exercise humility. On the other hand, participants also noted that conflicts due to personalities can lead to unsuccessful collaborations and the inability to build good working relationships. Unhealthy interpersonal relationships ultimately lead to poor collaborative team performance. Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) study found that researchers' personalities need to mesh in order for them to establish effective collaboration. High-performance in collaborative research depends on team members who possess interpersonal skills that involve greater "social sensitivity" and "emotional engagement" (Cheruvelil, Soranno, Weathers, Hanson, Goring, Filstrup, & Read, 2014, pp. 33-36). Team members who have these interpersonal skills are also able to positively influence the interactions among team members (e.g., team functioning and communications), and ultimately research outputs and outcomes (Cheruvelil, Soranno, Weathers, Hanson, Goring, Filstrup, & Read, 2014).

5.3.2   Team Viability

Hackman (1987) and Sundstrom, De Meuse, and Futrell (1990) claim that team effectiveness is contingent on the viability of the team (i.e., the prospect of team members

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wanting to work together again on future projects). Hackman (1987) states that the social

processes that occur in a team environment dictate whether a team works together again in the

future. These social processes need to be maintained or further improve the capabilities of the

team to motivate individual members to team up on future tasks. Team performance and team

viability rely on the interdependencies of team members who collectively work together to fulfill

the team's goals (Sundstrom, De Meuse, & Futrell, 1990).

      What I have learned in this study is that effective collaboration is contingent on team

members' willingness to work with the same team members on future projects. The motivation

to collaborate with the team members again is based on how well the team performed together to

achieve its project goals. According to many participants, one of the major drawbacks of having

an unsuccessful collaboration was the lack of desire to collaborate again with the same project

team members. For example, if the team was unsuccessful in achieving its goals, or the team

members experienced conflict within the team environment, or there were "failed efforts" with

no group ownership, researchers said they did not feel motivated to work with the same

individuals on future collaborations. A lack of trust also affected researchers' decisions to

collaborate with the same team members on future projects. The CWFC managers stated that the

CWFC, CFS, and FPInnovations need to create greater synergies and integration to increase

collaboration performance and the motivation to work together on future projects.

      The majority of the participants stated that shared communications has an impact on team

viability. The researchers declared that the desire to collaborate with the same people in the

future is contingent on how successful the communication exchanges were among the

researchers and how these exchanges led to greater synergies, interaction, and trust. Face-to-face communications were carried out in the earlier years of the CWFC and were considered to be very effective in enabling researchers to produce successful end-products. The employee science forums allowed researchers to get to know each other through face-to-face discussions and helped to establish trusted working relationships.

Hackman (1987) suggests that the future success of teams is dependent on their sustainability over time. Kozlowski and Bell (2001) state that there is a need to "examine the effects of group longevity on team processes and effectiveness over the long term" (p. 64). Spin-offs leveraged from collaborations are primarily based on teams successfully meeting their goals and a teams' intended outputs and outcomes. Moreover, researchers normally choose to collaborate with those whom they know and have worked well with on past projects. They establish a sense of trust within the project team, in which collaborations usually result in long-term relationships.

Although little research has been conducted on team viability (Kozlowski & Bell, 2001; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000), a more recent study has examined the multi-level influences of team viability perceptions of 254 teams who took part in a management simulation (Costa, Passos, & Barata, 2015). The findings "highlight the need to consider collective states of work groups as relevant for their effectiveness, and suggest that promoting positive interactions between team members may result in gains in team viability perceptions, mostly when individual emotions are less positive" (p.19).

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From a social interdependence perspective, I deduce that the participants highlighted successful teams as being dependent on positive social interdependence which "increases motivation by enhancing the sense of shared responsibility for, and reward value of, group accomplishment… and applies to tasks, goals, feedback, and rewards" (cited in Campion, Papper, & Medsker, 1996, p. 430). Cavalier, Klein, and Cavalier (1995) note that a relationship exists between positive interdependence and team achievement, and overall success. Behaviours that affect the effectiveness of a team include information-sharing, dynamic communication and empathic attitudes and behaviours, flexibility to handle shifting demands, leadership and clear team roles and responsibilities, and interdependency among team members (Cavalier, Klein, & Cavalier, 1995). Effective teams demonstrate "positive interdependence of team members" (Cheruvelil, Soranno, Weathers, Hanson, Goring, Filstrup, & Read, 2014, pp. 31-32), which leads to greater team achievement (Cavalier, Klein, & Cavalier, 1995. Guzzo and Shea (1992) also highlight that interdependence is related to team effectiveness.

5.3.3   Individual and Team Satisfaction

Hackman's (1987) normative model outlines that team effectiveness is also based on individual and team members' satisfaction with team experiences. Team satisfaction refers to researchers' individual and/or collective satisfaction or frustration with project team processes, outputs, and outcomes. Team members may ask how they personally benefited from being on the team. Were they satisfied with their individual or team contributions? Did they learn or gain knowledge from being on the team? Did they make friendships and enjoy making acquaintances

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with other people? Did they get along as they carried out their tasks? Did they trust each other as they conducted their tasks? Did they share information in an open environment?

The majority of the participants in this study expressed their belief that working together in a collective group is far better than working alone. One CWFC manager described his experiences as having a "collective sense of pride." Moreover, participants stated that a major consequence of an unsuccessful collaboration is the lack of personal satisfaction. The lack of personal satisfaction can be attributed to feelings of getting a bad reputation, both individually and organizationally, or not being able to achieve beneficial scientific or client-related outputs and outcomes.

One of the major consequences of an unsuccessful collaboration is the inability to build relationships for future projects. Negative fall-outs can lead to decreased morale; researchers may feel demotivated to work on future projects as a result of being involved in bad collaborations. Another consequence of poor collaborations is that project team members may become distrustful of each other. One researcher gave an example in which perceptions of stealing credit or not communicating information openly can lead to feelings of distrust and overall dissatisfaction. These examples are similar to Bozeman, Gaughan, Youtie, Slade, and Rimes' (2015) findings: bad collaborations result in not being able to meet work commitments, disagreements in crediting authors, personality clashes, selfishness/acting in one's own interest, "ghost authoring" (i.e., researchers insisting on being an author without making any contributions), exploitation by individuals in power, imbalanced collaboration investment,

organizational clashes, cultural or national differences, and "controlling collaborators" (p. 12). These factors can have an impact on individual/team satisfaction and the willingness to collaborate with researchers in the future.

5.4　RESEARCH QUESTION #3: *What impact, if any, does organizational change have on the effectiveness of scientific research collaborations?*

In this study, organizational change is examined in relation to the transformational and transitional changes emanating from the forest sector and the federal government. The implications of these changes on the effectiveness of research collaborations are explored, and include the effects on internal team processes, outputs, and outcomes that result from collaborations. The intent of this part of my study is to better understand how research collaborations, including the internal team processes, outputs, and outcomes, are affected by organizational change.

Collaborative Culture: The organizational and cultural changes stemming from the CWFC-FPInnovations partnership have affected collaborations, both positively and negatively. For example, the economic and political factors impacting the forest sector have led to the need to develop a stronger competitive forest sector. The creation of the CWFC and its key partner FPInnovations resulted in the integration and optimization of upstream and downstream wood fibre research. Greater innovation in the forest sector represents positive transformational change. Research collaborations between the CWFC and FPInnovations are intended to fully optimize the value chain to help situate Canada as an innovative and competitive contributor to the forest sector and other sectors. By optimizing a fully integrated value chain framework, the CWFC, in conjunction with FPInnovations, the CFS, and with other external partners, is able to

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engage in more promising collaborative research that includes both upstream and downstream research.

The premise behind this integrated culture can be attributed to Kotter's (1995) model of transformational change. For example, Kotter (1995) states that organizations need to establish a sense of urgency to initiate positive change. Findings from this study show that the CWFC/CFS and FPInnovations' leadership emphasized the urgency to change in order to become more viable, innovative, and competitive in the forest sector. Kotter (1995) also asserts that organizational leaders need to create a vision and strategies to lead the change process. Senior managers at the CWFC/CFS and FPInnovations developed and implemented their new strategic vision and strategy. Kotter (1995) further states that organizational leaders need to effectively communicate the new vision. Senior managers at the CWFC/CFS and FPInnovations have communicated the change vision and highlighted the importance of working together both intra-organizationally and inter-organizationally through an established collaborative culture to advance the forest sector. Governance played a key role in which researchers would be strongly encouraged to collaborate on projects. Values, such as mutual trust and respect, helped to foster good quality outputs and outcomes, and contributed to more trusted and respectful working relationships with internal and external researchers.

Leadership: Although the employees in the newly formed CWFC were initially very skeptical of the new change vision (e.g., some researchers felt threatened that they were going to be privatized), CWFC employees soon learned that the new change vision was truly an innovative approach with no hidden agenda. These employees went from having negative

perceptions to positive attitudes because they believed their senior leaders were enabling this new change vision, and the employees were part of this new vision.

Kotter (1995) emphasizes that leaders need to empower employees with the new vision. CWFC and FPInnovations managers recognized the need to empower their employees by facilitating a collective leadership approach to fostering greater forestry innovation. Kotter (1995) states that organizations need to look at generating short-term successes and recognize and reward people for embracing a new vision. The CWFC and FPInnovations have been generating successes for the past several years, and have been recognizing their employees for carrying out successful initiatives together (e.g., performance evaluations and promotions). Through a collective leadership approach with a congruent set of values, the CWFC and FPInnovations have been promoting a cultural change by supporting collaborative partnerships to advance the forest sector.

Human and Financial Resources: The need to leverage complementary knowledge, expertise, and skills enables greater research capacity to develop innovations for the forestry sector. During times of organizational change, the participants emphasized the importance of maintaining people from scientific disciplines that contribute to new knowledge and innovations. With limited human and financial resources, the participants highlighted that researchers need to leverage a sufficient amount of resources to produce the best outputs. During times of fiscal restraint, participants stated that it becomes necessary to prioritize research projects, research capacity, and financial resources when carrying out collaborative projects.

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Team Integration and Synergy: Kotter (1995) says that organizations need to consolidate the new improved changes and generate additional changes for further improvement. The CWFC and FPInnovations have been working together to enable better integration and have been examining different methods to foster improved integration and collaboration (e.g., LOCoP, NABC training, Innovation Agenda, employee science forums, integrated workshops, and this doctoral study). Kotter (1995) highlights that organizations need to institutionalize, sustain, and stabilize the new changes by empowering people to accept and adapt to the new organizational changes. Participants noted that culture change requires everyone's engagement in developing and sustaining an integrated organizational culture to advance innovation in the forest sector.

Shared Communications, Interpersonal Relationships, and Social Interdependence: According to the majority of the participants, face-to-face communications have played a central role in establishing effective collaborations. With the new changes in travel directives, researchers have not been able to travel to meet with project team members as in previous years. In the earlier years of the CWFC, face-to-face interactions were important for enabling researchers to form more effective collaborative working relationships. For example, the employee science forums were very instrumental for the CWFC researchers; they were able to physically meet researchers and managers, develop relationships with internal and external researchers, and build future projects together based on national priorities.

Participants in this study were adamant about the need for more face-to-face interactions because these interactions have played an instrumental role in establishing trusted interpersonal relationships and social interdependencies. These trusted collaborative relationships have

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contributed to greater team performance, product quality, the willingness to work together again, and overall satisfaction from the collaboration experience.

Lewin (1947) suggests that the impacts of change on team interdependence are so strong that a 'change in the state of any member or subgroup changes the state of any other member or subgroup' (qt. in Johnson, 2003, p. 935). During periods of organizational change, a culture's ability to adapt to change or to resist change may influence people's attitudes and behaviours in their everyday work performance. Daft (1986) notes that employees who reside in adaptive cultures experience more positive attitudes to organizational change such as greater cohesion and trust, versus those employees who reside in non-adaptive cultures to organizational change and exhibit more negative attitudes (Daft, 1986). Chreim (2006) also states that "employees will accept the change when they have a sense of ownership of, and control over, the change" (p.317). This finding was evidenced in this case study, where researchers were given a new mandate, a sense of ownership, and a new identity to help lead the transformation of the forest sector.

In summary, organizational leaders in the CWFC, CFS, and FPInnovations have tried to establish an integrated culture to enable the production of successful collaborative outputs and outcomes to advance the forest sector. In this case study, Lewin's change theory is applicable in understanding the process of change taking place in the CWFC and FPInnovations. Lewin's (1947) three step change model—unfreeze, change, and refreeze—describes the need to let go of older behaviours and adopt new behaviours as a result of organizational changes. The introduction of the CWFC and FPInnovations initiated the need to *unfreeze* the current state and generate greater collaborative integration and alignment to advance the forest sector. This

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development required changes in the social system, including organizational objectives, work processes and practices, norms, values, and employees' attitudes and behaviours to enable better team integration and synergy.

The *change* process helped to spawn a new vision to enable greater advancements in the forest sector. The new vision was based on optimizing the value chain of forestry innovation by blending both upstream and downstream research through public-private partnering. Researchers from the CWFC have had to adapt to their new environment and create greater collaborative partnerships with FPInnovations and with other external partners. Governance helped to establish better collaboration between the two organizations (e.g., funding research projects that demonstrated collaboration with FPInnovations). Kubr (1996) highlights that organizations "are continually forced to adapt to the environment within which they exist and operate" (p.73). Kubr (1996) claims that "in coping with organizational change, people have to change too: they must acquire new knowledge, absorb more information, tackle new tasks, upgrade their skills, give up what they would prefer to preserve and, very often, modify their work habits, [and] values and attitudes to the way of doing things in the organization" (p. 73).

Through a collective leadership approach, the CWFC/CFS and FPInnovations had to adapt to a new state by working together to generate greater forestry innovation. By seeing the merits of this new public-private partnership, CWFC and FPInnovations researchers worked together to stabilize the new way ahead. Lewin's (1947) concept of *refreeze* accounts for this new change. Senior leaders at the CWFC and FPInnovations have tried to generate a collaborative approach to advance forestry innovations. However, participants noted that there

were particular challenges that affected research collaborations between the organizations. For example, in trying to maintain a collaborative culture, CWFC researchers experienced challenges with FPInnovations' organizational business processes. Organizational factors (e.g., culture, mandates, and business practices) affected the relationship between the CWFC and FPInnovations. Because both organizations exercise unique mandates and business practices, these organizational factors have influenced the internal team processes that enable effective collaboration (e.g., motivations to collaborate, trust among researchers, communications between researchers, and team integration and synergy). Edgar and Geare (2011) note that "because culture impacts the work-related attitudes and behaviours of individuals working within departments, then it also seems likely that it will impact their performance outcomes" (p.5). FPInnovations has a cost-recovery business model based on short-term research that responds to members' needs; the CWFC conducts long-term research founded on a different planning cycle. However, these organizations have interdependent research programs. Some participants indicated that there needs to be an aligned forest sector planning platform to enable better integration and collaboration of forest sector research programming. More effective collaboration will occur through better staff engagements between organizations (e.g., employee exchanges or secondments).

The CWFC participants also discussed the differences in performance standards between the organizations that sometimes impede their ability to produce good research outputs. For example, the CWFC produces peer-reviewed scientific reports; FPInnovations primarily produces reports that respond to its members' needs. For the CWFC researchers, peer-reviewed

reports are part of the research promotional criteria which recognize individual scientific merit and overall performance. These differences have affected the quality of the collaborative research outputs generated by the CWFC and FPInnovations researchers (e.g., differences in scientific standards, product quality, and internal team processes).

The organizational changes stemming from the federal government led to several changes, namely different processes, structures, governance, and policies; restructured programming, services, and capabilities; a leaner Public Service; and the reorganization of employees. CWFC participants were vocal about the bureaucratic changes that affected the conduct of scientific research. Several transitional changes have influenced researchers' perceptions of how they engage in the conduct of collaborative research. For example, researchers stated that the changes in administrative duties have affected the time spent on conducting scientific research, including the bureaucratic processes for establishing collaborative partnerships. For some researchers, the bureaucracy behind establishing collaborative partnerships created a disincentive to work on collaborative research project which may have impacted the quality and quantity of collaborations between the organizations.

Although organizational change theory purports that people adapt to organizational changes, there are a few observations that shed light on the elements that enable more effective collaboration between researchers. For example, the transitional changes in the federal government (e.g., new administrative processes and tools) have had an influence on how researchers engage in collaborations. CWFC managers acknowledged the importance of the policy side of transformation; there is a strong push to make the Canadian forest sector a valued

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contributor to the national innovation system. However, these managers also talked about a government-driven shift to centralize services across the federal government which is impacting the way collaborative science is being carried out. The need to learn new administrative processes and tools have led to decreased scientific productivity among collaborative teams. For example, new travel directives and procedures are the responsibility of each individual researcher to learn (e.g., how to complete travel forms and procedures online) as opposed to having an administrative worker complete these tasks. Several researchers and managers felt that these administrative tasks have impacted scientific productivity.

Social systems theory plays a fundamental role in understanding organizational change and how change impacts effective collaborations. Changes occurring in the larger social system can bring about changes in the collaborative teams that are positioned in it (Guzzo & Dickson, 1996). Kotter (1995) says that resistance is based on obstacles in an organization's structure that impede change. Implementing change within the CWFC required the establishment of a collaborative culture, trust, visionary and collective leadership, face-to-face communications, good interpersonal relationships, and a strong commitment to greater innovation of the forest sector. As a result, organizations need to examine their internal structures and the social systems that enable people to participate in the change process and be able to adapt to the changes in their working environments.

5.5 New Model for Enabling Effective Scientific Research Collaborations

The models proposed by McGrath (1964), Hackman (1987), Salas, Sims, and Burke (2005), and Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) illustrate the factors that influence effective collaboration in research in this study. The effective collaboration model proposed by Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) is used here as a base model for my new framework, with additional team processes and mechanisms stemming from Salas, Sims, and Burke (2005), Hackman (1987), and McGrath (1964). For instance, Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) propose several main factors that enable effective collaboration (i.e., external factors, team characteristics, individual/team members, and team management). Salas, Sims, and Burke (2005) provide the internal team factors and coordinating mechanisms that enable effective teamwork and collaboration. Hackman (1987) provides a good understanding of how internal team processes impact collaborative team performance, team viability, and individual/team satisfaction. McGrath (1964) provides the foundational underpinnings of team effectiveness theory, including the input factors (e.g., external and internal factors), process factors (e.g., collaborator factors and team management factors), and the output factors (e.g., effective collaboration).

As shown in Figure 1, my new model proposes a more in-depth overview of researchers' perceptions of effective collaboration and highlights the external, internal, collaborator, and team management factors that impact effective collaboration.

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Figure 1 New Model for Enabling Effective Collaboration in Scientific Research
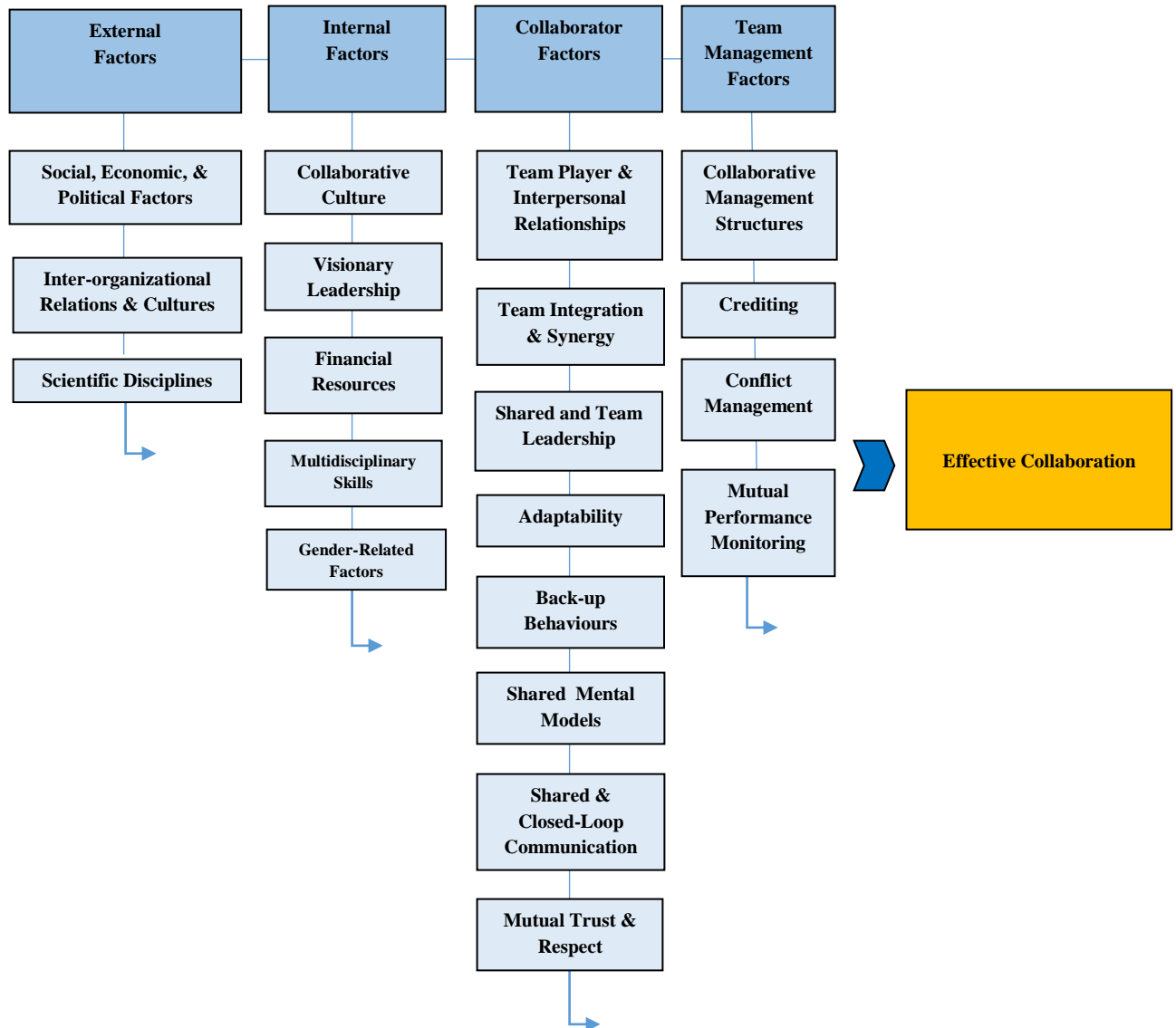
Using the qualitative findings in this study, I employ ***external factors*** to represent

external and environmental conditions that affect an organization. These external factors can

include *social, economic, and political factors*, such as the transformation of the forest sector,

and the transformational and transitional changes in the federal government. Evidenced in this

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study, the transformation of the forest sector and the changes stemming from the federal government influenced how collaboration was carried out across the organizations. External factors also include the *inter-organizational relations* with external partners. External partners come with different organizational cultures, practices, norms, values, perceptions, experiences, and expectations which influence researchers' partnerships and collaborations. In this study, researchers spoke about their relations with external organizations such as FPInnovations, academia, and other external partners, and the differences that exist among their organizational cultures and research practices. *Scientific disciplines* refer to the different branches of science that researchers come from, including differences in knowledge, models of inquiry, and methodological approaches to studying research phenomena. Researchers and managers noted that perspectives stemming from different scientific disciplines may impact the success of collaborations. These external factors may influence the internal factors, collaborator factors, and team management factors that influence effective collaboration.

Internal factors are attributed to the inner working mechanisms of an organization (i.e., collaborative culture, visionary leadership, financial resources, multidisciplinary skills, and gender-related/diversity issues). *Collaborative culture* refers to the collective goals, social norms, values, practices, and processes that enable an organization to engage in greater research integration. In this study, collaborative culture was a strong enabling factor that included shared vision, goals, and objectives, governance, and values of mutual trust and respect. Maintaining a strong collaborative culture during a period of organizational change enabled the researchers to remain focused on achieving their goals and objectives. *Visionary leadership* is essential for

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fostering a collaborative culture that enables researchers to work together to achieve greater team performance. In this study, visionary leadership was a main precursor that enabled greater buy-in from the CWFC employees during a time of organizational change and uncertainty. Visionary leadership provided greater trust among the CWFC participants as they embarked on a new way of conducting forestry research. *Financial resources* provide the necessary budgets and commitment for carrying out the research. *Multidisciplinary skills* enable researchers to leverage off of each other to produce the best research products, as was shown in this study. *Gender-related factors* were not evidenced in this study due to the small number of female researchers; however, Bozeman, Gaughan, Youtie, Slade, and Rimes (2015) discovered that female researchers experienced different challenges in the workplace (e.g., workplace dynamics, and career stages) which negatively impacted their collaborations. Gender-related factors are predominantly evidenced in the Science, Technology, Engineering, and Mathematics (STEM) fields, and need to be considered as part of this new collaboration model (e.g., use of gender-based analysis). Based on the models discussed earlier, these internal factors influence the collaborator and team management factors that enable effective collaboration. During periods of organizational change, these internal factors (e.g., collaborative culture and leadership) provide a foundational understanding of the internal mechanisms that enable effective collaboration practices.

Collaborator factors examine individual and team-related characteristics and internal team processes, namely team player and interpersonal skills, team integration and synergy, shared leadership and team leadership, adaptability, back-up behaviours, shared mental models,

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shared and closed-loop communications, and values of mutual trust and respect. *Team player and interpersonal skills* include researchers' roles, responsibilities, and accountabilities, and personality attributes that enable effective teamwork. In this study, the participants noted that being a team player with team-oriented interpersonal skills, and understanding one's role on the project team helped the team to work collectively in achieving team goals. *Team integration and synergy* requires shared commitment and cohesion among researchers, particularly during periods of organizational change. In this study, team integration and synergy resulted in more cohesive teams that remained focused and committed to achieving their project team goals. *Shared leadership and team leadership* enable greater trust, responsibility, and accountability for achieving collective goals. In this study, a shared form of leadership and team leadership facilitated a greater sense of empowerment, commitment, mutual trust, and focus to produce successful team outputs. *Adaptability* enables greater flexibility to the changes taking place as team members carry out their tasks. Adaptability is an important characteristic because researchers need to be flexible to the changing cultural elements, as was evidenced in this study. *Back-up behaviours* allow team members to help each other in completing their tasks. *Shared mental models* provide the awareness for all team members to understand the team goals and the day-to-day information required for completing their tasks. *Shared communication and closed-loop communication* are essential for all team members to keep each other posted, to understand the tasks at hand, and to develop greater relationships through face-to-face interactions. In this study, shared communications (i.e., face-to-face communications) was pivotal in creating greater positive social interdependencies among researchers (e.g., heathy team dynamics and goal

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completion). *Mutual trust and respect* enable team members to build a stronger commitment to achieving team goals. In this study, these values were fundamental to maintain among researchers and organizations, particularly during periods of organizational change. Hence, these collaborator factors represent the internal team processes that influence effective collaboration, and promote greater relationships and interdependencies during periods of organizational change. During times of change, the inter-relationships of these factors promote healthy internal team processes that enable greater team integration, synergy, commitment, and cohesion among researchers, and in turn, impact effective collaboration.

Team management factors look at the processes and mechanisms that enable a project team to collaborate effectively (e.g., collaborative management structures, crediting, conflict management, and mutual performance monitoring). *Collaborative management structures* were noted by the participants in this study, namely the processes that enable researchers to work better together (e.g., high-quality technologies to enable effective virtual teamwork; formal training on collaborative team performance; employee exchanges/rotational assignments between organizations; and formal and informal recognition and reward structures or systems that acknowledge the importance of collaboration and teamwork). Although *crediting* falls under collaborative management structures in Bozeman, Gaughan, Youtie, Slade, and Rimes' (2015) study, crediting practices and consensus among organizations and among collaborators (e.g., publications framework for writing and publishing reports/journal articles) need greater attention so that expectations between researchers and organizations are better managed, as was evidenced in this study. *Conflict management* plays an important role in ensuring greater cohesion and

understanding among team players, particularly when egos and personalities interfere with goal attainment. *Mutual performance monitoring* also enables team members to help and support each other to complete team member tasks and project goals. As noted in this study, researchers worked more effectively when team members looked after each other to complete tasks and research goals. These team management factors are also impacted by the external, internal, and collaborator factors, and are contingent on the development of positive social interdependencies among research team members.

My proposed new model for enabling effective collaboration is based on external factors, internal factors, collaborator factors, and team management factors. These factors impact the effectiveness of research collaborations, and are evidenced through collaborative team performance, team viability, and individual/team satisfaction. These factors need to be examined within a social systems context to better determine how researchers interact and influence each other's behaviour in collaborative research projects. This model may also help to examine the social interdependencies among researchers, organizations, and cultures to advance innovation for the forestry sector. Moreover, the direct and indirect impacts of organizational change on these factors may help to refine the current processes employed in collaborative research projects.

The implications of this model need to be examined more carefully with other case studies and larger sample sizes to determine the factors that influence effective research collaborations, particularly during periods of organizational change. By examining the interrelationships of these factors in other case studies, the merits of this model will speak to the

relevance of the factors that enable effective collaboration. This new model also needs to look at issues related to diversity (e.g., using gender-based analysis plus) in organizations to better understand the cultural and social implications impacting effective collaboration practices. It is envisaged that a further exploration of this model will contribute to a more advanced understanding of how research teams experience organizational changes and the subsequent effects of change on the factors that influence effective collaborations.

5.6 Summary

This chapter has examined the three research questions that guided this study: (1) What factors influence researchers' attitudes and behaviours in scientific research collaborations (i.e., intra-organizationally and inter-organizationally)?; (2) How do the key factors that influence researchers' attitudes and behaviours in scientific research collaborations affect the quality and quantity of team outputs and outcomes?; and (3) What impact, if any, does organizational change have on the effectiveness of scientific research collaborations? The answers to the research questions contributed to my development of a new model to illustrate a more probing overview of researchers' perceptions of effective collaboration.

CHAPTER SIX: CONCLUSION, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Conclusion

This ethnographic study examined the factors that influence effective collaboration in scientific research in the CWFC. Given the transformation of the forest sector and the transformation of the federal government, this case study explored the factors that have influenced successful collaborations, and the possible impacts of organizational change on researchers' attitudes and behaviours as they work on collaborative research projects with internal colleagues and external collaborators. I used a theoretical framework of teamwork and collaboration models, social interdependence theory, social systems theory, and organizational change theory to better determine the factors that influence collaboration in scientific research.

The findings of the study reveal researchers' and managers' perceptions of collaboration, and also take into account the perceptions of a key industry partner—FPInnovations. Based on ethnographic interviews, a focus group, and site visits, the findings suggest that there are specific factors that explain effective collaborations. These factors include collaborative culture (i.e., shared vision, goals, and objectives, governance, and values of mutual trust and respect), leadership (i.e., visionary leadership, collective leadership, and team leadership), resources (i.e., human and financial resources), team integration and synergy (i.e., shared commitment and team cohesion), shared communications (i.e., face-to-face communications), and interpersonal relationships through social interdependence.

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The findings also suggest that these factors positively influence the quality of collaborative team performance (e.g., team outputs and outcomes), team viability (i.e., willingness to collaborate again), and individual/team satisfaction. Team performance was evidenced by an organizational culture that promoted collaboration through a shared vision, an established governance, and values that enabled researchers to work smarter together. Visionary, collective, and team leadership contributed to an integrated collaborative environment that fostered greater responsibility and accountability in collective decision-making and goal attainment. An integrated team environment also promoted the synergy required for completing goals and generating good quality outputs. Shared communications fostered greater trust between researchers, and enabled greater team productivity. Social interdependence allowed researchers to form and nurture relationships over time and gave them an emotional capacity to perform well in a team environment (e.g., adaptability, open-mindedness, truthfulness, openness to criticism, self-confidence, risk-taking, and ability to exercise humility). The team members' willingness to work with the same individuals on future projects was based on how well the team performed together to achieve its project goals, and if researchers trusted each other and shared information throughout the collaboration. Participants also felt that individual and team satisfaction measured how content researchers were in producing successful scientific or client-related outputs and outcomes. The interrelationships of these factors help to demonstrate the internal team processes that contribute to excellence in team performance, the willingness to collaborate again with the same people, and researchers' overall satisfaction, both individually and from a team perspective.

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In addition, the findings propose that organizational change affects the factors that influence effective collaboration both positively and negatively, and is contingent on researchers' adaptability to organizational change. Positive changes were attributed to the external environment that led to the creation of the CWFC and its key partner FPInnovations for optimizing upstream and downstream wood fibre research to enable greater innovation in the forest sector. Fostering a collaborative culture with visionary and collective leadership and governance led to more successful collaborations because there was an urgency to change the culture to become more viable, innovative, and competitive in the forest sector. Managers at the CWFC and FPInnovations communicated the 'change vision' and highlighted the importance of working within a collaborative culture. They employed methods to foster improved integration (e.g., team training and employee science forums). Negative impacts of transformational change included unaligned organizational business models and practices between organizations; differences in outputs and performance standards; bureaucratic changes in administrative duties which impacted time spent on conducting science, and in establishing collaborative agreements; and the lack of face-to-face communications among researchers due to travel restrictions. As a result, there is a need to re-examine the integration of research programs among the main partner organizations to enable more integrated cultures and collaboration. There is also a need to review alternative methods for contending with administrative processes that hinder scientific productivity and team performance. Finally, the benefits of face-to-face communications need to be reconsidered because researchers reported in this study how much they profited from these interactions (e.g., employee science forums).

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The proposed model on effective collaboration demonstrates the need to further examine effective collaboration among researchers by looking at the specific factors attributed to external factors, internal factors, collaborator factors, and team management factors that lead to collaborative team performance, team viability, and individual/team satisfaction. Theoretical models on teamwork and collaboration demonstrate that collaboration is a dynamic process that needs to be examined from different angles and with researchers who come from diverse disciplines and backgrounds. A better understanding of the interrelationships between the factors will enable greater awareness of how these factors influence effective collaboration.

I anticipate that the findings of this study will provide new insights into scientific research collaborations. I also envisage that this study will inform federal government leaders, managers, and scientific researchers on how to improve policies, directives, strategies, programs, and practices that impact scientific collaborations. I hope this study will also contribute to a better alignment of government strategies for enabling and sustaining greater performance in scientific research. Collaboration in scientific research requires greater social interdependencies among researchers, organizations, and cultures. Researchers' collective social interdependencies will bridge the collaboration gap, and will help to advance innovation and excellence for the forest sector as well as other sectors.

6.2   Implications

Collaboration is an elusive concept that needs to be explored further. Although there are many definitions of collaboration, my study examined collaboration from a socio-cognitive perspective to better understand the factors that enable effective collaboration. Collaboration is

also a dynamic process that needs to be examined from different perspectives. Researchers come from diverse scientific disciplines and backgrounds that impact researchers' working relationships. For example, intergroup leadership would be important to examine in relation to collaborative intergroup performance (Hogg, Van Knippenberg, & Rast, 2012). According to these authors, "effective intergroup leadership is called for to transform sub-group self-interest and detrimental competition between groups into collaboration and cooperation that optimize intergroup performance" (Hogg, Van Knippenberg, & Rast, 2012, 234-235). This creates a shared team identity that enables researchers to work more effectively together. Cultural diversity may also affect team members as they engage in inter-organizational collaboration. In a globalized world, diversity may impact how researchers perceive the whole area of collaboration. These factors need to be examined more carefully in relation to organizational culture and the implications for enabling effective intra-organizational and inter-organizational collaboration. The use of longitudinal studies may provide a more thorough understanding of the implications of cultural and scientific diversity and their effects on effective collaboration.

Accordingly, effective collaborations need to be examined by better defining the metrics that assess the merits of collaboration outcomes in achieving end-products, impacts, and other organizational benefits (Gray & Wood, 1991). These metrics will help to further refine our understanding of enabling effective collaboration and teamwork strategies.

6.3   Limitations

The primary limitation of this study centered on my role as a researcher in the federal government. As a fellow researcher, I had to ensure that my positionality would not bias the

results of the study. I exercised self-reflexivity throughout the research process to guarantee the validity of the data collection and reporting of the results. Self-reflexivity compelled me to concentrate on my personal assumptions and observations that may have tried to influence my research. Self-reflexivity became a tool that allowed me to be aware of my identity as a researcher and person, my sense of voice and perspectives, my assumptions and sensitivities, and my experiences and values while undergoing the study. My research design included a reflection of my own identity. I endeavored to turn my emotions, passions, and biases into research tools, and outline in field notes my own self-reflections as I collected the data. Bracketing of my personal experiences enabled me to objectively perceive the phenomena under study. Maintaining a sense of empathic neutrality was important as I learned from participants' experiences and stories. From concept to research design to data analysis and report writing, I looked at all of these aspects carefully to determine if I had significantly influenced any part of my research due to my own beliefs, values, experiences, and expectations. My role as a researcher has taught me the importance of conducting rigorous and non-biased research.

A second limitation involved the total number of cases for conducting this study. There was only one science-based organization under investigation which may limit the generalizability of the findings. However, the construct of *transferability* (Lincoln & Guba, 1985) can be used in this context. For example, transferability allows readers to determine if the findings of this research can be applicable to their own experiences and circumstances. In other words, the study findings may be germane to others who may be in similar positions and who may have comparable research questions and experiences (Marshall & Rossman, 2011).

A third limitation centred around the low morale we were all experiencing in the Public Service as a result of the outcomes of the Strategic Review and the Deficit Reduction Action Plan (2010-2012) within the federal government. This period has been a difficult one for federal government employees because a number of people were losing their jobs, changing their areas of expertise, or looking for new jobs within or outside the federal government. The uncertainty of working for the Canadian federal government raised many questions regarding the future of Public Service workers.

6.4   Recommendations for Future Research

The following set of recommendations for future research are put forward as strategies to examine effective collaboration in scientific research communities.

My first recommendation is that future research examine the factors that influence scientific collaborations based on this study and to look at expanding this research through the use of survey instruments. Case studies are beneficial because they enable researchers to look at the detailed descriptions of organizational cultures. However, survey instruments allow researchers to assess the perceptions of a larger population than with the use of qualitative methods. The newly proposed model on effective collaboration could be used to advance the research on intra-organizational and inter-organizational collaboration. By employing a survey instrument across the CWFC, the greater CFS, and FPInnovations, researchers have an opportunity to respond to the team processes and other factors that are impacting the effectiveness of their research collaborations. Expanding the current methodology to include

virtual collaboration may provide greater insights into the factors that affect collaborative team performance, team viability, and individual/team satisfaction.

My second recommendation is that future research look at face-to-face communications research, and the elements that dictate the need for greater social interaction between researchers. Pentland (2012) pointed out that face-to-face communication is essential for high-performing teams who rely on good communication skills to enable effective interactive team performance. In my study, interpersonal relationship building represented a key factor for enabling good working relationships. As a result, more research should examine the benefits between face-to-face communications and social interdependency in enabling effective collaboration among researchers.

My third recommendation is that future research examine the technologies that would enable more effective virtual collaboration in the federal government. Distributed collaborative technologies need to be examined for their efficacy in enabling researchers to work effectively together on research projects. The current technologies (e.g., Tandbergs and other videoconferencing systems) are unreliable and somewhat challenging for researchers during team meetings. In addition, research needs to explore the impacts of virtual collaboration in relation to team processes that enable effective collaboration (e.g., shared leadership, team cohesion, mutual trust, and shared communications). With the introduction of a shared document/information management system (i.e., GCDOCS) in the federal government, it will be important to conduct research on the efficacy of this system as a communications tool for

enabling collaboration inter-organizationally (e.g., with external partners such as FPInnovations and academia).

My fourth recommendation for future research highlights the importance of working relationships. A qualitative study could examine working relationships, particularly the organizational, team, and individual factors that foster and sustain long-term partnerships in public-private sector organizations. Research on sustaining long-term partnerships helps to establish greater trust, team viability, and effective collaboration practices.

My fifth recommendation is that future research examine organizational change, and the critical factors that could enable greater adaptability and resilience to organizational changes in the federal research community. For example, the changes highlighted in this study (e.g., introduction of new administrative systems, integration of research programs between organizations, and travel restrictions impacting scientific collaborative interrelationships) could be examined more closely to better determine their impacts on scientific productivity.

Finally, my sixth recommendation for future research is to examine the merits of the new model on effective collaboration using larger and broader samples to determine if the model can be generalized to other research and development organizations across the whole government, and across other sectors other than forestry. This model might become a whole-of-government approach to improve effective collaboration practices in the federal government.

These research recommendations may further advance the knowledge on effective collaborations and the science of team science.

6.5   Recommendations for Practical Organizational Applications

The following set of recommendations may help to develop and implement more progressive strategies for the CWFC, the greater CFS, and FPInnovations to enable effective collaboration in federal science and technology organizations, including those that have established public-private partnerships.

My first recommendation is that the organizations need to look at implementing a training program in collaboration and teamwork to enable improved integration of the CWFC, the greater CFS, and FPInnovations. Such a program would involve the need for managers and researchers to develop greater collaborative leadership skills to advance the integration of cultures (e.g., alignment of visions, goals, objectives, and value systems), that work more collectively in a virtual capacity. Such training would be linked to new performance metrics that would give special weighting to collaboration and teamwork, and would further recognize the importance of working collaboratively in team environments for the collective good.

My second recommendation is that the organizations reinstate formal collaborative initiatives (e.g., employee science forum) to foster better integration, collaboration, relationship-building, and face-to-face communications. Such formal networks help to establish greater trust and community-spirit, and enhance shared communication, team integration and synergy, shared visioning, mutual trust and respect, and shared or collective leadership. Other forums or social networks (e.g., open houses, workshops, presentations, white papers, and communities of practice) may need to be explored to create better engagement and integration of researchers, programs, and business models.

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My third recommendation is that the organizations look at initiatives to instill greater collaboration through formal and informal mentoring and coaching, shadowing, and 'warm body exchanges' or secondments among organizations. For example, mentoring between junior and senior researchers provides additional opportunities to learn about the interpersonal skills and processes that enable successful collaborations, including the tacit knowledge that is shared among researchers. This allows greater interaction and integration among researchers across the partnering organizations. It also enables a better appreciation of the research programs, the scientific disciplines, the people who reside in the organizations and their expertise, the organizational culture for conducting research, and the sustainability of new and long-lasting relationships and partnerships.

My fourth recommendation is that the organizations examine current leadership practices across all organizational levels, and establish integrated procedures for enabling effective collaborations. Such a practice creates better alignment of the organizational cultures, priorities, programs, processes, and systems that facilitate more effective collaboration throughout the transformational journey.

The final recommendation is that the organizations examine innovative ways to demonstrate the effectiveness of research collaborations between public-private organizations (e.g., storytelling, open forums, and co-presentations). The intent would be to demonstrate the importance of aligning partners to advance innovation for the forestry sector.

These practical recommendations are intended to contribute to the further development and sustainment of interdependent working relationships across federal science and technology

organizations and with external partners. An integrated approach requires greater interpersonal

relationships and continued personal and professional growth for the advancement of science and

innovation.

REFERENCES

Amabile, T.M. & Conti, R. (1999). Changes in the Work Environment for Creativity during Downsizing. *Academy of Management Journal, 42*(6), 630-640.

Amabile, T.M., Patterson Nasco, C., Mueller, J., Wojcik, T., Odomirok, P.W., Marsh, M., & Kramer, S.J. (2001). Academic-Practitioner Collaboration in Management Research: A Case of Cross-Profession Collaboration. *Academy of Management Journal, Vol. 44*(2), 418-431.

Anand, N., & Nicholson, N. (2004). *Change: How to adapt and transform the business.* Norwich: Format Publishing.

Baird, F., Moore, C.J. & Jagodzinski, A.P. (2000). An ethnographic study of engineering design teams at Rolls-Royce Aerospace. *Design Studies*, *21*(4), 333-355.

Bandow, D. (2001). Time to create sound teamwork. *The Journal for Quality and Participation, 24*, 41-47.

Beaver, D., & Rosen, R. (1978). Studies in scientific collaboration. Part I. The professional origins of scientific co-authorship. *Scientometrics, 1*(1), 65-84.

Beer, M., & Nohria, N. (2000). *Breaking the Code of Change*. Boston, Mass: Harvard Business School Press.

Beyerlein, M. (2011). *Virtual teams as complex systems: Transitioning from complicated to complex structure for higher levels of creativity*. Presentation at the INGroup Annual Conference, Minneapolis, July 23.

Beyerlein, M., Freedman, S., McGee, C. & Moran, L. (2003). *Beyond Teams.* San Francisco, CA: Jossey-Bass/Pfeiffer.

Birnholtz, J.P. (2007). When Do Researchers Collaborate: Toward a Model of Collaboration Propensity. *Journal of the American Society for Information Science and Technology, 58*(14), 2226-2239.

Bloomberg, L.D., & Volpe, M. (2012). *Completing Your Qualitative Dissertation: A Road Map from Beginning to End*. 2nd Edition, Los Angeles: SAGE Publications, Inc.

Bond, C., & Thompson, B. (1996). *Collaborating in Research.* Higher Education Research and Development Society of Australasia Inc., Australia.

Collaboration in Scientific Research: *Factors that Influence Effective Collaboration during a Period of Transformational Change*

Boxx, W.R., Odom, R.Y., & Dunn, M.G. (1991). Organizational Values and Value Congruency and their Impact on Satisfaction, Commitment and Cohesion: An Empirical Examination within the Public Sector. *Public Personnel Management, 20*(1), 195-205.

Bozeman, B., & Corley, E. (2004). Scientists' collaboration strategies: implications for scientific and technical human capital. *Research Policy, 33*(4), 599-616.

Bozeman, B., Gaughan, M., Youtie, J., Slade, C.P., & Rimes, H. (2015). Research collaboration experiences, good and bad: Dispatches from the front lines. *Science and Public Policy*, 2015, 1-19.

Branson, C.M. (2008). Achieving organizational change through values alignment. *Journal of Educational Administration, 46*(3), 376-395.

Bryant, M., & Wolfram Cox, J. (2006). The expression of suppression: Loss and emotional labour narratives of organizational change. *Journal of Management and Organization, 12*(2), 116-130.

Burke, C.S., Fiore, S.M., & Salas, E. (2004). The role of shared cognition in enabling shared leadership and team adaptability. In C.L. Pearce & J.A. Conger (Eds.), *Shared leadership: Reframing the hows and whys of leadership*, 103-121. Thousand Oaks, CA: SAGE.

Burke, C.S., Stagl, K.C., Salas, E., Pierce, L., & Kendall, D. (2006). Understanding team adaptation: A conceptual analysis and model. *Journal of Applied Psychology, 91*, 1180-1207.

Burke, W.W., & Litwin, G.H. (1992). A Causal Model of Organizational Performance and Change. *Journal of Management, 18*(3), 523-545.

Burns, J. M. (1978). *Leadership*. NY: Harper & Row.

Campbell, C. (2007). On the journey towards wholeness in leader theories. *Leadership and Organizational Development Journal, 28*(2), 137-153.

Campion, M.A., Papper, E.M., & Medsker, G.J. (1996). Relations Between Work Team Characteristics and Effectiveness: A Replication and Extension. *Personnel Psychology, 49*(2), 429-452.

Canada School of Public Service. (2007). *A Learning Needs Assessment of the Science and Technology Community.* Public Service for the Federal Science and Technology Community Management Secretariat, Ottawa.

Canada School of Public Service. (2016). *Frequently asked questions for learners on the public service transformation curriculum.* Retrieved from http://www.csps-efpc.gc.ca/forlearners/coursesandprograms/programs/Chng_Innov/FAQ-eng.aspx

Canadian Council of Forest Ministers. (2015). *Forest Sector Innovation in Canada: 2015*. Ottawa, Canada. Retrieved from http://www.ccfm.org/pdf/CCFM%20Innovation%20White%20Paper%20-%20May%2028%202015%20-%20English.pdf

Canadian Wood Fibre Centre. (2010). *Implementation Plan 2009-2011*, Natural Resources Canada, Ottawa, ISBN 978-1-100-51263-1.

Canadian Wood Fibre Centre. (2012). *Canadian Wood Fibre Centre: Who we are and what we do, 2011-2012*. Natural Resources Canada, Ottawa, Cat. No. Fo146-1/2011E-PDF, ISSN 1927-8292.

Canadian Wood Fibre Centre. (2013). *Canadian Wood Fibre Centre: Who we are and what we do, 2013-2014*. Natural Resources Canada, Ottawa, Cat. No. Fo146-1/2013E-PDF, ISSN 1927-8292.

Canadian Wood Fibre Centre. (2014). *Paper ProMIS, CWFC's Component Planning Worksheet*. Natural Resources Canada, Ottawa.

Carron, A.V., Brawley, L.R. & Widmeyer, W.N. (1998). The measurement of cohesiveness in sport groups. In J.L. Duda (Ed.), *Advances in sport and exercise psychology measurement*, 213-226, Morgantown, WV: Fitness Information Technology.

Carron, A.V., & Hausenblas, H.A. (1998). *Group dynamics in sport,* (2nd ed.), Morgantown, WV: Fitness Information Technology.

Carson, J.B., Tesluk, P.E., & Marrone, J.A. (2007). Shared Leadership in Teams: An Investigation of Antecedent Conditions and Performance. *Academy of Management Journal, 50*(5), 1217-1234.

Cavalier, J.C., Klein, J.D., & Cavalier, F.J. (1995). Effects of cooperative learning on performance, attitude, and group behaviours in a technical team environment. *Educational Technology Research and Development, 43*(3), 61-71.

Champoux, J.E. (2011). *Organizational Behavior: Integrating Individuals, Groups, and Organizations*. Fourth Edition, New York: Routledge.

Chen, G., & Tjosvold, D. (2008). Organizational values and procedures as antecedents for goal interdependence and collaborative effectiveness. *Asia Pacific Journal of Management, 25*, 93-112.

Cheruvelil, K., Soranno, P., Weathers, K., Hanson, P., & Goring, S. (2014). Creating and maintaining high-performing collaborative research teams: the importance of diversity and interpersonal skills. *Frontiers in Ecology and in the Environment, 12*(1), 31-38.

Chreim, S. (2006). Postscript to change: survivors' retrospective views of organizational changes. *Personnel Review, 35*(3), 315-335. Retrieved from http://dx.doi.org/10.1108/00483480610656711

Christiansen, J.K. & Vendelo, M.T. (2003). The Role of Reputation Building in International R&D Project Collaboration. *Corporate Reputation Review, 5*(4), 304-329.

Clark, J.T. (2008). *Developing Collaborative Leadership: A Study of Organizational Change towards Greater Collaboration and Shared Leadership*. Dissertation. Antioch University.

Clark, T.A. (1992). Collaboration to Build Competence: The Urban Superintendents' Perspective. *Eric Review*, *2*(2), Fall 1992, 2-6.

Cohen, S.G., and Bailey, D.E. (1997). What makes teams work: Group Effectiveness Research from the Shop Floor to the Executive Suite. *Journal of Management, Vol. 23*(4), 239-290.

Costa, P.L., Passos, A.M., & Barata, M.C. (2015). Multilevel influences of team viability perceptions. *Team Performance Management, 21*, 1/2, 19-36.

Council of Canadian Academies. (2012). *The State of Science and Technology in Canada, 2012. The Expert Panel on the State of Science and Technology in Canada.* Ottawa, Canada. Retrieved from

http://www.scienceadvice.ca/uploads/eng/assessments%20and%20publications%20and%20news%20releases/sandt_ii/stateofst2012_fullreporten.pdf

Creswell, J.W. (2007). *Qualitative Inquiry and Research Design: Choosing Among Five Approaches.* Thousand Oaks, CA: SAGE Publications, Inc.

CSUB. (2010). *Social Systems Theory*. Retrieved from *www.csub.edu/~rmejia3/Social%20Systems%20Theory.ppt, California State University Bakersfield*

Daft, R.L. (1986). *Organizational Theory and Design*. St Paul, MN: West Publishing, 2nd Edition.

Dasgupta, P. (1988). Trust as a commodity. In D. Gambetta (Ed.), *Trust making and breaking cooperative relations*, 49-72, New York: Basil Blackwell.

Dawson, P. (2003). *Understanding Organizational Change*. London: SAGE Publications, Inc.

Dean, K.S. (2010). *Strategies and Benefits of Fostering Intra-Organizational Collaboration.* College of Professional Studies Professional Projects. Paper 15.

Decker, D., Wheeler, G., Johnson, J., & Parsons, R. (2001). Effect of Organizational Change on the Individual Employee. *Health Care Manager*, *19*(4), 1-12.

Deetz, S.A. (1994). Future of the discipline: The challenges, the research, and the social contribution. In S.A. Deetz (Ed.), Communication yearbook (Vol. 17, pp. 565-600). Thousand Oaks, CA: SAGE Publications, Inc. Cited in, Salas, E., Shuffler, M., Thayer, A., Bedwell, W., and Lazzara, E. (2014). *Understanding and Improving Teamwork in Organizations: A Scientifically Based Practical Guide*. Human Resource Management.

Denzin, N.K., & Lincoln, Y.S. (2005). *The SAGE Handbook of Qualitative Research*. Third Edition, Thousand Oaks, CA: SAGE Publications, Inc.

Department of Fisheries and Oceans. (2011). *Barriers to Science and Technology Collaboration: A DFO Perspective.* Presentation given to the federal Science and Technology Integration Board, July 12, 2011, Ottawa.

Deutsch, M. (1949). A theory of cooperation and competition. *Human Relations, 2*, 129-152.

Deutsch, M. (1962). Cooperation and trust: Some theoretical notes. In M.R. Jones (Ed.), *Nebraska symposium on motivation*, 275-319. Lincoln, NE: University of Nebraska Press.

Dietrich, P., Eskerod, P., Dalcher, D., & Sandhawalia, B. (2010). The Dynamics of Collaboration in Multipartner Projects. *Project Management Journal, 41*(4), 59-78.

Dirks, K.T. (1999). The Effects of Interpersonal Trust on Work Group Performance. *Journal of Applied Psychology, 84*, 445-455.

Dodgson, M. (1992). The strategic management of R&D collaboration. *Technology Analysis & Strategic Management*, *4*(3), 227-244.

Dose, J., & Klimoski, R.J. (1999). The diversity of diversity: work values effects on formative team processes. *Human Resource Management Review*, *9*(1), 83-108.

Eckert, R. (2001). Where Leadership Starts. *Harvard Business Review*. November, 53-59.

Edgar, F., & Geare, A. (2011). Factors influencing university research performance. *Studies in Higher Education*, doi:10.1080/03075079.2011.601811.

Fedor, D.B., Caldwell, S., & Herold, D.M. (2006). The effects of organizational changes on employee commitment: A multi-level investigation. *Personnel Psychology, 59*, 1-29.

Fetterman, D.M. (1998). Ethnography: Step by Step. *Applied Social Research Methods Series*, *17.* Second Edition, Thousand Oaks, California: SAGE Publications, Inc.

Fitzpatrick, R.L. (2005). *Exploring Values Alignment as a Strategy for Enhancing Collaboration in a Government Agency*. Master's Thesis, Royal Roads University.

Fitzpatrick, R.L. (2007). A literature review exploring values alignment as a proactive approach to conflict management. *International Journal of Conflict Management, 18*(3), 280-305, doi 10.1108/10444060710826007.

Flakke, E. (2008). *The challenge of organizational change—A comparative study of private organizations' reflections on change processes.* Master of Philosophy in Psychology, University of Oslo. Retrieved from https://www.duo.uio.no/bitstream/handle/10852/18418/MASTERxTHESISxKLARxFORxL EVERING.pdf?SEQUENCE=2

Collaboration in Scientific Research: *Factors that Influence Effective Collaboration during a Period of Transformational Change*

Fletcher, JK. (2001). *Disappearing Acts: Gender, Power, and Relational Practice at Work*. Cambridge, MA: MIT Press.

FPInnovations. (2013). *Overview of the Organization.* Retrieved from https://fpinnovations.ca/media/factsheets/Documents/overview-of-the-organisation.pdf

FPInnovations. (2016). *FPInnovations.* Retrieved from https://fpinnovations.ca/about-us/pages/organization.aspx)

Globe and Mail (The). *Tory budget axes 19,200 public service jobs.* March 29, 2012. Retrieved from http://www.theglobeandmail.com/news/politics/tory-budget-axes-19200-public-service-jobs/article4096640/

Goodman, E.A., Zammuto, R.F., & Gifford, B.D. (2001). The competing values framework: Understanding the impact of organizational culture on the quality of work life. *Organization Development Journal, 19*(3), 58-68.

Government of Canada. (2006). *Overcoming Barriers to Science and Technology Collaboration: Steps toward Greater Integration, March 9, 2006.* Ottawa, Canada.

Government of Canada. (2013). *Blueprint 2020. Getting Started—Getting Your Views: Building Tomorrow's Public Service Together.* Government of Canada, Ottawa, Canada.

Government of Canada. (2014). *Destination 2020.* Government of Canada, Ottawa, Canada.

Gray, B., & Wood, D. (1991). Collaborative Alliances: Moving from Practice to Theory. *Journal of Applied Behavioral Science, 27*(2), 3-22.

Griepentrog, B.K., & Fleming, P.J. (2003). Shared mental models and team performance: Are you thinking what we're thinking? Paper presented at the 18th Annual Conference of the Society of Industrial Organizational Psychology, Orlando, Florida. Cited in, Salas, E., Sims, D.E., and Burke, C.S. (2005). Is There a "Big Five" in Teamwork? *Small Group Research, 36*(5), October, 555-599.

Guzzo, R.A., & Dickson, M.W. (1996). TEAMS IN ORGANIZATIONS: Recent Research on Performance and Effectiveness. *Annual Review of Psychology, 47*, 307-338.

Guzzo, R.A., & Shea, G.P. (1992). Group performance and intergroup relations in organizations. In M.D. Dunnette, & L.M. Hough (Eds.), *Handbook of industrial and organizational psychology* (2nd ed., Vol 3, pp. 269-313). Palo Alto, CA: Consulting Psychologists Press.

Hackman, J.R. (1983). *A Normative Model of Work Team Effectiveness. Technical Report #2. Research Program on Group Effectiveness.* Yale School of Organization and Management, November, 1983.

Hackman, J.R. (1987). The design of work teams. In j. Lorsch (Ed.), *Handbook of organizational behavior,* 315-342. Englewood Cliffs, NJ: Prentice-Hall.

Hackman, J.R. (1990). *Groups that work (and those that don't): Conditions for effective teamwork.* San Francisco, CA: Jossey-Bass.

Hammersley, M., & Atkinson, P. (1995). *Ethnography: Principles in practice* (2nd ed.). New York: Routledge.

Hansen, M., & Nohria, N. (2004). How to Build Collaborative Advantage. *MIT Sloan Management Review*, Fall 2004, *46*(1), 22-30.

Hara, N., Solomon, P., Kim, S-L., & Sonnenwald, D.H. (2003). An Emerging View of Scientific Collaboration: Scientists' Perspectives on Collaboration and Factors that Impact Collaboration. *Journal of the American Society for Information Science and Technology, 54*(10), 952-965.

Heimeriks, K. (2002). *Alliance Capability, Collaboration Quality, and Alliance Performance: An Integrated Framework*. Eindhoven Centre for Innovation Studies, The Netherlands. Working Paper 02.05. Department of Technology Management, Technische Universiteit Eindhoven, The Netherlands.

Herold, D.M., Fedor, D.B., Caldwell, S., & Liu, Y. (2008). The effects of transformational and change leadership on employees' commitment to a change: a multilevel study. *Journal of Applied Psychology, 93*(2), March 2008, 346-357.

Hoegl, M., & Gemuenden, H.G. (2001). Teamwork quality and the success of innovative projects: A theoretical concept and empirical evidence. *Organization Science*, *12*, 435-449.

Hoevemeyer, V. (1993). How Effective is Your Team? *Training & Development,* September, 67-71.

Hogg, M., Van Knippenberg, D., & Rast, D. (2012). Intergroup Leadership in Organizations: Leading Across Group and Organizational Boundaries. *Academy of Management Review*, *37*(2), 232-255.

Huxham, C. (2003). Theorizing collaboration practice. *Public Management Review, 5*(3), 401-423.

Isabelle, D.A., & Heslop, L.A. (2011). *Triple Helix Collaborations: Success Factors and Capitalization of Knowledge in International Scientific Collaborations.* Retrieved from http://www.aomevents.com/media/files/ISS%202012/ISS%20SESSION%208/Isabelle.pdf

Jassawalla, A.R., & Sahittal, H.C. (1998). An Examination of Collaboration in High-Technology New Product Development Process. *Journal of Product Innovation Management*, *15*, 237-254.

Jehn, K.A., Northcraft, G.B., & Neale, M.A. (1999). Why Differences Make a Difference: A Field Study of Diversity, Conflict, and Performance in Workgroups. *Administrative Science Quarterly, 44*, 741-763.

Jick, T.D., & Peiperl, M.A. (2003). *Managing Change: case and concepts* (2nd ed). New York: McGraw-Hill/Irwin.

Johnson, D.W. (2003). Social Interdependence: Interrelationships among Theory, Research and Practice. *American Psychologist*, November, 934-945.

Johnson, P.R., Heimann, V.L., & O'Neill, K. (2000). The wolf pack: team dynamics for the 21st century. *Journal of Workplace Learning: Employee Counselling Today*, *12*(4), 159-164.

Johnson, D.W., & Johnson, R.T. (1995). Social interdependence—Cooperative learning in education. In B. Bunker, & J.Z. Rubin (Eds.), *Conflict, cooperation, and justice*, 205-251. San Francisco: Jossey-Bass Publishers.

Johnson, D.W., & Johnson, R.T. (1999). *Learning together and alone: Cooperative, competitive, and individualistic learning (5th Ed.).* Needham Heights: Massachusetts: Allyn and Bacon.

Collaboration in Scientific Research: *Factors that Influence Effective Collaboration during a Period of Transformational Change*

Johnson, D.W., & Johnson, R.T. (2005). New Developments in Social Interdependence Theory. *Genetic, Social, and General Psychology Monographs*, *131*(4), 285-358.

Johnson, P.R., Heimann, V.L., & O'Neill, K. (2000). The wolf pack: team dynamics for the 21st century. *Journal of Workplace Learning: Employee Counselling Today, 12*(4), 159-164. Cited in Tarricone, P. & Luca, J. (2002). Employees, teamwork and social interdependence: A formula for successful business? *Team Performance Management, 8*(3/4), 54-59.

Jones, G., & George, J. (1998). The Experience and Evolution of Trust: Implications for Cooperation and Teamwork. *Academy of Management Review, 23*(3), 531-546.

Kanter, R.M. (1983). The change masters: Transformations in the American corporate environment: 1860-1980s, New York: Simon & Schuster. Cited in Robinson, O., & Griffiths, A. (2005). Coping With the Stress of Transformational Change in a Government Department. *Journal of Applied Behavioral Science, 41*(2), 204-221.

Katz, S. J., & Martin, B. (1995). *What is research collaboration?* Centre for Science, Technology, Energy and Environment Policy, University of Sussex. Retrieved from http://www.sussex.ac.uk/Users/sylvank/pubs/Res_col9.pdf

Katzenbach, J.R., & Smith, D.K. (1993a). *The wisdom of teams: Creating the high-performance organization.* Boston, MA: Harvard Business School Press.

Katzenbach, J.R., & Smith, D.K. (1993b). The Discipline of Teams. *Harvard Business Review*, *71*(2), 111-120.

Kazantzi, K. (2010). *Do we need any more hierarchical structures? Combining vertical and shared leadership considering the organizational culture, structure and processes. Literature Review.* May 15th, 2010. IACCM 2010, at UCLAN, Preston, UK.

Kelly, K., & Schaefer, A. (2014). *Creating a Collaborative Organizational Culture*. UNC Executive Development.

Keyton, J., & Stallworth, V. (2003). On the verge of collaboration: Interaction processes versus group outcomes. In L.R. Frey (Ed.), *Group communication in context: Studies of bona fide groups,* 235-260. Mahwah, NJ: Erlbaum.

Collaboration in Scientific Research: *Factors that Influence Effective Collaboration during a Period of Transformational Change*

Kotter, J.P. (1995). Leading change: Why Transformation Efforts Fail. *Harvard Business Review*, March-April, 59-67.

Kozlowski, S.W.J., & Bell, B.S. (2003). Work groups and teams in organizations. In W.C. Borman, and D.R. Ilgen (Eds.), *Comprehensive handbook of psychology: Industrial and organizational psychology, 12*, 333-375. New York: Wiley.

Kraut, R.E., Galegher, J., & Egido, C. (1987). Relationships and Tasks in Scientific Research Collaboration. *Human-Computer Interaction, 1987-1988, 3*, 31-58.

Kubr, M. (1996). *Management consulting: A guide to the profession.* (3rd Ed.). Geneva: International Labour Office.

Lafond, D., Irandoust, H., Tremblay, S., Price, W., & Benaskeur, A.R. (2009). *C2 and Agility: A Context-Sensitive Functional Model of Teamwork Processes.* Topic 3: Information Sharing and Collaboration Processes and Behaviors, 14th ICCRTS.

Larson, C.E., & LaFasto, F.M.J. (1989). *Team Work: What must go right/ What can go wrong*. London: SAGE Publications, Inc.

Leana, C., & Van Buren, H. III. (1993). Social capital and employment practices. *Academy of Management Review, 24*(3), 538-555.

Lee, H.Y., & Kamarul, Z.B.A. (2009). The moderating effects of organizational culture on the relationships between leadership behaviour and organizational commitment and between organizational commitment and job satisfaction and performance. *Leadership & Organization Development Journal, 30*(1), 53-86.

Lewin, K. (1947). Group Decision and Social Change. In T.M. Newcomb & E.L. Hartley (Eds.), *Readings in Social Psychology*, 330-344, New York: Henry Holt.

Lieberman, M.A., Yalom, I.D., & Miles, M.B. (1973). *Encounter Groups: First Facts*. New York: Basic Books.

Lin, Y., & Beyerlein, M. (2006). Communities of Practice: A Critical Perspective on Collaboration. In M. Beyerlein, S. Beyerlein, & F. Kennedy (Eds.), *Innovation through Collaboration. Advances in Interdisciplinary Studies of Work Teams*, *Vol. 12*, 53-79.

Lincoln, Y.S., & Guba, E. (1985). *Naturalistic Inquiry*. Beverly Hills, CA; SAGE.

Luca, J., & Tarricone, P. (2001). Does Emotional Intelligence Affect Successful Teamwork? In Meeting at the Crossroads. *Proceedings of the 18th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education.* Melbourne, Australia, 367-376. Retrieved from http://ro.ecu.edu.au/ecuworks/4834

Lyons, J.B., Swindler, S.D., & White, J.A. (2008). Network Centric Warfare: Organizational Collaboration as a Key Enabler. *IEEE*, 367-374.

Maierhofer, N., Rafferty, A., & Kabanoff, B. (2003). When and Why are Values Important in Organizations? In S. Gilliland, D. Steiner, & D. Skarlicki (Eds.), *Emerging Perspectives on Values in Organizations*, 3-32. A Volume in Research in Social Issues in Management, Connecticut: Information Age Publishing Inc.

Marcus, E.C. (2000). Change Processes and Conflict. In M. Deutsch, & P.T. Coleman (Eds.), *The Handbook of Conflict Resolution*, 366-381. San Francisco: Jossey-Bass Publishers.

Marshall, C., & Rossman, G.B. (2011). *Designing Qualitative Research*. Fifth Edition. Thousand Oaks, CA: SAGE Publications, Inc.

Mathieu, J.E., Heffner, T.S., Goodwin, G.F., Salas, E., & Cannon-Bowers, J.A. (2000). The influence of shared mental models on team process and performance. *Journal of Applied Psychology, 85*, 273-283.

Mattessich, P.W., Murray-Close, M., & Monsey, B.R. (2001). *Collaboration: What makes it work?* (2nd Ed.), St. Paul, MN: Amherst H. Wilder Foundation.

McGrath, J.E. (1964). *Social psychology: A brief introduction*. New York: Holt, Rinehart & Winston.

McGrath, J.E. (1991). Time, Interaction, and Performance (TIP): A Theory of Groups. *Small Group Research, 22*(2), 147-174.

McIntyre, R.M., & Salas, E. (1995). Measuring and managing for team performance: Emerging principles from complex environments. In R.A. Guzzo, E. Salas, and Associates (Eds.), *Team effectiveness and decision making in organizations*, 9-45. San Francisco, CA: Jossey-Bass.

Mdltye, A., Coetzee, J., & Ukpere, W. (2012). The impact of transformational change in the Department of Correctional Services of South Africa. *African Journal of Business Management, Vol. 6*(50), 11986-11998.

Meadows, D. (2008). *Thinking in Systems: A Primer*. Chelsea Green Publishing.

Merriam-Webster's Collegiate Dictionary. (2003). 11th Edition.

Mishra, A.K. (1996). Organizational responses to crisis: The centrality of trust. In R.M. Kramer, & T.R. Tyler (Eds.), *Trust in organizations: Frontiers of theory and research,* 261-297, Thousand Oaks, CA: SAGE Publications, Inc.

Mohammed, S., Klimoski, R., & Rentsch, J.R. (2000). The measurement of team mental models: We have no shared schema. Organizational Research Methods, 3, 123-165. Cited in, Salas, E., Sims, D.E., & Burke, C.S. (2005). Is There a "Big Five" in Teamwork? *Small Group Research, 36*(5), October, 555-599.

Mohr, J., & Spekman, R. (1994). Characteristics of partnership success: Partnership attributes, communication behavior and conflict resolution. *Strategic Management Journal, 15*, 135-152.

Murrell, K.L. (1997). Emergent theories of leadership for the next century: Towards relational concepts. *Organization Development Journal, 15*(3), 35–42.

Nachmias, D., & Nachmias, C. (1987). *Research Methods in the Social Sciences*. Third Ed. New York: St. Martin's Press.

Nadler, D.A. (1982). Managing transitions to uncertain future states. *Organizational Dynamics, 11*, 37-45.

Nadler, D.A., & Tushman, M.L. (2007). The organization of the future: Strategic imperatives and core competencies for the twenty-first century. In J. Osland, M. Turner, D. Kolb, & I. Rubin (Eds.), *The organizational behaviour reader* (8th Ed.), 639-654. Upper Saddle River, N.J.: Pearson Education, Inc.

Namey, E., Guest, G., Thairu, L., & Johnson, L. (2008). Data Reduction Techniques for Large Qualitative Data Sets. In G. Guest, & K. MacQueen (Eds.), *Handbook for Team-Based Qualitative Research*, Chapter 7, 137-161. Lantham, Maryland: Altamira Press.

National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine. (1999). *Government, University and Industry Roundtable on Overcoming Barriers to Collaborative Research: Report of a Workshop.* Government-University Industry Research Roundtable. Washington, D.C: National Academy Press.

Natural Resources Canada. (2010). *Science and Technology Strategy*. Ottawa, Canada.

Natural Resources Canada. (2014a). *Canadian Wood Fibre Centre*. Ottawa, Canada. Retrieved from http://www.nrcan.gc.ca/forests/research-centres/cwfc/13457

Natural Resources Canada. (2014b). *Innovation.* Ottawa, Canada. Retrieved from https://www.nrcan.gc.ca/forests/innovation/13329

Natural Resources Canada. (2016a). *Forest Topics*. Ottawa, Canada. Retrieved from http://www.nrcan.gc.ca/forests/topics/13505

Natural Resources Canada. (2016b). *Evaluation of Forest Sector Innovation Sub-Program.* Ottawa, Canada. Retrieved from http://www.nrcan.gc.ca/evaluation/reports/2014/17126

Natural Resources Canada. (2016c). *Squeezing more value from trees*. Ottawa, Canada. Retrieved from http://www.nrcan.gc.ca/forests/industry/tools-research/13331

Natural Resources Canada. (2016d). *Transformative Technologies*. Ottawa, Canada. Retrieved from http://www.nrcan.gc.ca/forests/industry/products-applications/13343

Natural Resources Canada. (2016e). *Report on Annual Expenditures for Travel, Hospitality and Conferences*. Ottawa, Canada. Retrieved from http://www.nrcan.gc.ca/proactive-disclosure/expenditures/11550

Nicholson, N. (1998). *The Blackwell Encyclopedic Dictionary of Organizational Behavior.* Massachusetts: Blackwell Publishers Ltd.

Noble, D., Buck, D., & Yeargain, J. (2001). Metrics for Evaluation of Cognitive-Based Collaboration Tools. *6th International Command and Control Research and Technology Symposium*, Annapolis: 2001, 1-12.

Northouse, P.G. (2007). *Leadership Theory and Practice*. 4th Edition. Thousand Oaks, CA: SAGE Publications, Inc.

Pallot, M., Bergmann, U., Kühnle, H., Pawar, K.S., & Riedel, J. (2010). *Collaborative Working Environments: Distance Factors Affecting Collaboration.* 16th International Conference on Concurrent Enterprising and Collaborative Environments for Sustainable Innovation, 21-23 June, 2010, Lugano, Switzerland. Centre for Concurrent Enterprise, University of Nottingham, Nottingham.

Parsons, T. (1951). *The Social System*. New York, Free Press.

Patton, M.Q. (2002). *Qualitative Research & Evaluation Methods.* 3rd Edition, Evaluation, Thousand Oaks, CA: SAGE Publications, Inc.

Pearce, C.L., & Conger, J.A. (2003). All Those Years Ago. In C.L. Pearce, & J.A. Conger (Eds.), *Shared Leadership*, 1-18, Thousand Oaks, California: SAGE Publications, Inc.

Pentland, A, (2012). The New Science of Building Great Teams. The chemistry of high-performing groups is no longer a mystery. *Harvard Business Review*, *April*, 2012, 1-11.

Perrault, E.L.J. (2008). *Community-University Interorganizational Collaboration: A Case Study of the Important Factors for Success*. Dissertation. Faculty of Social Work, University of Calgary.

Powers, B.J. (2004). *A Test Methodology for Reliability Assessment of Collaborative Tools.* Master's Thesis, Naval Postgraduate School, Monterey, California. Retrieved from http://faculty.nps.edu/ncrowe/oldstudents/bpowers thesis.htm

Privy Council Office. (2012). *Moving Ahead: Public Service Renewal in a Time of Change*. Prime Minister's Advisory Committee on the Public Service. Sixth Report to the Prime Minister. March 2012. Ottawa, Canada.

Rentsch, J.R., & Klimoski, R.J. (2001). Why do 'great minds' think alike? Antecedents of team member schema agreement. Journal of Organizational Behavior, 22, 107-120. Cited in, Salas, E., Sims, D.E., & Burke, C.S. (2005). Is There a "Big Five" in Teamwork? *Small Group Research, 36*(5), October, 555-599.

Robinson, O., & Griffiths, A. (2005). Coping With the Stress of Transformational Change in a Government Department. *Journal of Applied Behavioral Science, 41*(2), 204-221.

Rokeach, M. (1968). *Beliefs, Attitudes and Values*. San Francisco: Jossey-Bass.

Rokeach, M. (1973). *The nature of human values.* New York: Free Press.

Rousseau, D.M. (1990). Quantitative assessment of organizational culture: The case for multiple measures. In B. Schneider (Ed.). *Frontiers in industrial and organizational psychology*, *Vol. 3*, 153-192. San Francisco: Jossey-Bass.

Rousseau, D.M., Sitkin, S.B., Burt, R.S., & Camerer, C. (1998). Not so different after all: A cross-discipline view of trust. *The Academy of Management Review, 23*(3), 393-404.

Salas, E., Burke, C.S., & Stagl, K.C. (2004). Developing teams and team leadership: Strategies and principles. In D.V. Day, S. Zaccaro, J., & S.M. Halpin (Eds.), *Leader development for transforming organizations: Growing leaders for tomorrow*, 325-355. Mahwah, N.J.: Lawrence Erlbaum Associates.

Salas, E., Goodwin, G.F., & Burke, C.S. (2009). *Team Effectiveness in Complex Organizations: Cross-Disciplinary Perspectives and Approaches.* New York: Psychology Press.

Salas, E., Rosen, M.A., Burke, C.S., & Goodwin, G.F. (2009). The wisdom of collectives in organizations: An update of the teamwork competencies. In E. Salas, G.F. Goodwin, & C.S. Burke (Eds.), *Team Effectiveness in Complex Organizations: Cross-Disciplinary Perspectives and Approaches*, 39-79. New York: Psychology Press.

Salas, E., Sims, D.E., & Burke, C.S. (2005). Is There a "Big Five" in Teamwork? *Small Group Research, 36*(5), October, 555-599.

Salas, E., Shuffler, M., Thayer, A., Bedwell, W., & Lazzara, E. (2014). *Understanding and Improving Teamwork in Organizations: A Scientifically Based Practical Guide*. Human Resource Management.

Scarnati, J.T. (2001). On becoming a team player. *Team Performance Management: An International Journal, 7*(1/2), 5-10.

Schein, E.H. (2004). *Organizational Culture and Leadership*. San Francisco: John Wiley & Sons.

Schwartz, S.H., & Bilsky, W. (1987). Toward a universal psychological structure of human values. *Journal of Personality and Social Psychology*, *53*, 550-562.

Senge, P. (1990). *The Fifth Discipline: The Art and Practice of the Learning Organization*. New York: Doubleday/Currency.

Smith, K. (1996). Cooperative learning: make groupwork work. New Directions for Teaching and Learning, 67, Fall, 71-82. Cited in Tarricone, P. & Luca, J. (2002). Employees, teamwork and social interdependence: A formula for successful business? *Team Performance Management, 8*(3/4), 54-59.

Smith, D., & Katz, J.S. (2000). *Collaborative Approaches to Research*. HEFCE Fundamental Review of Research Policy and Funding. Final Report. 1-67.

Smollan, R., & Sayers, J. (2009). Organizational Culture, Organizational Change and Emotions: A Qualitative Study. *Journal of Change Management*, *9*(4), 435-457.

Sonnenwald, D.H. (2006). *Scientific Collaboration: A Synthesis of Challenges and Strategies.* Swedish School of Library and Information Science, Goteborg University and University College of Boras Sweden.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research* (2nd ed.). Newbury Park, CA: SAGE Publications, Inc.

Suba, B. (2011). *Collaboration Quality. Management and Organization*. Master's Thesis, University of Tampere, School of Management.

Sundstrom, E., De Meuse, K., & Futrell, D. (1990). Work Teams: Applications and Effectiveness. *American Psychologist, 45*(2), February, 120-133.

Tarricone, P., & Luca, J. (2002). Employees, teamwork and social interdependence: A formula for successful business? *Team Performance Management, 8*(3/4), 54-59.

Thomson, A.M., & Perry, J.L. (2006). Collaboration processes: Inside the black box. *Public Administration Review, 66*(S1), 20-32.

Tran, M.Q., & Biddle, R. (2008). *Collaboration in serious game development: A case study.* Carleton University. Proceedings of the 2008 Conference on Future Play: Research, Play, Share. NY, 49-56.

Turnley, J.G., & McNamara, L.A. (2007). *An Ethnographic Study of Culture and Collaborative Technology in the Intelligence Community*. SAND 2007-2593-J., 1-21.

Collaboration in Scientific Research: *Factors that Influence Effective Collaboration during a Period of Transformational Change*

Van der Vegt, G., & Van de Vliert, E. (2001). Intragroup interdependence and effectiveness: review and proposed directions for theory and practice. *Journal of Managerial Psychology, 17*(1), 50-67.

Van Tonder, C. (2004). Organisational Transformation: Wavering on the Edge of Ambiguity. *SA Journal of Industrial Psychology, 30*(3), 53-64.

Vangen, S., & Huxham, C. (2003). Enacting Leadership for Collaborative Advantage: Dilemmas of Ideology and Pragmatism in the Activities of Partnership Managers. *British Journal of Management, Vol. 14,* S61-S76.

Vasleiadou, E. (2011). *Research teams as complex systems and implications for research governance.* Atlanta Conference on Science, Technology and Innovation Policy, 1-9.

Wagner, C.S., & Leydesdorff, L. (2005). Mapping the network of global science: comparing international co-authorships from 1990 to 2000. *International Journal of Technology and Globalisation, 1*(2), 185-208.

Way, L., & Dale, P. (2013). *The 7 principles of effective governance: Lessons-learned for Science-Based Departments and Agencies.* NRCan-Canadian Forest Service. Ottawa, Canada.

Webber, S.S. (2002). Leadership and trust facilitating cross-functional team success. *Journal of Management Development, 21*, 201-214.

Whitford, A.B., Lee, S.Y., Yun, T., & Jung, C. (2010). Collaborative behavior and the performance of government agencies. *International Public Management Journal, 13*, 321-349.

Wood, D.J., & Gray, B. (1991). Toward a Comprehensive Theory of Collaboration. *Journal of Applied Behavioral Science, 27,* 139-162.

Wouters, W.G. (2012). *Nineteenth Annual Report to the Prime Minister on the Public Service of Canada.* Clerk of the Privy Council and Secretary to the Cabinet. Ottawa.

Zaccaro, S.J., Rittman, A.L., & Marks, M.A. (2001). Team Leadership. *The Leadership Quarterly, 12*, 451-483.

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APPENDIX A: Collaboration and Team Characteristics

Kraut, Galegher & Egido (1987)	Larson & Lafasto (1989)	Hoegl & Gemuenden (2001)	Heimeriks (2002)	Huxham (2003)	Keyton & Stallworth (2003)	Fitzpatrick (2005)	Salas, Sims & Burke (2005)	Perrault (2008)	Lyons, Swindler & White (2008)	Lafond et al (2009)	Dietrich et al (2010)	Pallot et al (2010)	Isabelle & Heslop (2011)	Suba (2011)
	Goal and Vision			Common aims	Shared goal	Common purpose		Learning purpose	Common goal	Goal specification /Mission analysis			Shared vision	Shared goal
	Leadership			Leadership	Leadership		Team/Shared Leadership	Shared leadership		Leadership		Leadership		
Trust			Mutual Trust	Trust		Trust		Mutual respect, understanding & trust	Trust	Trust		Mutual Trust	Trust	Trust
Information sharing		Information sharing/ communication	Information sharing/ communication			Communication		Informal relationships & communication	Information sharing	Communication / Shared knowledge, representations & intentions	Communication	Lack of shared knowledge		Communication
Coordinating activities/ division of labor	Results-driven team structure	Coordination	Coordination of roles & responsibilities	Membership structure	Multiple roles		Team orientation	Role clarification		Division of labour	Coordination			Coordination
Doing the work/ writing the manuscript	Unified commitment	Effort	Commitment		Member motivation/ maturity					Group Motivation/ Commitment	Aligned efforts	Incentive/ Motivation	Unified commitment	Commitment
		Cohesion			Member interdependence				Cohesion	Group cohesion & team identity	Cohesion			Collaborative attitude
		Mutual support								Mutual monitoring	Mutual support			
Division of credit		Balanced contributions			Shared decision-making							Unbalanced IP approaches		
	Collaborative climate					Consciousness			Collaboration Enablers					Unified culture
Finding a partner			Resource configuration				Back-up behavior			Resource sharing				
			Compatibility		Right chemistry		Adaptability	Flexibility	Collaboration Adaptability	Adaptability/ Conflict management				
Supervising & sustaining progress							Mutual Performance Assessment		Collaboration Effectiveness	Monitoring progress				Resource configuration
	High standard of excellence			Power						Planning & synchronization			Mutually beneficial collaboration	
Sharing assumptions	External support									Systems interoperability				Competence
Generating ideas/ planning	Competent team recognition								Job Characteristic	Training & education		Lack of meaning		

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APPENDIX B: Invitation Letter

INVITATION LETTER

May, 2014.

Dear Prospective Participant:

My name is Barbara Waruszynski, and I would like to recruit researchers and managers to take part in a research project that I am conducting, entitled: ***Collaboration in Scientific Research—Exploring the Factors that Influence Effective Collaboration during a Period of Transformational Change***. As a researcher within the federal government, I am interested in exploring the area of intra-organizational and inter-organizational collaboration in scientific research. This research project is part of the requirement for a Doctorate of the Social Sciences at Royal Roads University. My credentials can be established by telephoning ██████████ ██.

The aim of this research is to examine the key factors that influence researchers' attitudes and behaviours in collaborative scientific research, particularly as the federal government goes through a period of transformational change. The study findings will inform departmental policies, practices and programs with the goal of improving how collaboration in scientific research is carried out across the federal community.

The main criterion for recruiting research participants is to enlist researchers who are engaged in collaborative projects that have both internal (intra-organizational) and external (inter-organizational) team membership. A sample of eight collaborative project teams will be recruited to participate in this study. Managers will also be recruited in order to obtain their views on collaboration, and to further examine their perceptions of collaboration through management and leadership practices.

The foreseen questions will refer to perceptions and experiences of collaboration within the Canadian Wood Fibre Centre (CWFC)/Canadian Forest Service (CFS) and with FPInnovations, along with perceptions and experiences of collaboration with other government departments, industry, and academia. The research project will consist of:
- *Individual Interviews*: The research will consist of 24 individual interviews with researchers (up to three participants per project team) and approximately 15 individual interviews with managers from across CWFC/CFS. Each interview will last approximately 60 to 90 minutes.
- *Focus Group Interviews*: The research will consist of two focus groups with researchers (up to eight participants per focus group). Each focus group will last approximately two hours.

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- *Non-Participant Observations*: The research will consist of non-participant observations of researchers' collaborative project team meetings. Three project teams will be observed for approximately ten hours per project team.

Information will be recorded in both hand-written and audio-recorded format. The results will be anonymous and summarized into themes and categories for the final dissertation report. At no time will any specific comments be attributed to any individual unless permission has been explicitly given to the principal investigator of this study. In addition, all documentation, including the transcripts from the audio recordings, will be kept strictly confidential and under lock and key.

In addition to submitting my final dissertation to Royal Roads University in partial fulfillment for a Doctorate of the Social Sciences, I will also be sharing my research findings with CWFC/CFS (Natural Resources Canada). The results of the data will be communicated to government, industry, and academic and non-academic communities. A copy of the final published report will be housed at Royal Roads University, available online through UMI/Proquest and the Theses Canada portal and will be publicly accessible. Access and distribution will be unrestricted.

Your participation would be greatly appreciated and will contribute to a better understanding of how we could optimize collaboration in scientific research within the federal science and technology community. Please note that prospective participants are not compelled to participate in this research project. Participants who agree to participate in this study will have the freedom to withdraw at any time, without prejudice.

If you would like to participate in this research project, please contact me at:

- Email: ███████████████████████
- Telephone: ███████████

Sincerely yours,

Barbara T. Waruszynski (Doctoral Candidate)

With support and endorsement from:

███████████████

Canadian Wood Fibre Centre
Canadian Forest Service (Natural Resources Canada)

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APPENDIX C: Interview Guide for Researchers

1. Let us begin by you briefly introducing yourself and your role within CWFC? *You may use your first name or a pseudonym, if you prefer.*

2. What does the word collaboration mean to you within a research context?
   a. PROMPT: What does collaboration look like to you?
   b. PROMPT: How do you know when you see it? *Please give me an example.*

3. How would you describe collaboration in scientific research within CWFC? Across CFS? With FPInnovations? With External Organizations *(Prompts are for each organization)*
   a. PROMPT: What are the incentives, if any, to collaborate?
   b. PROMPT: Why do researchers collaborate?
   c. PROMPT: What are the disincentives, if any, to collaborate?
   d. PROMPT: What impedes or interferes with their attempts to collaborate?

4. Based on your experience:
   a. How would you <u>define</u> successful collaboration?
      i. PROMPT: What are the characteristics of *successful* collaboration in scientific research?
   b. How would you <u>describe</u> unsuccessful collaboration?
      i. PROMPT: What are the characteristics of *unsuccessful* collaboration in scientific research?

5. Based on your experience:
   a. What are the <u>benefits</u> of *successful* collaboration in scientific research?
   b. What are the <u>consequences</u> of *unsuccessful* collaboration in scientific research?

6. Please describe a <u>collaborative project</u> that you currently are/were a part of.
   a) PROMPT: What motivated you to get involved in this collaborative project?
   b) PROMPT: Please describe what elements of the collaborative project were successful. What made these elements possible?
   c) PROMPT: Please describe what elements of the collaborative project were unsuccessful.

7. Please describe the <u>outcome of your collaborative project</u>?
   a) PROMPT: How successful were you in accomplishing the goal(s) of your project?
   b) PROMPT: How would you describe team member roles and responsibilities in the project?
   c) PROMPT: How would you describe the social atmosphere (interpersonal relationships) within your collaborative project?

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8. Please describe <u>how information was communicated</u> in your collaborative project?
   a) PROMPT: How was information shared?
   b) PROMPT: Was the project team co-located or distributed (virtual)?
   c) PROMPT: What technology was employed in your collaborative project?

9. Please describe your experiences of working on collaborative projects with:
   a) Co-workers within CWFC?; Co-workers across CFS?; Co-workers with FPInnovations?; and External organizations (e.g., Other Government Departments, government agencies and/or other government organizations, industry and/or academia)?

10. In your opinion, how have senior managers tried to enable collaboration in scientific research:
   a. Within CWFC?
      i. What worked well?/What didn't work well?
   b. Across CFS?
      i. What worked well?/What didn't work well?
   c. With FPInnovations?
      i. What worked well?/What didn't work well?
   d. With external partners (e.g., Other Government Departments, agencies and organizations, industry, and academia)?
      i. What worked well?/What didn't work well?

11. The federal government is undergoing a period of transformation. In your experience, how has this transformation influenced research collaboration?

12. In this period of transformation, please describe what factors would:
   a. <u>ENABLE</u> researchers to collaborate more effectively… …
      i. Within CWFC?; Across CFS?; With FPInnovations?; With external organizations (e.g., Other Government Departments, agencies and organizations, industry, and academia)?
   b. <u>CONSTRAIN</u> researchers to collaborate:
      i. Within CWFC?; Across CFS?; With FPInnovations?; With external organizations (e.g., Other Government Departments, agencies and organizations, industry, and academia)?

13. If you were given an opportunity to improve collaboration in scientific research <<within CWFC>>, what would be the <u>three most important elements</u> that would increase collaboration performance?
      i. Across CFS?; With FPInnovations?; With external organizations (e.g., Other Government Departments, agencies/organizations, industry, and academia)?

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APPENDIX D: Telephone/VTC Contact-Informed Consent Form

Telephone and VTC Informed Consent Form for Ethnographic Interviews

Thank you for agreeing to participate in this study on *Collaboration in Scientific Research— Exploring the Factors that Influence Effective Collaboration during a Period of Transformational Change*. My name is Barbara Waruszynski, and this research project is part of the requirement for a Doctorate of the Social Sciences at Royal Roads University. My credentials with Royal Roads University can be established by telephoning ███████████ ██.

The aim of this research is to examine the key factors that influence researchers' attitudes and behaviours in collaborative scientific research, particularly as the federal government goes through a period of transformational change. The study findings will inform departmental policies, practices and programs with the goal of improving how collaboration in scientific research is carried out across the federal community.

In this research, collaboration in scientific research is defined as researchers working collectively to achieve a common goal in the pursuit of producing new scientific knowledge or technology (Katz & Martin, 1995; Bond & Thompson, 1996; Jassawalla & Sashittal, 1998; Smith & Katz, 2000; Bozeman & Corley, 2004; Lin & Beyerlein, 2006). Transformational change within the federal community is defined as changes in organizational business strategies and policy development, and in the reorganization of employees, processes, systems, projects, structure, and power (Robinson & Griffiths, 2005).

Your participation will be based on one individual interview which will last approximately 60 to 90 minutes. The questions will refer to your perceptions and experiences of collaboration within the Canadian Wood Fibre Centre (CWFC), across the Canadian Forest Service (CFS), with FPInnovations, and/or with other government departments, industry, and academia. The interview will be audio-recorded to ensure an accurate description of your responses to the questions. No one besides myself will have access to the recordings. Your personal thoughts and experiences will be summarized into themes and categories (in anonymous format) for the final dissertation report. At no time will any specific comments be attributed to any individual unless permission has been explicitly given to the principal investigator of this study. In addition, all audio recordings and documentation, including the transcripts from the audio recordings, will be kept strictly confidential and will be placed in a locked filing cabinet.

The risks of this research study are minimal. The risks would be similar to work-related issues that you may disclose to others during a workday (e.g., concerns about collaboration, organizational culture, organizational change, and/or leadership/management practices).

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As part of the requirements for a Doctorate of the Social Sciences, I will need to submit my final report to Royal Roads University. I will also be sharing my research findings with all of the participants, including CWFC/CFS (Natural Resources Canada). The results of the data will be communicated to government, industry, and academic and non-academic communities so that they benefit and learn from CWFC's experiences on intra-organizational and inter-organizational collaboration in scientific research. The results will be communicated through articles in refereed journals, conferences, and through the publication of the dissertation manuscript/book. The results may also be communicated through conference presentations, press coverage and speaking engagements. A copy of the final report will be published and housed at Royal Roads University, available online through UMI/Proquest and the Theses Canada portal. Access and distribution will be unrestricted.

Please note that you are not compelled to participate in this research project. If you choose to participate, you are free to omit answering any question that you may prefer to skip, and/or you may withdraw at any time, without prejudice. If you choose not to participate in this research project, this information will be maintained in confidence.

If you have any questions that need to be addressed, please ask me before we proceed with the interview questions.

Do you agree to participate in this research project?

◯   **YES:** Oral consent is documented below.

◯   **NO:** Thank the potential participant for his/her time.

_____
NAME OF **PARTICIPANT** *(PLEASE PRINT)*

PERSON OBTAINING CONSENT:

I have read this form to the participant. To the best of my judgment, I truly believe that the person understood all aspects of the project. The participant has given his/her oral consent to participate in this research project.

_____
NAME AND **TITLE** *(PLEASE PRINT)*

_____   _____
SIGNATURE OF **PERSON OBTAINING INFORMED CONSENT**   **DATE**

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APPENDIX E: Interview Guide for CWFC Managers

1. Let us begin by you briefly introducing yourself and your role within CWFC? *You may use your first name or a pseudonym, if you prefer.*

2. What does the word collaboration mean to you in a research context?
   a. PROMPT: What does collaboration look like to you?
   b. PROMPT: How do you know when you see it? *Please give me an example.*

3. How would you describe collaboration in scientific research within CWFC? Across CFS? With FPInnovations? *(Prompts are for each organization)* ……
   a. PROMPT: What are the incentives, if any, to collaborate?
   b. PROMPT: Why do researchers collaborate?
   c. PROMPT: What are the disincentives, if any, to collaborate?
   d. PROMPT: What impedes or interferes with their attempts to collaborate?

4. Based on your experience:
   a. How would you define successful collaboration?
      i. PROMPT: What are the characteristics of *successful* collaboration in scientific research?
   b. How would you describe unsuccessful collaboration?
      i. PROMPT: What are the characteristics of *unsuccessful* collaboration in scientific research?

5. Based on your experience:
   a. What are the benefits of *successful* collaboration in scientific research?
   b. What are the consequences of *unsuccessful* collaboration in scientific research?

6. In your opinion, how have senior managers tried to enable collaboration in scientific research:
   a. Within CWFC?
      i. What worked well?/What didn't work well?
   b. Across CFS?
      i. What worked well?/What didn't work well?
   c. With FPInnovations?
      i. What worked well?/What didn't work well?
   d. With external partners (e.g., Other Government Departments, agencies and organizations, industry, and academia)?
      i. What worked well?/What didn't work well?

7. The federal government is undergoing a period of transformation. In your experience, how has this transformation influenced research collaboration (if at all)?

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8. In this period of transformation, please describe what factors would:
    a. ENABLE researchers to collaborate more effectively… …
        i. Within CWFC?
        ii. Across CFS?
        iii. With FPInnovations?
        iv. With external organizations (e.g., Other Government Departments, agencies and organizations, industry, and academia)?
    b. CONSTRAIN researchers to collaborate:
        i. Within CWFC?
        ii. Across CFS?
        iii. With FPInnovations?
        iv. With external organizations (e.g., Other Government Departments, agencies and organizations, industry, and academia)?

9. If you were given an opportunity to improve collaboration in scientific research <<within CWFC>>, what would be the three most important elements that would increase collaboration performance?
    a. Across CFS?
    b. With FPInnovations?
    c. With external organizations (e.g., Other Government Departments, agencies and organizations, industry, and academia)?

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APPENDIX F: Interview Guide for Industry Managers

1. Before we begin with the main interview questions, can you give me a brief <u>overview of your role in FPInnovations</u>?

2. When you think of "collaboration in scientific research", what <u>characteristics</u> come to mind?

3. How would you describe the <u>culture</u> of collaboration in scientific research:
   a. Within *FPInnovations*?; With *CWFC*?; With *CFS*?; With *external organizations* (e.g., other government departments, agencies and organizations, other industry organizations, and academia)?

4. If you were given an opportunity to improve collaboration in scientific research <<*within FPInnovations*>>, what would be the <u>three most important elements</u> that would increase collaboration performance?
   a. Within *FPInnovations*?; With *CWFC*?; With *CFS*?; With *external organizations* (e.g., other government departments, agencies and organizations, other industry organizations, and academia)?

5. You're given the opportunity to design Canada's forest sector for the year 2025, what are the elements that would enable <u>more integrated working relationships</u>:
   a. Within *FPInnovations*?; With *CWFC*?; With *CFS*?; With *external organizations* (e.g., other government departments, agencies and organizations, other industry organizations, and academia)?

6. The Public Service of Canada holds the following enduring values: *Respect for Democracy*, *Respect for People*, *Integrity*, *Stewardship* and *Excellence*. What would be the <u>main enduring values for FPInnovations</u> that would build your capacity to deliver innovative R&D for the Canadian forest industry in the year 2025?

   a. PROMPT: What would be the <u>main enduring values for FPInnovations</u> that would shape the integration of collaborative science with policy and management in the year 2025?

7. Is there anything else that you would like to add that would help to better understand the area of collaboration in scientific research?

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APPENDIX G: Focus Group Guide

1.   When you think of "collaboration in scientific research", what characteristics come to mind?

2.   Based on your experience, what are the personal attributes that make up a good collaborator in scientific research?

3.   How would you describe the culture of collaboration in scientific research:
      a.   Within CWFC?
      b.   Across CFS?
      c.   With FPInnovations?
      d.   With external organizations (other government departments/agencies, industry, academia, etc.)?

4.   The federal government is going through a period of transformational change. Based on your experience, what are some of the big drivers of change that are affecting collaboration in scientific research?

5.   During this period of transformational change, what approaches to organizational change need to be considered to enable effective collaboration in scientific research within the Canadian forest sector?

6.   You're given the opportunity to design Canada's forest sector for the year 2025, what are the elements that would enable more integrated working relationships:
      a.   Within the CWFC?
      b.   Across CFS?
      c.   With FPInnovations?
      d.   With external organizations (i.e., other government departments/agencies, industry, academia, etc)?

7.   *Blueprint 2020* "envisions a capable and a high-performing Public Service that embraces innovation, transformation and continuous renewal." Please describe the characteristics that would foster a federal science and technology community that embraces "innovation, transformation and continuous renewal."

8.   The Public Service of Canada holds the following enduring values: *Respect for Democracy*, *Respect for People*, *Integrity*, *Stewardship* and *Excellence*. What would be the main enduring values that would shape the integration of collaborative science with policy and management in the year 2025?

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APPENDIX H: Informed Consent Letters

INFORMED CONSENT LETTER
Ethnographic Interviews with Researchers and Managers

My name is Barbara Waruszynski, and this research project is part of the requirement for a Doctorate of the Social Sciences at Royal Roads University. My credentials with Royal Roads University can be established by telephoning ███████████████████████ ██████████████████████.

This document constitutes an agreement to participate in my research project, entitled: ***Collaboration in Scientific Research—Exploring the Factors that Influence Effective Collaboration during a Period of Transformational Change.*** The aim of this research is to examine the key factors that influence researchers' attitudes and behaviours in collaborative scientific research during a period of transformational change. Your participation is greatly appreciated and will contribute to a better understanding of how we could optimize collaboration in scientific research within the federal science and technology community, particularly during periods of organizational transformations.

The research will consist of individual interviews and is anticipated to last approximately 60 to 90 minutes. The foreseen questions will refer to perceptions and experiences of collaboration within the Centre, and with other government departments, industry, and academia. In addition to submitting my final report to Royal Roads University in partial fulfillment for a Doctorate of the Social Sciences, I will also be sharing my research findings with the Canadian Wood Fibre Centre (Natural Resources Canada). The results of the data will be communicated to government, industry, academic and non-academic communities. With respect to government, industry and academic communities, the results will be communicated through articles in refereed journals, conferences and through the publication of the dissertation manuscript/book. Dissemination of the results to non-academic communities will be communicated through a manuscript/book to attract others who may be interested in advancing science and technology collaboration. The results may also be communicated through conference presentations, press coverage and speaking engagements.

The interview will be audio-recorded to ensure an accurate description of your response to the questions. No one besides myself will have access to the recordings. The information will be summarized into themes and categories (in anonymous format) for the final dissertation report. At no time will any specific comments be attributed to any individual unless permission has been explicitly given to the principal investigator of this study. In addition, all documentation, including the transcripts from the audio recordings, will be kept strictly confidential and under lock and key.

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A copy of the final report will be published. A copy will be housed at Royal Roads University, available online through UMI/Proquest and the Theses Canada portal and will be publicly accessible. Access and distribution will be unrestricted.

You are not compelled to participate in this research project. If you do choose to participate, you are free to withdraw at any time, without prejudice. Similarly, if you choose not to participate in this research project, this information will also be maintained in confidence. If you have any questions that need to be addressed, please ask me before we proceed with the study.

By signing this letter, you give free and informed consent to participate in this research study.

Name *(please print)*: _____

Signed: _____

Date: _____

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INFORMED CONSENT LETTER
Focus Group with CWFC Managers

This document constitutes an agreement to participate in a research project, entitled: ***Collaboration in Scientific Research—Exploring the Factors that Influence Effective Collaboration during a Period of Transformational Change***. My name is Barbara Waruszynski, and this research project is part of the requirement for a Doctorate of the Social Sciences at Royal Roads University. My credentials with Royal Roads University can be established by telephoning ██ ██████████.

The aim of this research is to examine the key factors that influence researchers' attitudes and behaviours in collaborative scientific research, particularly as the federal government goes through a period of transformational change. The study findings will inform departmental policies, practices and programs with the goal of improving how collaboration in scientific research is carried out across the federal community. Your participation is greatly appreciated and will contribute to a better understanding of how we could optimize collaboration in scientific research through management and leadership practices within the federal science and technology community.

There are eight main focus group questions which will focus on your perceptions of collaboration in scientific research, particularly within CWFC, across CFS, with FPInnovations and with external organizations (e.g., other government departments, industry and academia) during a period of transformational change within the federal government. The focus group session will last approximately two hours. The session will be audio-recorded to ensure an accurate description of your responses to the questions. No one besides myself will have access to the recordings. The information will be summarized into themes and categories (in anonymous format) for the final dissertation report. At no time will any specific comments be attributed to any individual unless permission has been explicitly given to me. In addition, all documentation, including the transcripts from the audio recordings, will be kept strictly confidential, and under lock and key.

The risks of this research study are minimal. The risks would be similar to work-related issues that you may disclose to others during a workday (e.g., concerns about collaboration, organizational culture, organizational change, and/or leadership/management practices).

As part of the requirements for a Doctorate of the Social Sciences, I will need to submit my final report to Royal Roads University. I will also be sharing my research findings with all of the participants, including CWFC/CFS (Natural Resources Canada). The results of the data will be communicated to government, industry, and academic and non-academic communities so that they benefit and learn from CWFC's experiences on intra-organizational and inter-organizational collaboration in scientific research. The results will be communicated through articles in

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refereed journals, conferences, and through the publication of the dissertation manuscript/book. The results may also be communicated through conference presentations, press coverage and speaking engagements. A copy of the final report will be published and housed at Royal Roads University, available online through UMI/Proquest and the Theses Canada portal. Access and distribution will be unrestricted.

Please note that you are not compelled to participate in this research project. If you choose to participate, you are free to omit answering any question that you may prefer to skip, and/or you may withdraw at any time, without prejudice.

If you have any questions that need to be addressed, please ask me before we proceed with the focus group interview questions.

By signing this letter, you give free and informed consent to participate in this research study.

Name: (Please Print): _____

Signed: _____

Date: _____