Contesting Risk: Science, Governance and the Future of Plant Genetic Engineering

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Dedication

For my grandparents

Abstract

As a process to synthesize science and characterize potential ecological risks to inform decision making, ecological risk assessment (ERA) influences how the potential for harm is studied and is foundational to national and international decision making on genetically modified organisms and other technologies. Existing literature has argued that ERA is built on values-based judgments that should be subject to critical scrutiny, and that conflicts about risk are influenced by competing understandings of what constitutes ecological harm, beneficial technology, desirable scientific research. However, there has been a lack of empirical work that explores the implications of these insights. As a contribution to this work, I use interviews, document analysis and participant observation to explore three case studies involving plant genetic engineering and the contestation of risk.

The first case study examines the differences between two competing ERA guidelines for assessing the impacts of genetically modified plants on non-target organisms. Findings include that the guidelines proposed consequentially different processes for the study of potential risks as a result of divergent judgments about hazard identification, substantial equivalence, species selection, and indirect effects. The second case study explores how expert stakeholders envision future environmental regulation for plants produced by novel, targeted genetic modification techniques. Their views varied based on different underlying assumptions associated with what constitutes environmental risk and the adequacy of existing regulations. For the third case study, I

participated in and studied a collaborative committee that, in response to issues concerning wild rice and the potential for its genetic engineering, is engaged in an anticipatory process to influence scientific research policy at the University of Minnesota. I found that the committee pursued the inclusion of Native American worldviews into wild rice scientific research by using a conceptual framework of "bridging worldviews" that made explicit how wild rice research is based upon contestable assumptions about risk, science, and the desired state of the environment. Across three diverse case studies, this research demonstrates the importance of interrogating the values-based judgments and assumptions that underlie ERA and decision making processes for genetically modified plants and environmental issues more broadly.

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Introduction

Conflicts over environmental risk are an important aspect of decision making for emerging technologies such as genetic engineering, as well as for environmental issues like climate change, invasive species, and fracking. In addition to conflict over whether well-understood environmental risks influence decision making when weighed against economic or political priorities, another important site of conflict involves the very ways in which environmental risk is studied and articulated. In other words, what types of potential environmental harms are recognized and how are scientific studies and risk assessments conducted to characterize the potential for that harm? Although many scholars have argued for the need to critique the values-based judgments and assumptions that underlie risk assessment and risk discourse, there has yet to be adequate empirical research examining conflicts over these judgments and assumptions. Furthermore, there is a need to not only identify where such values-based judgments have the greatest influence within risk assessment and risk discourse, but to reflect upon the consequences of these judgments, including what is at stake in how they are made. This dissertation uses three case studies to explore how the contestation of risk influences the science, the governance, and ultimately the future of plant genetic engineering.

Risk assessment is a topic of interest across a host of disciplines including public policy, the natural sciences, and the social sciences. At its most basic, risk assessment is a process used to synthesize science to study and describe risks for decision making. A specific type of risk assessment, called ecological risk assessment (ERA), is employed to examine the potential for environmental harm (EPA 1998). Ecological risk assessment consists of four major steps: problem formulation, exposure analysis, effects analysis and risk characterization. Problem formulation is the first stage, where many foundational decisions are made including identifying the goals of the assessment as well as the hazards and valued ecological entities to be examined. Exposure analysis seeks to determine if and how the valued ecological entity will be exposed to the hazard, while effects analysis seeks to determine how that exposure adversely affects the ecological entity. An ecological entity must be both exposed and susceptible to the hazard for an adverse effect to take place. Lastly, the risk characterization stage synthesizes the previous stages into information that is relevant to the original goals of the ecological risk assessment and to environmental decision making.

ERA's importance to public policy stems from its essential role in regulatory decision making for genetically modified plants and for environmental issues more broadly (McHughen and Smyth 2012; EPA 2004; EFSA 2010). From the World Trade Organization to national environmental agencies such as the United States Environmental Protection Agency and the European Food Safety Authority, ERA is a privileged framework to inform and justify decision making (Bonneuil and Levidow 2012; EPA 2004; EFSA 2010). ERA is also a key synthesizing framework for diverse research in the natural sciences. It provides a variety of approaches to deal with the complexities and uncertainties surrounding contemporary environmental stressors such as biotechnologies, nanotechnologies, and invasive species. Using a risk assessment framework to help organize the study of potential stressors is a way to make the findings relevant for decision making.

Yet, interest in and critique of ERA has grown within the social science literatures. For example, risk assessment's privileged place in decision making is critiqued for how social and political concerns that involve technology can become marginalized when they are not compatible with a risk assessment framework (Wynne 2002). Scholars evaluate and critique how risk assessment has been understood and deployed as an objective process in order to justify decisions, in a way that marginalizes the values-based judgments that inform risk assessment (Winickoff et al. 2005). Risk assessment has also been a focus for scholarship on public and stakeholder participation. Building upon the work that argues that risk assessment contains a set subjective of assumptions and decisions that can be opened to wider scrutiny (Jasanoff 1993; Thompson 2003; Jensen et al. 2003), there has been substantial scholarship arguing for and demonstrating the use of participatory principles in conducting risk assessment (Stern and Fineberg 1996; Kuzma and Besley 2008; Nelson, Andow, and Banker 2009).

Literatures from fields such as science and technology policy and science and technology studies have also provided critical insights on how to further engage with and question risk assessment and its role in decision making. For example, if values-based assumptions are acknowledged within the conduct of risk assessment, what other areas of, and approaches to, inquiry concerning risk assessment should be fostered? There are three insights in particular that these literatures contribute, focused on the identification and scrutiny of assumptions and judgments that inform decision making processes. First, although the role of participation has been acknowledged and studied within risk assessment, this input has generally been restricted to the problem formulation phase. Less attention has been paid to the judgments that are made throughout a risk assessment, including the judgments that inform the analysis phase of risk assessment. Furthermore, little focus has been given to examining the assumptions within the guidelines used to organize risk assessment, as opposed to the actual conducting of risk assessment. Yet any differences among approaches to risk assessment are potentially consequential and should be open to examination and scrutiny (Dean 2010; Holifield 2009a). It is necessary to explore, then, where important judgments are made throughout a risk assessment, what assumptions they are based on, what their implications are, and how they could be made otherwise.

A second area of inquiry highlights the significance of discourse. The specific meanings provided to risk, science, technology, and the environment can differ considerably (Lash, Szerszynski, and Wynne 1996). These differences concerning what constitutes risk, what is desirable science and technology, and what is the desired state of the environment are consequential, as such understandings "by representing reality in one particular way rather than in other possible ways… make certain types of actions relevant and other unthinkable" (Phillips and Jorgensen 2002, 145). For example, framing an environmental issue in terms of risk will privilege certain knowledge and certain actors and will marginalize other possible ways of providing meaning to the issue (Jasanoff 1999). Through the study of discourse surrounding risk, science, technology, and the environment one can better call attention to the assumptions and implications of particular understandings.

Finally, a third area of inquiry addresses the broader question of anticipatory governance of technology. Instead of studying the potential consequences of a technology through risk assessment just prior to its release for broad use, how can potential social and environmental impacts of a technology be considered and incorporated into the early stages of the research process? Many scholars have explored these questions (Barben et al. 2008; Owen, Macnaghten, and Stilgoe 2012; Von Schomberg 2012), yet there is a call within this literature for reflexive scrutiny of the assumptions that such anticipatory efforts are based upon. Even when challenging reactionary technology assessment or risk assessment by pursuing an anticipatory approach to governance, it is necessary to hold "a mirror up to one's own activities, commitments and assumptions, being aware of the limits of knowledge and being mindful that a particular framing of an issue may not be universally held" (Stilgoe, Owen, and Macnaghten 2013, 1571). Without exploring the basic assumptions they are based upon, anticipatory efforts may unwittingly reinforce certain ways of considering the desired state of science, technology, and the environment at the expense of others.

This dissertation explores how risk is contested by studying three diverse case studies involving plant genetic engineering. Each chapter provides a different site for examining what is at stake in diverse assumptions and judgments concerning risk assessment, risk discourse, and technology governance. In my first chapter, *Delimiting* *the Study of Risk: Exploring Values and Judgments in Conflicting GMO Ecological Risk Assessment Guidelines*, I explored the consequential nature of values-based judgments in risk assessment for science and governance concerning genetically modified plants. Specifically, I examined the important judgments that differ between two competing risk assessment guidelines for studying the potential impacts of genetically modified plants on non-target organisms. To inform this study I reviewed social science literatures that argue risk assessment builds upon a set of assumptions open to critique, influences how scientific studies on a topic are completed, and ultimately delimits what knowledge will influence decision making (Dean 2010; Elliott 2012; Jasanoff 1993; Holifield 2009a). I also built upon this literature to develop a conceptual model that makes explicit how science, risk assessment guidelines, and the conduct of risk assessment relate to one another when values-based judgments are acknowledged in each. I completed a document analysis and in-depth interviews with the scientists involved with each set of guidelines to examine the following research questions: How do values-based judgments within genetically modified organism ERA guidelines delimit the study of risks from genetically modified plants? How do the scientists involved in conflicting ERA guidelines justify the judgments within their guidelines? Findings from this chapter include that judgments about hazard identification and substantial equivalence testing, species selection, and indirect effects delimit how each set of guidelines examines the risks from GM plants, including influencing what scientific experiments are conducted. The divergences between the two approaches lead them to differ over which potential harms are in need of examination, with one approach designed to assess indirect effects that the other approach deems unnecessary to assess. One of the implications of this chapter is that without open scrutiny of risk assessment guidelines and their constitutive judgments, consequential judgments in risk assessments may not be realized and scrutinized, and may instead be informed by an unquestioned acceptance of the status quo, decided upon in a nontransparent fashion in favor of those who exert undue influence, or arrived at in an unsystematic, ad hoc manner.

In my second chapter, *Conflicting Futures: Environmental Regulation of Plant Targeted Genetic Modification*, I studied new plant breeding techniques and how expert stakeholders understand their implications for environmental risk and regulation. Novel targeted genetic modification (TagMo) techniques for plants have the potential to increase the speed and ease of genetic modification and fall outside existing regulatory authority (Podevin et al. 2012). It is, however, unclear how regulatory agencies are going to address these techniques. To inform this research I reviewed the tenets of anticipatory governance in light of future studies literature on emerging technology, focusing on how to contribute to reflexivity by making explicit the assumptions within envisioned futures. I conducted in-depth interviews with expert-stakeholders to explore the differing visions they have for the future of plant TagMo environmental regulation. I specifically asked: How do expert-stakeholders provide meaning to the future of plant TagMo and its environmental regulation? How do the articulated futures of plant TagMo regulation conflict? Findings include that the environmental regulation futures articulated by expert-stakeholders could be classified into three categories – optimistic, pragmatic, and critical – based on their differing underlying assumptions concerning what constitutes environmental risk and the adequacy of existing United States genetically modified plant regulations. By gathering these diverse perspectives on the future and studying how they differ, this chapter furthers the anticipatory governance-informed engagement with regulation and fosters a productive discussion of plant TagMo regulation.

To inform my third chapter, *Protecting Wild Rice from Harm: A Collaboration to Reconceive Scientific Research – The Case of Genetic Engineering*, I participated in and studied a collaborative committee that, in response to issues concerning wild rice and the potential for its genetic engineering, is pursuing an anticipatory process to influence scientific research policy at the University of Minnesota. Wild rice is a plant of great cultural, spiritual and economic importance to the Anishinaabeg (Ojibwe) of North America. In the late 1990s, scientists at the University of Minnesota began to map the wild rice genome to aid in its conventional breeding. No attempts were made to either inform or consult Tribal Nations or their community members as the mapping work was being proposed or implemented. Although no genetically engineered varieties are currently being pursued by University of Minnesota scientists, the development of a genomic map that could be the basis for pursuing an engineered variety raises a host of concerns about the relationship between the University of Minnesota and the Ojibwe. The collaborative committee coalesced in response to these issues. It was comprised of Ojibwe elders and community members, and University of Minnesota faculty, staff, and students who were interested in protecting natural stand wild rice and improving the relationship between the University of Minnesota and the Ojibwe. Using participant observation, document analysis, and in-depth interviews, I examined the following questions: How can different worldviews inform anticipatory processes for public scientific research? How does scientific research need to be understood in order to require consideration of different worldviews? What particular understandings of science and risk did the committee critique and draw upon as it reconceived scientific research? I found that the committee challenged the understanding of scientific research that was used to justify the initial reaction by the University of Minnesota administration to the issues concerning wild rice and genetic engineering. In its actions, the committee employed the theme of "bridging worldviews" to help make explicit how scientific research is not universally beneficial but can negatively impact communities, in addition to being based on contestable assumptions about the desired state of the environment and the desired ends of science. This chapter shows the potential of anticipatory efforts to help foster a less harmful and more inclusive approach to scientific research when based on revealing and questioning the dominant assumptions informing scientific research.

Implications

Several overarching implications of this research bear further discussion. First, this research reinforces previous findings that values-based judgments inform risk assessment and the discourses around risk and technology in important ways. The case studies in this dissertation provide three new examples of how contestations involving risk may influence the future of plant genetic engineering, specifically. These case studies expose the consequences of underlying assumptions and judgments, from how differing judgments influence the ways in which the potential for harm is studied in GMO ERA, to how definitions of genetic engineering and environmental risk influence the regulation of novel plant breeding techniques, to how understandings of risk and science influence the level to which the Ojibwe community is involved in decision making surrounding scientific research on wild rice.

Second, this research highlights how such consequential judgments are obscured by objectivist views of risk assessment and universally beneficial views of science. There is no conceptual space for considering the role of judgments when risk assessment is seen as an objective process that is solely informed by experts and when scientific research is seen as best completed without consideration of its potential negative impacts. Yet only by viewing risk assessment in terms of its constitutive judgments was it possible to highlight the differences between the two approaches to GMO ecological risk assessment, and only by challenging the view of scientific research provided by the University administration could the collaborative committee build a different approach to scientific research. Therefore, it is essential for research to continue the work of challenging objectivist notions of risk assessment and universally beneficial views of science by examining the impacts of, and values-based judgments underlying, risk assessment and science. Without challenge, these judgments will continue to be made within a black box that prevents them from being interrogated.

A third finding of this research is that the judgments that underlie risk assessment, governance, and scientific research are unavoidable. It is impossible to complete risk assessments, conduct scientific research, or determine regulatory policy without them. The goal then becomes not to remove these judgments or reduce their frequency, but to arrive at them in the best way possible. This leads to the question: how should we best make these judgments? A beginning point, in line with the participatory paradigm, is to acknowledge that judgments exist, begin to identify the specific judgments being made, and open these judgments to deliberation from a relevant group of people (Stern and Fineberg 1996; Rowe and Frewer 2000). Yet this assumes that participants in such an exercise would be able to discern what judgments align with their values and interests, which is not always the case, particularly in many risk-related areas where the processes and judgments are highly complex. There is a need therefore, for research that helps foster and contribute to reflection concerning these judgments (Holifield 2012). Research that helps explore what is at stake in one set of judgments as compared to another could subsequently inform decision making, societal discussions, or participatory processes taking place on such issues. In this dissertation, I demonstrate an approach based on identifying consequential judgments and then exploring both their underlying assumptions and their implications.

Finally, this research has implications for discussions surrounding controversial environmental issues such as GMOs, fracking, invasive species, and climate change. Often the discourse around these issues is focused solely on the questions of whether scientific research is being conducted to examine potential risks, and whether the assessed environmental risks will outweigh political and economic interests in decision making. As this dissertation shows however, assessments of potential environmental harm are foundationally dependent upon the assumptions used in these assessments. Therefore, equal attention should be paid to the question of *how* these assessments are conducted as is paid to *whether* these assessments are conducted. And such scrutiny should not be structured in terms of the objectivity of such assessments, but rather should be focused on identifying and reflecting upon the judgments and assumptions informing the assessments. This type of transparency would move away from the paradigm of using objectivity as a shield from scrutiny, and could ultimately help improve the trust of environmental agencies and environmental science (Jasanoff 2003). And as demonstrated by the wild rice collaborative committee, transparency surrounding these judgments and assumptions could also help open technology decision making to consideration of its negative impacts. This dissertation points to the need for further research of this kind and provides an example of how this type of work can be completed.

Chapter 1 – Delimiting the Study of Risk: Exploring Values and Judgments in Conflicting GMO Ecological Risk Assessment Guidelines

1.1 Introduction

Recent conflicts surrounding environmental decision making for emerging technologies have brought a renewed focus to risk assessment. From the national to international level, decision making bodies rely on risk assessment to study if and how proposed products or actions cause harm to the environment to inform decisions concerning those products or actions (EPA 1998; EFSA 2010). Given the centrality of risk assessment in decision making, it is often a focal point for conflict. One important issue in risk assessment conflict is how risk assessment guidelines are designed, or what specific steps are followed when conducting a risk assessment. While some scholarship has viewed risk assessment as a largely objective process completed outside of values-based judgments, other scholarship has demonstrated the existence and influence of subjective assumptions and judgments within risk assessment (Jensen et al. 2003; Meyer 2011, among others). Yet there remains a lack of work that explores the relationship between risk assessment, decision making, and scientific studies by focusing on the role of judgments within risk assessment guidelines. This is a significant gap because the judgments within risk assessment guidelines influence what types of scientific studies are conducted and how they inform decision making. There is a need, therefore, to explore the judgments within risk assessment guidelines that delimit what science is completed and what information informs decision making. To further the work on judgments within risk assessment, I study two competing sets of risk assessment guidelines for assessing the impacts of genetically modified (GM) plants on non-target organisms.

Recent conflict focused on risk assessment spans a variety of issues with regard to agricultural biotechnology. Internationally, risk assessment was at the center of the ruling from the 2003 World Trade Organization case brought by the United States, Canada and Argentina against the European Union for their banning of genetically modified organisms (GMOs). A key part of this ruling stated that the moratoria placed on GMOs were not legal because the decisions to do so were not based upon risk assessment (Bonneuil and Levidow 2012). The ruling left open the possibility for restricting the use of GMOs if, through risk assessment, the potential for significant harm to human health or the environment was determined. In another case, within the United States, the Center for Food Safety challenged the US Department of Agriculture's environmental assessment for GM alfalfa, arguing, among other things, that the assessment did not adequately examine the impact on organic growers (Dickinson 2010). In the European Union (EU), environmental regulatory review is a primary site for the conflict concerning whether GMO use is allowed or not in different member states (Seifert 2010). A recent exchange between Wickson and Wynne (2012a; 2012b) and members of the European Food Safety Authority (Perry et al. 2012) highlights the importance of whether subjective, values-based judgments are seen as existing within risk assessment. In that case, understanding risk assessment to contain subjective judgments influenced whether one could see different member states conducting legitimate risk assessments that led to differing conclusions. Finally, conflicts in India surrounding the potential use of GM brinjal (eggplant) involved contestations over how risk assessment would be used to inform decision making (Gupta 2011). This range of examples demonstrates how risk assessment is central to and yet contested in decision making regarding genetically modified organisms.

At its most basic, risk assessment is a process used to synthesize science to study and describe risks for decision making. In the particular, risk assessments are essential to GM plant decision making in oversight agencies such as the United States Environmental Protection Agency (USEPA) and the European Food Safety Authority (EFSA) (Johnson et al. 2007; EFSA 2010). With regards to examining the potential for environmental harm, a specific type of risk assessment called ecological risk assessment (ERA) is used. As described in one influential report on ERA in the US (EPA 1998), ERA is used to:

> "systematically evaluate and organize data, information, assumptions, and uncertainties in order to help understand and predict the relationships between stressors and ecological effects in a way that is useful for environmental decision making" (p.1).

Generally, risk assessment is made up of four major stages: problem formulation, exposure analysis, effects analysis, and risk characterization (EPA 1998). Problem formulation is the first stage, where many foundational decisions are made including identifying the goals of the assessment as well as the hazards and valued ecological entities to be examined. The problem formulation stage generates a conceptual model and analysis plan to examine how the stressor and valued ecological entities may interact.

The conceptual model and analysis plan are then examined in the exposure and effects analyses stages. Exposure analysis seeks to determine if and how the valued ecological entity will be exposed to the hazard, while effects analysis seeks to determine how that exposure adversely affects the ecological entity. An ecological entity must be both exposed and susceptible to the hazard for an adverse effect to take place. Lastly, the risk characterization stage synthesizes the previous stages into information that is relevant to the original goals of the ecological risk assessment and to environmental decision making. Depending on the specific scope, a risk assessment can be informed by existing scientific studies, if they adequately access what is needed, or by new studies conducted specifically for the assessment.

Although I focus on conflict involving the structure of risk assessment guidelines, there exist many other types of conflict involving risk assessment. For example, risk assessment's privileged place in decision making is critiqued for how social and political concerns involving emerging technologies can become marginalized because they are not compatible with a risk assessment framework (Wynne 2002). In addition, risk assessment is contested when it is framed as the objective and singular way to study the potential for environmental harm. Risk assessment, due to its focus on demonstrable harm, has been critiqued for not being well suited to address unknown unknowns and for not being consistent with decision making based on the precautionary principle (Ahteensuu 2010). Finally, once risk assessment guidelines are agreed upon, or once there is agreement upon the steps that should be completed during the assessment of risk, there is often conflict over whose values and priorities will inform the actual conducting of the risk assessment. So who is involved, and what values and priorities are privileged, in the actual conducting of the risk assessment is also a site of conflict (Kuzma and Besley 2008).

Within these studies of risk assessment, there has been a lack of work engaged with risk assessment guidelines. By focusing on an example of conflict between two competing sets of risk assessment guidelines, I further explore the role of values-based judgments in risk assessment guidelines and provide new insights on the relationship between risk assessment, science, and decision making. Here I report on my study of two competing sets of risk assessment guidelines used to examine the potential impacts of GM plants on non-target organisms. This study was guided by two overarching questions: 1) how do values-based judgments within GMO ERA guidelines delimit the study of risks from GM plants? 2) how do the scientists involved in conflicting ERA guidelines justify the judgments within their guidelines? In this chapter, I first review scholarship on judgment and conflict in risk assessment. I then outline the conceptual framework I use to structure this study of conflicting risk assessment guidelines. Results are structured around three different consequential judgments in the conflicting risk assessment guidelines: hazard identification, species selection, and indirect prey-quality effects. For each judgment I explore the implications of the differences between the two approaches as well as how those involved with each set of guidelines justified their judgments. I conclude with an exploration of the implications of this work for environmental decision making and the study of risk assessment.

1.2 Judgment, conflict, and risk assessment guidelines

Although risk assessment is sometimes understood as objective or value-free, judgment and the accompanying potential for conflict within risk assessment have been identified as issues in need of addressing as far back as the first influential study of risk assessment in the United States (National Research Council 1983). This National Research Council (NRC) study was foundational to risk assessment in the United States (Suter 2008) and, most famously, is known for the call to separate risk assessment and risk management as a way to establish the credibility and accuracy of regulatory decision making (National Research Council 1983, 151). However, the NRC report also argues that subjective values-based "risk assessment policy" or "judgments made in risk assessment" (p. 37) are integral to risk assessment itself. This risk assessment policy is different from policy considerations used within risk management which include political, social and economic considerations used to inform decision making. Risk assessment policy includes judgments made within the risk assessment process for each instance of "missing or ambiguous information on a particular substance and gaps in current scientific theory"(National Research Council 1983, 28). These are instances where a choice must be made among "several scientifically plausible options," named in the report as "inference options" (National Research Council 1983, 28). A long list of judgments essential to risk assessment policy is provided in the report, including topics such as how to determine the value of studies with different results and how to make extrapolations (National Research Council 1983, 29–33). The report recognizes that these necessary choices have implications for a risk assessment: "That a scientist makes the choices does not render the judgments devoid of policy implications. Scientists differ in their opinions of the validity of various options, even if they are not consciously choosing to be more or less conservative" (National Research Council 1983, 36). It also recognizes how the factors that influence these decisions are not easily distinguished:

> "A scientist's weighting of these variables may not easily be expressed explicitly, and the result is a mixture of fact, experience (often called intuition), and personal values that cannot be disentangled easily. As a result, the choice made may be perceived by the scientist as based primarily on informed scientific judgment. From a regulatory official's point of view, the same choice may appear to be a value decision as to how conservative regulatory policy should be, given the lack of a decisive empirical basis for choice" (National Research Council 1983, 36–37).

This report sees guidelines as instrumental for dealing with the issues that arise from the judgments within and subjective structure of risk assessment. Risk assessment guidelines are proposed as a way to describe all aspects of risk assessment that are "subject to generic treatment" and provide "supplementary scientific discussion" for each point where a choice between inference options is needed. In other words, risk assessment guidelines should identify the general processes of risk assessment as well as highlight and analyze areas where specific judgments are needed because there is no scientific consensus. The NRC report provided numerous justifications for the role guidelines serve. First, guidelines help "separate risk assessment from risk management considerations, improve public understanding of the process, foster consistency, and prevent oversights and judgments that are inconsistent with current scientific thought" (National Research Council 1983, 162). Second, guidelines help ensure scientific studies provide relevant data for risk assessments. By articulating how the assessment will be conducted and what type of data is desired, guidelines can provide researchers insights on how to design their scientific studies to make them most relevant. Third, guidelines can provide a singular approach to decision making, which is much more efficient and justifiable for the regulatory agencies, while allowing for necessary updates when needed. As the report states, "guidelines themselves will help to foster evolutionary improvements by defining generic principles of risk assessment and focusing debate and empirical research on these principles" (National Research Council 1983, 169).

Far from describing an objective and universal notion of risk assessment, the foundational ideas of risk assessment articulated within this report were steeped with concerns about what form risk assessment should take, how the necessary judgments should be made, and the potential for conflict. Guidelines are used to deal with these judgments and they reveal at least two types of conflict within risk assessment. First, since guidelines lay out the structure of risk assessment, they identify what questions need to be answered at each stage of the risk assessment. As a consequence, there can be conflict over how the risk assessment guidelines should be structured, including what questions should be asked. Second, once risk assessment guidelines are agreed upon, there can be conflict over how the steps in a risk assessment should be completed.

1.2.1 Participation in risk assessment

A variety of studies have focused on how to examine and understand judgments and conflict in risk assessment. Early work challenged the distinction between risk assessment and risk management, and highlighted how risk assessment was a subjective and partial way to organize knowledge for decision making (e.g., Jasanoff 1993; Jasanoff

1999; Wynne 1996). These studies examined how risk assessment provides a particular way of evaluating an issue and is based on a set of subjective assumptions that could be opened to wider scrutiny than when risk assessment is kept to scientific experts. Scholarship and methods development associated with GMO ERA worked to articulate and make more transparent the values-based choices and assumptions within GMO ERA (Thompson 2003; Jensen et al. 2003) and to find ways to deliberately consider these choices when conducting a risk assessment (Nelson et al. 2004; Nelson, Andow, and Banker 2009). Thompson (2003) showed, for example, the values-laden nature of the decisions central to GMO ERA including choosing what ecological attributes to protect and determining how do deal with uncertainty. Myhr argued that the scientist's background or discipline will influence the choice of hypothesis, methods, and models, which can lead to differing data and disagreements as they conduct a risk assessment (2010). This vein of work fits well within the participatory paradigm in science and technology policy that seeks to include the public and stakeholders within decision making to help interrogate and determine the subjective or values-based decisions. Many risk assessment guidelines developed since the NRC's 1983 report have been influenced by these ideas (e.g., Stern and Fineberg 1996; Presidential/ Congressional Commission on Risk Assessment and Risk Management 1997; Renn 2005). Revised and new guidelines have emphasized the importance of deliberation and stakeholder participation as a way to improve risk assessment by incorporating a more diverse set of knowledge and by increasing the transparency and legitimacy of risk assessment.

1.2.2 Understanding differences between risk assessment guidelines

The analytical framework I use to examine the differences between guidelines for GMO ERA is informed by scholarship on risk assessment and science developed by the fields of science and technology studies and governmentality (Dean 2010; Elliott 2012; Jasanoff 1990; Holifield 2009b). This scholarship emphasizes the normative dimensions of risk assessment in that it provides a particular logic to envision and calculate potential harm, influences how scientific studies are conducted, and ultimately delimits what knowledge will inform decision making. This approach to the conceptualization of risk assessment and science is well suited to understand the conflicting risk assessment guidelines examined here.

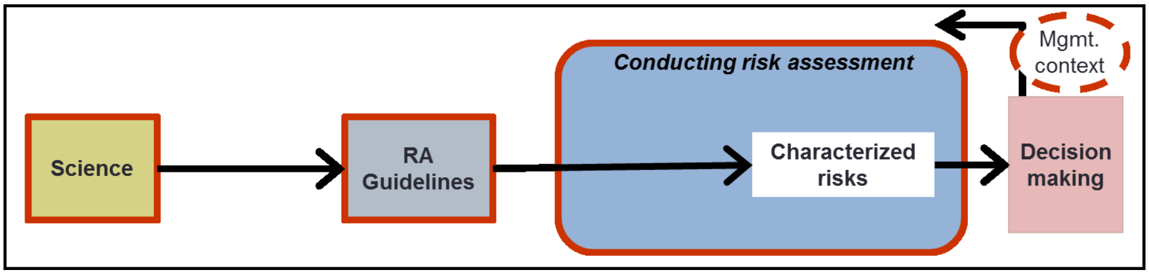
The first insight from this scholarship emphasizes that risk assessment is a process that orders and makes sense of the world in a particular way at the expense of other ways. Dean argues that risk assessment is "a set of different ways of ordering reality, of rendering it into a calculable form. It is a way of representing events in a certain form so they might be made governable in particular ways, with particular techniques and for particular goals" (2010, 206). To see the world in terms of hazards, endpoints and risk hypotheses is, then, not a natural or objective way to view the world and evaluate the potential for harm to the environment, but one that privileges certain experts, priorities, ways of knowing, and ways of thinking at the expense of others. There are other ways to inform decision making using empirical studies (e.g. those based on the precautionary principle) that do not adhere to the same assumptions as risk assessment.

A second insight is although risk assessment approaches share a basic set of assumptions that represent a certain way to organize and study the world, there can still exist important differences among risk assessment guidelines. Dean argues, for example, that "instead of assuming that the empirical varieties of risk are but instances of one type of instrumental rationality, it is possible to demonstrate that risk rationalities are not only multiple but heterogeneous and that practices for the government of risk are assembled from diverse elements and put together in different ways" (2010, 211). In other words, risk assessment is not a singular practice or logic, and the differences among risk assessments guidelines are potentially significant for what they privilege and marginalize. One way to study these differences is by exploring the judgments made within risk assessment guidelines. Differences between risk assessment guidelines exist for distinct topics (e.g. human health, invasive species, and genetically modified plants all take different forms), but different approaches also exist for the same topic. How particular guidelines structure a risk assessment will influence what potential harms are examined and how they are studied. Therefore, exploring how risk assessment approaches differ can provide important insights about how risk assessment influences decision making and what is at stake in different approaches to risk assessment.

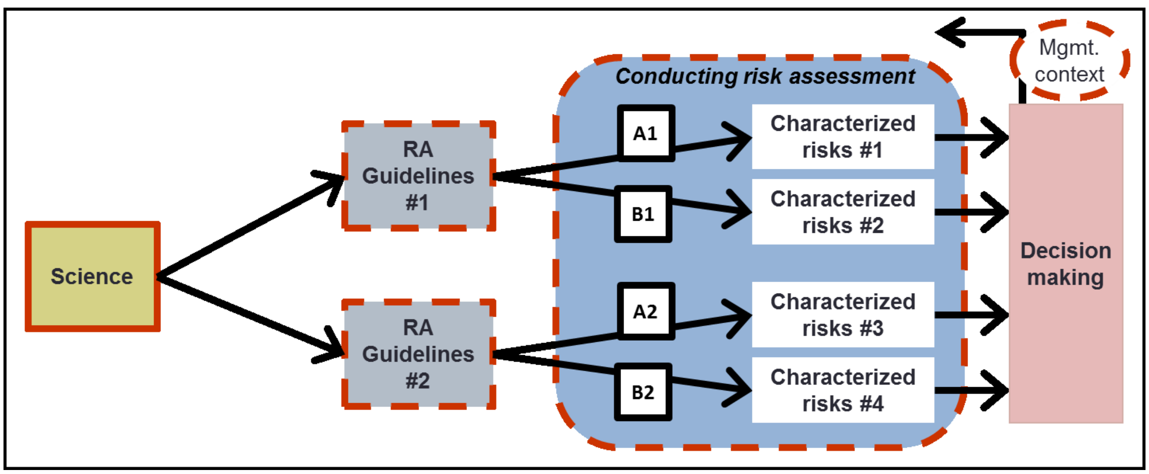
The implications from these differing risk assessment guidelines is further highlighted by considering a third insight, which emphasizes how scientific findings are dependent upon the assumptions and judgments used to derive them (Elliott 2012; Jasanoff 1990). How scientific experiments are designed influences their results and scientists working on the same topic may design and conduct experiments differently, and therefore, come to differing conclusions. Elliott, for example, develops the notion of "selective ignorance" to explore "the wide range of often subtle research choices or 'value judgments' that lead to the collection of some forms of knowledge rather than others" (2012, 331). He argues that it is important to consider how these "decisions about what questions to ask, what metrics or standards to employ, what concepts to use, what research strategies to pursue, what technological applications to develop, and what information to disseminate" lead us to be selectively ignorant of complex phenomenon (2012, 329). Holifield, in a study of how an indigenous community contested the human health risk assessment of a Superfund site, also emphasizes the need for reflection about what form a risk assessment takes and what questions are raised (2009b). He argues that in addition to ensuring adequate inclusion within political decision making, there is a need to scrutinize the risk assessment and science itself: "In the case of a Superfund risk assessment, this means that democracy and environmental justice require attending not just to who participates and how, but also—for example—to questions about how to sample and analyze soil or fish, or what to extrapolate from a series of lab rodent bioassays" (Holifield 2009b, 653). This literature emphasizes the importance of judgments in both risk assessment and science. Because risk assessment serves as the key framework for making sense of and interpreting science for decision making, the structure of a risk assessment influences what type of science is needed. Different risk assessment guidelines, as a result, may call for distinct scientific studies. The judgments within risk assessment guidelines, then, influence how the potential for harm is studied and what scientific studies are conducted. The structure of a risk assessment framework, therefore, delimits the science that is completed for risk assessment and that ultimately informs decision making.

Building upon this literature, I developed a conceptual model for understanding the role of values-based judgments in risk assessment guidelines and the importance of guidelines for risk-related decision making (Figure 1). I compare three different ways of understanding the relationship between risk assessment (RA) guidelines, the conducting of risk assessment, and science, by varying whether each aspect is considered to contain values-based judgments or not. I contrast the model I build upon, shown in part C of the figure, with two other ways of understanding risk assessment and science. In all three models (parts A through C), "decision making" involves combining broader social, political and economic values with the characterized risks provided by the risk assessment to determine whether and how the entity under consideration should be used. Part A of Figure 1 shows an objectivist model where science, risk assessment guidelines, and the conducting of risk assessment are all seen as objective, or not involving values-based judgments. This model is built on the assumption that there is an objective right way to conduct risk assessment and scientific studies outside of values-based judgments. Kuntz (2012) provides an example of an argument drawing upon this model.

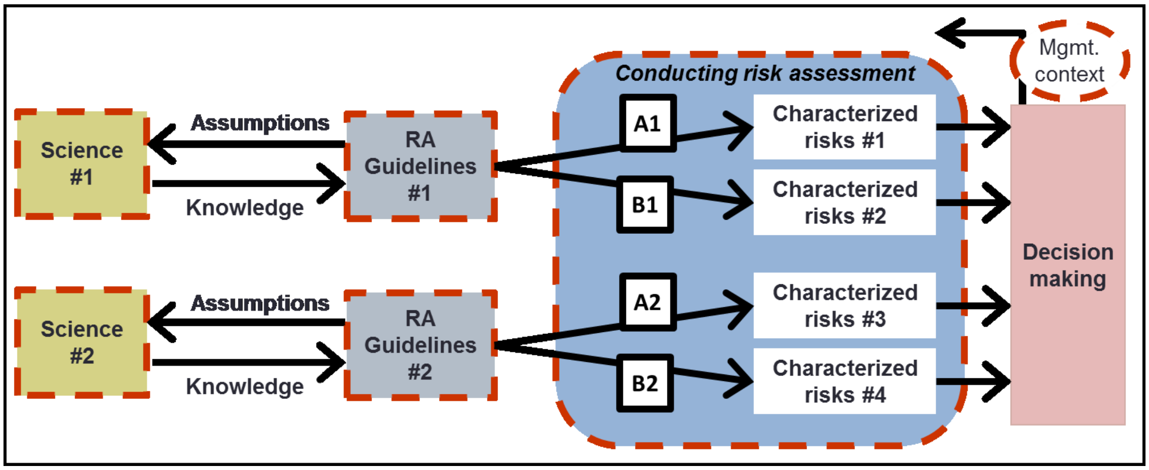
Part B shows the Values-based RA & Objective Science Model, where values-based judgments are acknowledged in the risk assessment guidelines and in the conducting of the risk assessment. Risk assessment guidelines can differ because of the differing judgments they are built upon. These judgments delimit the study of risk in



A. Objectivist Model: Science, risk assessment (RA) guidelines, and the conducting of risk assessment are all seen as objective, or not involving values-based judgments. After the basic management context is provided (e.g. the product under consideration and the relevant regulations), there will be a single right way to characterize the risks outside of values-based judgments. RA guidelines are seen as an objective way to synthesize objective science that exists or is created to address the question at hand.



B. Values-based Risk Assessment & Objective Science Model: Values-based judgments are acknowledged in the RA guidelines and in the conducting of the risk assessment. RA Guidelines #1 and #2 contain differing judgments that delimit the study of risk in particular ways; for example, they may contain different steps or pose different questions in need of answering. A and B represent two different parties using the same guidelines to conduct a risk assessment on the same topic. A and B diverge because they answer the questions posed by each set of guidelines differently. For example, if guidelines #1 provides a process for selecting which species to test, A and B would complete that process differently leading to differing characterizations of risk. The characterization of risk, therefore, could vary based on the differences between guidelines #1 and #2 and based on the differences between parties A and B. Science, in this model is seen as completed outside of values-based judgments and as producing non-conflicting singular knowledge.



C. Values-based Judgments Model: Values-based judgments are acknowledged in science, RA guidelines, and the conducting of risk assessment. In addition to the judgments described in part B, this model acknowledges the values-based judgments present within science. Science, here, is dependent upon the judgments or assumptions that inform it (e.g. what questions are asked, what methods are used). Furthermore, this model acknowledges how the judgments within RA guidelines can influence and delimit what form this science takes. Scientific findings can be different and potentially conflicting based upon the judgments informing them.

Figure 1: Three models examining the relationship between risk assessment (RA) guidelines, the conducting of risk assessment, science and decision making. The role of values-based judgments differs between these models. Dashed lines indicate the model assumes there are values-based judgments present in that aspect, solid lines indicate the model assumes the aspect can be objectively completed outside of values-based judgments. The management context acknowledges that even within the objectivist model there is a need for some decision making or management context to determine the scope of the risk assessment and science (e.g. product under consideration and regulatory context). The management context in these models does not represent a full problem formulation; this would be included under the "Conducting risk assessment." By extension, the objectivist model does not recognize the values-based judgments within problem formulation that could lead two parties to come to diverging characterizations of risk. Although decisions during the conducting of the risk assessment are made that influence what science is completed, the models here focus on the impact of the guidelines themselves.

particular ways and may take a variety of forms (e.g. asking different questions, using different steps). This model also distinguishes between risk assessment guidelines and the divergences that can occur through conducting a risk assessment informed by those guidelines (indicated by A and B). This conceptual model emphasizes that two groups of risk assessors (A and B) using the same guidelines for the same topic and context may still come to different characterizations of risk (indicated by characterized risks #1 vs.

#2), based on the values-based decisions made during the risk assessment (e.g. which species are most important to protect). Science, in this model, is seen as completed outside of values-based judgments and as producing non-conflicting and singular knowledge. This model is arguably the closest to that proposed in the previously discussed NRC report (1983), where values-based judgments are made in risk assessment guidelines to help structure how scientific studies should be synthesized and how to deal with the limitations and gaps within existing scientific knowledge.

Part C of Figure 1 is the model used to inform this work. In this model, values-based judgments are acknowledged within risk assessment guidelines, the conducting of risk assessment and science. There are multiple possible guidelines for risk assessment due to the different, possibly conflicting, judgments within risk assessment guidelines. The science deemed relevant for a risk assessment may differ due to the judgments made in the competing risk assessment guidelines, and the scientific findings provide partial, and potentially conflicting, knowledge based upon their assumptions. In other words, the conceptual model for this paper is built upon the idea that the results from scientific studies are dependent upon the assumptions that were used to produce them. Similarly, decision making, instead of informed by the outcome of a pre-determined risk assessment framework, must implicitly or explicitly consider how competing assumptions within risk assessment guidelines lead to different characterizations of risk. Therefore, decisions should be made through a consideration of the characterization of risk as well as the set of assumptions it is based upon. Competing risk assessment guidelines influence what type of science is relevant and conducted, ultimately delimiting what type of studies will inform the characterization of risk and decision making. The challenge, as I describe next, is to examine how competing risk assessment guidelines differ by exploring the divergence of key judgments within the guidelines and the science they call for.

1.3 Methods: Studying conflicting GMO ERA guidelines

As a case study I examined two competing sets of risk assessment guidelines for assessing the potential impacts of GM plants on non-target organisms. GMO ERA for non-target impacts examines how GMOs, and in this case GM plants, affect organisms that are not the target of the trait they are genetically modified to express. Much of the existing non-target impact work has examined plants engineered to express transgenes that produce insecticidal toxins from the bacterium *Bacillus thuringiensis* (Bt), used to provide protection against certain types of Lepidoptera caterpillar and Coleoptera beetle insect pests. Non-target GMO ERA examines how GM plants may impact other organisms that are not the targeted Lepidoptera or Coleoptera pests. Non-target GMO ERA contributes to environmental oversight by assessing whether GM plants have a significant negative effect on non-pest organisms.

The two differing non-target GMO ERA guidelines I studied are each supported by a different group of scientists. I refer to the two competing guidelines as they have been identified elsewhere: the *ecotoxicological* approach and the *ecological* approach (Meyer 2011). The ecotoxicological approach builds largely upon the risk assessment paradigm developed for toxicological testing of chemical substances, while the ecological approach builds upon critiques of that paradigm concerning its inability to capture the complexity of living biological organisms as stressors. Supporters of each of these approaches have published at length on their approach to ERA, providing insights on how to complete risk assessment using their guidelines and arguments as to why their approach is better than the other approach. Existing scholarship that has engaged with these guidelines singles out some of the differences between the two approaches, including how species are identified for testing, how risk hypotheses are determined, and when different types of experiments (e.g. lab, semi-field and field) are needed (Hilbeck et al. 2011; Meyer 2011). I build upon this work by further exploring the differences between and judgments within these risk assessment guidelines, considering the implications of these differences, and examining how those supporting the differing guidelines justify their approach. Specifically the analysis was guided by two overarching research questions: 1) how do values-based judgments within GMO ERA guidelines delimit the study of risks from GM plants? 2) how do the scientists involved in conflicting ERA guidelines justify the judgments within their guidelines?

I utilized two main methods, a document analysis of the published material surrounding the ERA guidelines and interviews with the scientists involved with the two approaches. I conducted a document analysis of the publications supporting the two non-target GMO ERA guidelines to identify general differences between the two approaches and their implications. I organized this analysis by examining on how, though based in risk assessment, each set of guidelines proposed a distinct approach for assessing risk based on differing judgments. I tracked the steps a GM plant goes through when considered by each set of guidelines in order to identify, for example, what questions were asked during the risk assessment stages and what studies were called for. With this basic information, I then conducted interviews with the scientists involved to confirm the significant differences between the approaches. I also examined how the scientists justified their approach and what they thought were the implications of the differences between the approaches. In-depth, semi-structured interviews were completed with 10 scientists actively involved with the differing guidelines, and each interview lasted approximately one to two hours (Appendix A). The interviews were transcribed and the qualitative analysis software Atlas.ti used to help analyze the key judgments and their justifications. Once the key differing judgments and their justifications were identified, I explored how they structured the risk assessment guidelines and the scientific studies that were called for. In other words, I explored how the guidelines delimited the study of potential harm from GM plants.

1.4 Findings: Different Judgments, Diverging Risk Assessments

Here I describe three key judgment areas – hazard identification and substantial equivalence, species selection, and indirect prey-quality effects – that emerged from my analysis of the two risk assessment guidelines for non-target effects of insect resistant GM plants. I focused on these judgment areas because they represent decisions that most significantly lead to divergences between the conflicting guidelines and that also delimit how the potential for harm from GM plants is studied. For each of these three judgment areas I explore both the justifications for the judgments provided by the scientists I interviewed as well as some of the implications of the differences between the two guidelines. Finally, in section 4.4, I review the underlying understandings of agriculture and risk that helps explain why those supporting each approach made the judgments they did.

1.4.1 Hazard identification and substantial equivalence

Hazard identification is the step of risk assessment where the entity that could cause harm is identified so that its relationship to valued ecological entities can be analyzed. In non-target GMO ERA this involves deciding what parts of the insect-resistant GM plant may cause harm to the environment and need to be studied. The two approaches differ over whether the Bt toxin, inserted in the plant genome to give the plant the insect resistant trait, can be singled out as the only hazard. The eco-toxicological approach is built upon the judgment that substantial equivalence testing can be used to ensure that the genetically modified plant is similar to the conventional plant in all ways other than the insertion of the Bt toxin. According to the eco-toxicological ERA framework, if the insertion of the Bt toxin is determined to be the only significant novel change in the GM plant, then the Bt toxin can be identified as the only hazard of concern. As described below, this then allows for a tiered approach that privileges laboratory testing of the Bt toxin in the analysis phase. The ecological approach, conversely, does not make the judgment that substantial equivalence testing can adequately determine that a Bt GM plant is similar to a conventional plant in all ways other than the Bt toxin. The ecological ERA framework, therefore, is open to including other hazards, such as the whole genetically modified plant based on the argument that potential unintended changes may have occurred within the plant during the modification process. A broader set of risk hypotheses may then exist, requiring a different set of procedures in the laboratory and field testing.

With the eco-toxicological approach, the Bt toxin is singled out as the hazard in need of assessment through substantial equivalence testing (Romeis et al. 2008; Romeis, Meissle, and Bigler 2006a). Substantial equivalence testing relies upon testing a number of compositional and agronomic characteristics of a GM plant to determine if there are any significant differences compared to its non-GM counterpart (EuropaBio 2003). If no significant differences are found through these tests, then one can identify the Bt toxin as the only hazard in need of addressing. If, however, a GM plant was found not to be substantially equivalent to its non-GM counterpart, whatever characteristics of the plant were found to be different would need to be analyzed as potential hazards. Once substantial equivalence of the GM plant has been established, the Bt toxin can then be analyzed like a chemical pesticide using a tiered approach that begins with worst-case exposure lab testing and proceeds to more realistic field testing only if the potential for adverse effects is found at the lower tiers of exposure. Figure 2 provides an overview of this approach and how it differs from the ecological approach. Worst-case exposure lab testing involves conducting a toxicity test that exposes an insect species to the Bt toxin in its purified form using an artificial diet at many times the highest level that would be encountered in the field. If no adverse effect is observed when insects are exposed to this level of toxin, then no further information is needed to determine that there is no

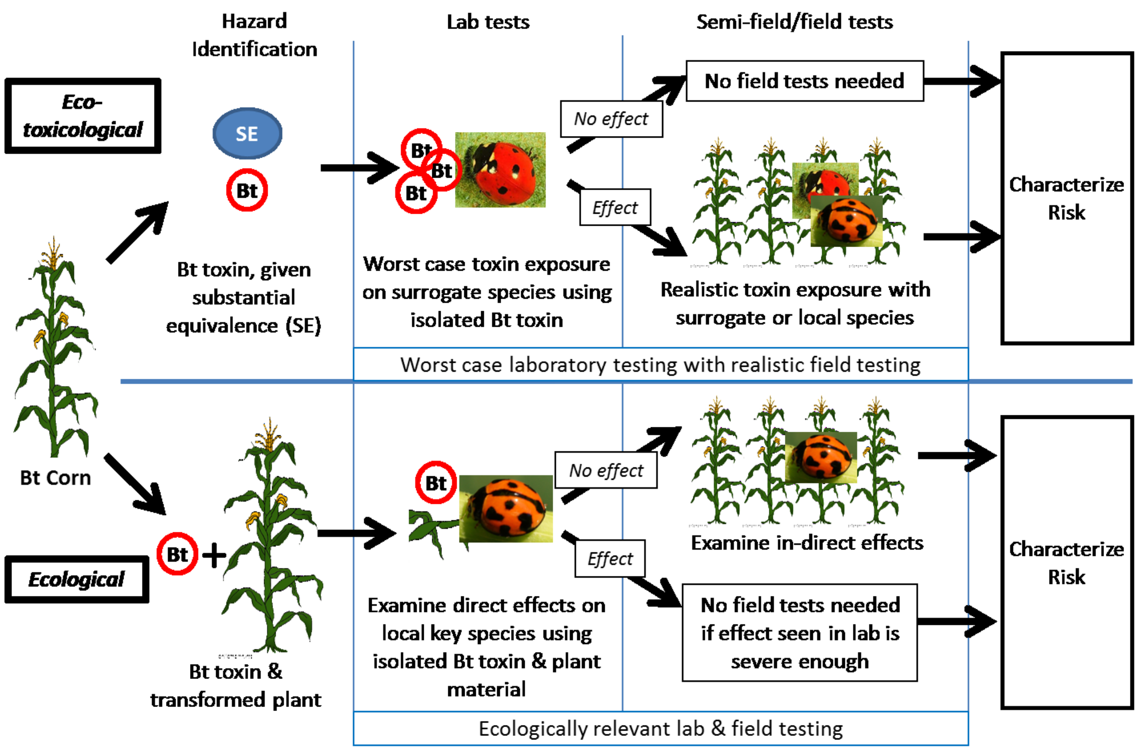


Figure 2: Overview of key differences between eco-toxicological and ecological GMO ERA guidelines. With eco-toxicological approach: 1) The hazard is identified as only the Bt toxin, using substantial equivalence testing to ensure that the presence of the Bt toxin is the only difference between the Bt and non-Bt variety; 2) Laboratory tests are conducted on surrogate species using worst case toxin exposure with isolated Bt toxin; 3) If no adverse effects are found in the worst case toxin exposure laboratory tests, then no additional field tests are needed to adequately characterize the risk; 4) If an adverse effect is found in the worst case toxin exposure laboratory tests then additional semi-field and field tests are called for to examine whether the adverse effects are found under more realistic conditions. With the ecological approach: 1) The hazard is identified as the Bt toxin and the transformed plant; 2) Laboratory tests are conducted on local key species using isolated Bt toxin and plant material to examine direct effects; 3) If no adverse effects are found in the laboratory tests examining direct effects, semi-field and field tests are conducted to examine indirect and direct effects not well able to be studied in the laboratory; 4) If severe enough adverse effects are found in laboratory tests, then no additional studies are needed to adequately characterize the risk.

significant risk to that species. Only in the event that an adverse effect is found within these worst-case exposure laboratory studies would you then continue to semi-field, or greenhouse, studies to see if under more realistic exposure scenarios – with lower levels of Bt toxin – the adverse effect is still found. And it is only after finding an adverse effect in laboratory and semi-field studies that you would continue to field studies to see if the adverse effect is found under the most realistic exposure scenario.

The ecological approach to non-target GMO ERA, conversely, uses a different tiered approach and does not make the judgment that substantial equivalence testing is an adequate way to assess the potential differences between a GM plant and its conventional counterpart (Andow, Lovei, and Arpaia 2006; Andow, Hilbeck, and Tuat 2008). Instead, the ecological approach is built around constructing and analyzing risk hypotheses for the most important possible adverse effects. These risk hypotheses are chosen by considering the possible hazards that could result from the GM plant and considering the non-target species that could be impacted by these hazards. These risk hypotheses consider hazards that could cause both direct and indirect effects. Direct effects include how the inserted Bt toxin, itself, could come into contact with, and negatively impact, non-target species. Indirect effects include potential negative impacts on non-target species resulting from both changes in the plant caused by the genetic modification process and changes in ecosystem dynamics caused by the GM plant (e.g. predators being harmed by having less Bt-susceptible prey to consume). Because the ecological approach considers adverse effects that could result from aspects of the genetically modified plant other than the Bt toxin itself, the genetically modified plant itself may be included as a stressor in this approach. To consider the GM plant a stressor means that semi-field or field studies need to be conducted to examine the stressor – one of the reasons a strict tiered approach would not work for the ecological approach.

1.4.1.1 Justifications

In examining the justifications for each approach, the adequacy of substantial equivalence testing emerged as a key point of contention. Supporters of the ecological approach argued that substantial equivalence testing is inadequate for capturing the potential changes caused in the genetically modified plant. They argued that the compositional and agronomic characteristics of a plant measured in substantial equivalence testing cannot discern the nuanced changes in a genetically modified plant that may lead the plant to interact differently with its environment. As one scientist said:

> "What we have never gotten to agree on is, is the GMO just an addition of a gene and the only new thing is the [Bt] chemical, so you only test the chemical? If you view this as only a chemical and everything else is going to be picked up under the substantial equivalence thing, yeah, then it is stringent to say all I need to test is the Bt protein, then life is fine with me and I picked up everything I need to know. So what you presume there is that if there is any difference caused by the transformation process, you would pick it up from the ash content or the total protein or amino acid, and that's roughly it. So that is a very crude and naïve view of how organisms function."

Yet the supporters of the eco-toxicological approach viewed substantial equivalence testing as a legitimate way to discern any significant unintended differences between a GM plant and its conventional counterpart. In articulating this view, one interviewee cited the history of substantially equivalence testing as one that has not revealed differences between GM and non-GM plants:

> "We are feeling more and more comfortable because look at the whole substantial equivalence testing. This was basically initiated because people were worried about this new type of technology, that it could do something to the plant. I think this was a very valuable risk hypothesis like 20 - 30 years ago… There is not a single example today where a plant that has been transformed and made it to market or to a late stage was not substantially equivalent. This, in my opinion,

> tells us that the transformation process might create a few strange things, like conventional breeding as well, but this, coupled with the conventional breeding and plant selection afterwards, gives us considerable safety without any testing... It will still go through the [substantial equivalence testing], but we probably don't even need that."

In these contrasting statements we see how the competing judgments about the adequacy of substantial equivalence testing are built on differing views of its past use. On the eco-toxicological side, the history that substantial equivalence testing has not found any evidence of significant differences between GM and non-GM plants, other than the desired trait, stands as evidence that plant genetic engineering techniques and selection processes rarely produce a plant that has unintended changes. This evidence supports an attitude that any unintended changes are being adequately addressed by the current system. The supporter of the ecological approach, conversely, was not reassured by a history of substantial equivalence testing that has not found significant differences between GM and conventional plants because the interviewee's attitude was that testing was incapable of capturing the biological nuance of potential changes within a GM plant. They assert that to address these inadequacies, methods need to be developed to capture the nuances. A key point of contention, then, involves how the potential unintended changes within a GM plant from the engineering process are tested for – a topic I return to in the discussion.

1.4.1.2 Implications

These differences involving hazard identification have implications for the transferability and specificity of the results from the scientific studies called for in the different guidelines. Scientists justified their approach to hazard identification in terms of either reasonableness or effectiveness. With the eco-toxicological approach, substantial equivalence testing is used to determine that the only significant difference between the GM and non-GM plant is the toxin. Therefore, the toxin is the only hazard. With this foundational judgment established, the results of laboratory studies on that toxin can be transferred to other GM plants engineered with the same toxin. That is, if you have a Bt corn plant engineered to express the Cry1Ab toxin (a particular type of Bt toxin), then the laboratory studies you conduct on that toxin to evaluate if the Bt corn plant will harm ladybird beetles can also be used to study if ladybird beetles will be harmed by a GM cotton plant engineered to expresses the same Cry1Ab toxin. As long as you establish substantial equivalence in all cases, the laboratory experiments examining how a specific Bt toxin affects an insect species are relevant whenever that toxin is being used in another plant.

With the ecological approach's method for hazard identification, the results from the studies conducted for the risk assessment are more specific to the GM plant under consideration. For the same reasons, however, the results from the studies for one GM plant do not have the same transferability to risk assessments for other GM plants. This emerges from the ecological approach's consideration of how the genetic modification may influence the plant and how the transgene may express itself in ways that are not well mirror by purified Bt toxin. In examining indirect effects using field studies involving the whole plant, the results are specific to that particular variety of GM plant being tested, as well as to that recipient agro-ecosystem. For example, an insect resistant

GM corn plant engineered with the Cry1Ab Bt toxin will potentially act differently a particular agro-ecosystem than a similar variety of corn plant engineered with different type of Bt toxin or than a soybean plant engineered with the same Cry1Ab toxin. In examining direct effects from the Bt toxin in a GM plant, using parts of the GM plant itself instead of the purified Bt protein will make the results more realistic, but also specific to that particular GM plant.

Those supporting the eco-toxicological approach argued that the specificity of this ecological approach is unreasonable and that their approach is reasonable in terms of resources and safety:

> "Now if you take the plant as the stressor, because there are strange interactions going on between the toxin and the plant compounds, you would basically have to do a risk assessment for every single maize hybrid… I think Spain has 50 Bt hybrids, you would have to do a risk assessment for all of them… I think we accept that we cannot have 100% safety. That in the end we have to do a reasonable risk assessment in a reasonable amount of time, and there are limitations in terms of time and money. And I think within this frame we are trying to do a risk assessment that is as good as possible."

Those supporting the ecological approach, on the other hand, argued that the selection of the most important risk hypotheses for each specific risk assessment can lead to a reasonable and effective assessment of the risk. They argued that the tiered approach using substantial equivalence testing is not an effective way to characterize the risk from a GM plant because it leaves out a significant set of potential risk hypotheses, as one scientist said:

> "Well, the whole purpose of these papers… is about whether or not we assess things properly… [If we use the other approach] it would mean that for a large class of things, we wouldn't really be assessing risks. We'd be sort of going

> through motions. I think over the long haul, maybe it would start to erode the legitimacy of risk assessment as a decision making tool."

Overall, those supporting the ecological approach argue that the eco-toxicological approach's use of simpler and easier lab testing is too limiting in the types of risks that it examines and in the ecological nuance it allows for. Therefore, it is not effective in examining potential risks. Conversely, those supporting the eco-toxicological approach make a case for their approach based upon its reasonableness. It does not capture all risk hypotheses, but enough to have adequate safety.

1.4.2 Species Selection

The two approaches also differ over species selection – choice of which insect species to study in experiments to adequately characterize the risk from a GM plant. There are far too many important non-target insect species potentially impacted by a GM plant to conduct studies on them all. As a result, those who conduct risk assessments need to choose the insect species to use for evaluation of the potential for significant harm to non-target species. Each risk assessment guideline proposes a different process or set of criteria for choosing the species to be tested. The eco-toxicological approach supports the use of surrogate species – species easily reared in the laboratory and whose results are extrapolated to the non-target insect species of concern. Conversely, the ecological approach follows a process that selects key insect species for testing based on the specific qualities of the GM plant under consideration and the potential release environment.

Surrogate species have been used in studies for a variety of toxicological testing, including for pesticides (Barrett et al. 1994). The eco-toxicological guidelines adapt this established use of surrogate species for testing insect resistant GM plants. Surrogate species are species that are relatively easy to rear and use in laboratory testing but that can indicate whether the key non-target organisms would be adversely affected by the stressor under consideration. As Carstens et al. describe, "Surrogates must be easily reared under controlled, standardized conditions to provide large numbers of consistent individuals having a high level of fitness; they must perform well on an artificial diet and be amenable to manipulation under laboratory conditions; and validated test protocols must be available that produce consistent, statistically robust data"(2014, 4). Utilizing surrogate species for species selection helps the eco-toxicological approach address one particular complicating factor it faces: not all insect species can be easily raised and used in a laboratory setting, a precondition for the laboratory-based tiered approach. If the surrogate species are not adversely impacted when exposed to a worst-case level of the Bt toxin in the laboratory, the eco-toxicological approach does not call for additional testing to judge that there is no significant risk to non-target species. The eco-toxicological approach proposes that surrogate species should represent key functional groups of non-target insects such as herbivores, pollinators, natural enemies, and decomposers. Information taken into account in the selection of surrogate species includes the risk hypotheses examined, and information about the plant, the Bt toxin, and the feeding habits of the potential test species (Romeis et al. 2008).

Instead of choosing surrogate species to represent important non-target organisms, the ecological approach uses a prioritization process to identify the most important insect species to study in the risk assessment given the specific GM plant and the local ecological context. This prioritization process begins by determining the appropriate functional groups (e.g. non-target herbivore pests, predators, parasitoids, or pollinators) in need of examination based on the novel trait of the transgenic crop, the characteristics of the crop, and the environment it will be released into (Hilbeck et al. 2008, 119). Species within each functional group are prioritized to determine a limited number of most important insect species that should be tested. This prioritization process to determine 'most important' considers each insect species association with the crop and their functional significance in the crop, associated crops, and natural areas. Criteria for association with the crop include, for example, "geographic distribution in the cropping regions, prevalence on the crop, abundance on the crop, phonological (temporal) overlap between the crop and taxon, and habitat specialization during the crop cycle" (Hilbeck et al. 2008, 122). Overall, functional significance considers the ecological importance of the insect species in the agro-ecosystem. The goal, then, is to determine the most important insect species for testing given the specific transgenic trait, type of crop, and local environment.

The consequential differences between these two approaches can be further comprehended by considering the specificity and transferability of their results. If species tested are specific to the local conditions, as in the ecological approach, then extrapolation from surrogate species is not needed, but the results are specific to that local context. Use of local species may help reveal adverse effects that result from a local species being uniquely susceptible to a GM plant in ways a surrogate species may not be. Studies examining how closely related species display significantly different susceptibilities to hazards have challenged the idea that surrogate species can adequately represent the diversity of non-target species (Banks et al. 2011; Lang et al. 2011; Banks, Ackleh, and Stark 2010; Stark, Banks, and Vargas 2004). From the point of view of the eco-toxicological approach, however, local species are not a requirement for adequate risk assessment and in addition, they may pose unnecessary challenges such as limited species knowledge compared to well-studied surrogate species or the practical difficulties of rearing the species in a laboratory. As those who support the eco-toxicological approach have argued in a publication,

> "The [ecological approach] has major drawbacks because the main criterion for the selection of species is the (regional) importance of the natural enemy in a given crop. Especially in tropical and subtropical countries, the natural enemy species are often not sufficiently described in taxonomic terms, cannot be reared in the laboratory or are not well studied in terms of their biology (e.g., prey spectrum) and function. Selecting such species for testing will cause serious problems with regard to the quality of such data and not increase the certainty and feasibility of the risk assessment" (Romeis, Meissle, and Bigler 2006b).

Whereas, one supporter of the ecological approach explained that the specificity in the ecological approach is its strength, "the concept is to try to figure out the specific case, a specific crop, the specific traits, and the specific receiving environment. And then you choose the species that are more likely able to indicate to you that something is going wrong."

1.4.3 Indirect prey-quality effects

The third area of divergence I identify involves how each approach considers indirect, prey-quality effects. Indirect, prey-quality effects are those impacts on beneficial insects caused by a decrease in the quality of their prey as a result of the prey being negatively impacted by a GM plant. This has implications for the risk hypotheses each approach examines and under what conditions each approach conducts laboratory or field studies. For example, is it necessary to consider the potential adverse effects from a reduction in natural enemies, if their populations decline because GM plants kill a pest species that the natural enemies feed upon? In other words, if a ladybug that normally feeds on a lepidopteran caterpillar pest is negatively impacted when those lepidopteran caterpillars are killed by a Bt crop, do you need to conduct studies to consider how ladybugs are impacted by having fewer lepidopteran pests to feed on and the potential adverse effects from having fewer ladybug natural predators to consume other pests? Those supporting the eco-toxicological approach make the judgment that it is unnecessary to conduct studies to examine potential reductions in predator species due to a reduction in Bt susceptible pests. They maintained that if Bt plants were not used, then non-target prey species would still be adversely affected from the pesticides that would need to be used to control pest species. In other words, they argued that the existing status quo or baseline for comparison would be one that involves pesticides that hurt natural enemies. As one scientist supporting the eco-toxicological approach put it during an interview:

> "People who weren't working in conventional agriculture and thought that organic or something like that was much more the right path anyhow, would tend to want to look at a comparison of Bt crops compared to no insecticide sprays. And under

> those circumstances you'd say, well look, if a Bt [crop] does anything at all its risks are greater than having nothing out there. Where the people who were much more steeped in conventional agriculture would say, well hang on, the reality is if you haven't got Bt out there, you got 12 sprays, and there are no beneficial [insects] and you're probably going to kill birds as well, right? If you put a Bt crop out there, it's true, maybe there won't be as many Braconid [parasitoid natural predator] wasps because there isn't as much to eat as if you grew a non-GM crop that wasn't sprayed, but let's be realistic here, what are 99 percent of growers really going to do, they're going to grow a crop and spray when the bugs turn up."

To support this argument supporters of the eco-toxicological approach also contend that the reduction of pests is the obvious goal of any crop protection method, and that "such effects on natural enemies, that are a consequence of an intended effect (that is, control of a pest), are common for all pest control methods, including insecticides, biological control and conventional host-plant resistance and are generally not regarded as a risk" (Romeis, Meissle, and Bigler 2006a, 69). The goal of pest management is the reduction of pest species, no matter the method used, so the risks from the reduction in pest species are not unique to GM plants and do not need assessing (Romeis et al. 2008, 206–207).

Therefore, those supporting the eco-toxicological approach believed, that because the agricultural status quo as they see it contains similar or more severe prey-quality indirect effects on natural enemies, it is not necessary to assess those risks. As a consequence, the eco-toxicological risk assessment guidelines do not provide a methodology for assessing the indirect prey-quality risks. This judgment aligns with the focus on laboratory testing privileged in the eco-toxicological approach, because assessing the risk from prey-quality indirect effects is most effectively done using field studies that capture the complex ecological interactions between natural predator species, herbivore species, and plants. As echoed by someone who supports the ecological approach,

> "You very rarely have a linear tritrophic food chain, for example… So then in my view, because of the ecological complexity, there could be very significant interactions or changes in conditions which you simply cannot reasonably mimic or model in a [laboratory] setting which is lower in complexity."

Requiring field studies to adequately assess the risk of a GM plant conflicts with the tiered approach central to the eco-toxicological approach but does not conflict with the ecological approach.

Those who support the ecological approach, conversely, believe that prey-quality indirect effects should be potentially included within the overall risk assessment (Andow, Lovei, and Arpaia 2006). Although they believe the decision to do so should be left to those conducting the risk assessment, they cite two justifications for why prey-quality indirect effects could be included (Pham et al. 2008). First, supporters of the ecological approach highlight the significance of biodiversity for agroecosystems, especially the role of natural enemy insect species that help keep pest populations under control (Pham et al. 2008). They argue that one should not just assume that a change in an agroecosystem, such as a drastic reduction in a particular pest species, would not cause significant adverse effects. They maintain that whether a reduction in natural enemies may cause an outbreak of another pest would certainly be useful information that would inform decision making surrounding a particular GM plant. Furthermore, they argue that the significant negative impacts from damaging pesticides should not keep one from examining the impacts from a potentially harmful GM crop technology, even if the associated harm is found to be less severe. As a supporter of the ecological approach said,

> "If something is causing a bad thing to happen, that doesn't mean that anything that gets in its way is good. You want to look at why it's being caused and how you can keep that from happening... [If pesticides are causing a problem you should look at] the pesticide problem. The other attitude is the way of getting solutions that actually bring bigger problems along with them."

A second reason that those supporting the ecological approach believe prey-quality indirect effects should be considered is because they disagree with the judgment that a pesticide intensive agricultural practice is always the appropriate status-quo baseline for comparison (Andow, Lovei, and Arpaia 2006). The baseline for comparison, in this reasoning, needs to be made in the problem formulation phase and should be founded on "policy goals of the regulatory authorities, the potential users of the technology and the potential affected parties" (Andow, Lovei, and Arpaia 2006, 750). If, for example, one was to examine the potential impacts of a GM plant from the baseline of an organic or non-pesticide intensive conventional agricultural system, it would not be reasonable to assume that natural enemies would necessarily be significantly adversely affected in the status quo. Furthermore, in these types of organic and non-pesticide intensive methods, the importance of natural enemies for pest control becomes more significant. And to study these indirect effects, conducting field studies may often be the most useful approach.

1.4.4 Competing understandings of agriculture and risk

In sections 1.4.1 – 1.4.3 I outlined some of the most consequential differences between the two risk assessment guidelines and the specific justifications provided by those scientists for the judgments that they made. Through the interviews, I also identified differences in the underlying understandings of agriculture and risk that helped explain why those supporting each approach made the judgments they did. Although scientists from both approaches agreed that GMO ERA should be used to protect agro-ecosystems and to inform agricultural decision making, they differ over how the current state of agriculture and the ease of interpretation should influence risk assessment.

Those supporting the eco-toxicological approach viewed the use of GM plants in agriculture (especially insect resistant GM plants – those that have been of most concern for non-target impacts) as an obvious improvement to using harmful pesticides in conventional agriculture. They viewed insect resistant GM plants as desirable given that conventional farmers would otherwise rely upon more harmful pesticides to address these pests. They argued that by utilizing sound judgments (e.g. not considering indirect prey-quality effects) and widely accepted assumptions for risk assessments of other agricultural hazards such as pesticides (e.g. surrogate species and privileging laboratory testing) their approach adequately assesses the potential risks associated with GM plants. In addition, they viewed their approach as much more practical and reasonable than the ecological approach. In discussing what form risk assessment should take to best inform decision making, those supporting the eco-toxicological defended their practicality argument by defending an understanding of risk assessment that privileges scientific studies that are easily replicable and easily interpreted. As one supporter of the eco-toxicological approach stated:

> "I've had lots of debates with the EFSA… they want these plant studies [examining the plant as a stressor] because they are more confident in the risk assessment… I think this will not help risk assessment, it will create confusion because you will occasionally see some effects, and you have no idea what that tells you. What I learned now in risk assessment: only ask for data where you know how to use it, which hypotheses they address and how to interpret the data. Everything else costs money and disturbs. That does not only cost money to the company, but when I have to review that as part of the regulatory process, it costs my time to look at them and it confuses me."

This interviewee is arguing, in short, that the full plant studies and field studies are more likely to find effects that fall outside of well understood risk pathways, and therefore their effects are harder to interpret and may not be of importance or attributable to a direct effect from the Bt toxin. With the eco-toxicological approach's focus on direct effects, many indirect effects are deemed not important to assess because they would occur in pesticide intensive conventional agriculture. The argument is that for the goal of studying direct effects, it is easier and more precise to interpret a laboratory study where you find that insects do or do not die at a significant rate when exposed to Bt toxin than it is to interpret a field study of a Bt plant where a population of a beneficial insect is negatively affected. In a field study there are many more possible factors at play, including those considered indirect. In addition, it is easier to run replicates and gain statistical significance with laboratory experiments than it is to run replicates of field experiments.

Those supporting the ecological approach questioned both the assertion that GM plants were the best path forward for agriculture and the assumption that pesticide intensive conventional agriculture is the harmful but needed status quo. They believed that the adverse ecological effects from all types of agriculture should be well assessed to inform decision making. They also believed that the assumptions made within the eco-toxicological approach that allows it to privilege laboratory work excludes many important potential harms from its purview, leading it to inadequately assess the risks from GM plants. Supporters of the ecological approach viewed their approach as the best way to adequately and thoroughly assess the risks on non-target organisms from GM plants. In explaining their approach to risk assessment, those supporting the ecological approach highlighted their emphasis on direct and indirect adverse effects. In complex ecological systems, they argued, the presence or absence of an adverse effect is the most important consideration, even if it results from an indirect pathway or the exact dynamics that caused it are not fully understood. As someone supporting the ecological approach stated,

> "When I think about it, I'm thinking about direct and indirect effects. I also think about it in terms of effects, not necessarily causal pathway… If all you do is think about the causal pathway, then you don't pick up harms that may be occurring outside of that causal pathway. That's, I think a lot of why risk assessment doesn't focus only on causal pathway… You could be missing [things]."

Given the differences in how the approaches view indirect effects, these contrasting views about risk and decision making are not surprising. With the eco-toxicological approach's focus on direct effects and well established risk pathways, the outcome of the scientific studies are more likely to be straightforward and easily interpretable, something that will not "create confusion." The ecological approach, by including the study of many different types of indirect effects through whole plant and field studies, is more likely to find potential adverse effects that are poorly understood and, therefore, potentially more confusing and in need of further study. Yet to understand the breadth of possible adverse effects for a range of agricultural systems, those supporting the ecological approach argue that these effects need to be assessed. Therefore, a key tension between the two approaches concerns the ease of design, transferability, and interpretation of scientific studies versus the breadth of potential harm examined. Those supporting the eco-toxicological approach believe their approach adequately assesses the potential adverse effects in a much more practical way, while those supporting the ecological approach view the assumptions of the eco-toxicological approach as overly limiting the types of harms examined.

1.5 Discussion: Implications of conflicting risk assessment guidelines

This discussion reveals four key areas of insight, by exploring the potential harms studied within one approach but not the other, demonstrating how guidelines have already refined decision making, highlighting the challenges faced by efforts to change risk assessment guidelines, and finally, examining what the study results mean for the study of guidelines and risk assessment in environmental science and decision making.

1.5.1 Understanding conflicting guidelines: Unexamined harm

The judgments made within these risk assessment guidelines delimit what types of potential ecological harms are examined and how they are studied. Even though these two guidelines use a risk assessment framework for examining the potential harms to non-target organisms from GM plants and share many assumptions, they are not the same. Our findings show how empirical varieties of risk assessment are heterogeneous and consequentially so (Dean 2010). Previous research revealed how values-based judgments influence GMO risk-related science (Levidow 2003; Myhr 2010), but the results presented here highlight how consequential judgments are present within risk assessment guidelines themselves. The same arguments used to support the use of deliberative and participatory methods to help inform how values-based decisions are made while conducting a risk assessment can be used to support deliberative and participatory approaches to deciding upon guidelines and their constitutive judgments (e.g., Meghani 2009; Stern and Fineberg 1996). To inform discussions about what form risk assessment guidelines should take, it is important to explore the implications of differing judgments. In the context of the study presented here, one way to understand the implications of the different judgments used by the conflicting guidelines is in terms of what potential risk hypotheses are examined in one set of guidelines but not in the other. This emphasizes what knowledge on potential ecological harms would be excluded from decision making and the societal discussion about GM plants. The point of this exercise is not to imply that all possible risk hypotheses should be examined; which, as stated before, is not possible. Nor is it to imply that an approach that examines the largest number of risk hypotheses should be assumed to be most desirable – shear number does not ensure those of most import are included. Rather, it is to call attention to how judgments within risk assessment guidelines have implications for what potential harms will be studied and how – insights useful to consider when deciding upon risk assessment guidelines. In this study, critical judgments that delimit risk hypothesis – leaving potential harms unexamined – involve indirect effects, substantial equivalence, and species selection.

First, there are potential harms through indirect pathways that the ecological approach deems necessary to assess but that the eco-toxicological approach does not. The ecological approach promotes the use of semi-field or field studies to analyze the indirect ways that the Bt toxin from the insect resistant GM plant may negatively impact beneficial non-target organisms. For the eco-toxicological approach, if substantial equivalence is established and laboratory testing with purified Bt toxin reveals no direct impacts on the non-target organisms, then no field testing is needed to characterize the risk as insignificant. Under those conditions, the potential indirect ways a GM plant may negatively impact beneficial insects – those that could become measureable through field experiments – would not be studied.

Second, the eco-toxicological approach's reliance upon substantial equivalence testing may leave unexamined potential harms from any unintended changes in GM plants. The eco-toxicological approach promotes using substantial equivalence testing that measures compositional (e.g. protein, fat, ash, moisture, carbohydrates, fatty acids, amino acids, minerals, vitamins, anti-nutrients) and agronomic (e.g. plant count, time to flowering, yield, susceptibility to pests and disease) characteristics of both the GM plant and its non-GM counterpart (Romeis, Meissle, and Bigler 2006b; EuropaBio 2003). Only if this testing reveals a biologically relevant significant difference between the GM and non-GM plant is further study call for on the potential effects from unintended changes in the GM plant on non-target organisms. The use of substantial equivalence testing to establish similarity between GM plants and their non-GM counterparts for safety studies is an essential part of GM plant regulation but has not gone without critique (Millstone, Brunner, and Mayer 1999; Kearns and Mayers 1999; Kuiper et al. 2002; Herman and Price 2013). For example, Kuiper et al. (2002) highlight the difficulties of finding adequate non-GM plants for comparison, determining when differences between GM and non-GM plants become significant, and bringing into common use profiling methods that could identify potential protein and genetic changes between GM and non-GM plants. Herman and Price (2013), conversely, argue that the studies examining compositional similarity between GM and non-GM plants may no longer be justified given that past studies have always found that such equivalence exists.

Yet, how does using substantial equivalence testing affect the study of risks to non-target organisms from potential unintended changes in GM plants? Substantial equivalence testing restricts the conditions under which the eco-toxicological approach would use semi-field or field studies to examine the potential effects on non-target organisms from unintended changes in the GM plant. Unless substantial equivalence testing finds significant differences between GM plants and their non-GM counterpart in the compositional and agronomic characteristics listed above (something Herman and

Price (2013) argue is unlikely to happen), the whole GM plant, and any unintended changes, will never be studied to see how it impacts non-target organisms. This means that no semi-field or field tests would be conducted to study the impacts of unintended changes in the plant on non-target organisms. Whereas, the ecological approach supports using semi-field and field studies to examine ways the whole GM plant (and any unintended changes) may impact non-target organisms, the eco-toxicological approach only calls for such studies if the results from substantial equivalence testing do not establish equivalence. What this assumes, then, is that the characteristics of the plant measured in substantial equivalence testing would indicate any significant, and potentially harmful for non-target organisms, unintended change in the GM plant. It also assumes then that any changes to the GM plant not captured by the substantial equivalence measures must not be significant and therefore need not be studied. Substantial equivalence testing, then, limits the focus on unintended changes to those that would emerge through substantial equivalence testing instead of those that would emerge through semi-field and field studies designed to study non-target organisms.

Finally, species selection influences the study of potential harm by affecting how the scientific studies examining the risk hypotheses are conducted. Specifically, using surrogate species in laboratory studies instead of testing local non-target species increases the likelihood that the differences between surrogate species and local species will lead to erroneous characterizations of risk. In selecting local insect species for testing, the ecological approach addresses the potential that local species may react differently and more severely than the surrogate species. There is evidence to question the assertion that surrogate species can adequately represent the diversity of susceptibilities of non-target species (Banks et al. 2011; Stark, Banks, and Vargas 2004; Peacock et al. 1998). In promoting the use of local species and removing the need for extrapolation from surrogate species, the ecological approach is privileging the local context in its study design. Although this does not necessarily expand the risk hypotheses being examined (if the risk hypothesis involves the GM plant adversely effecting natural predators – the question may just concern which natural predator is used, a surrogate species or a local species), it does lead the study design to address the potential specificity of the local species.

As we see from these three examples, the ecological approach to non-target GMO ERA considers a broader set of potential harms by examining risk hypotheses involving indirect risk hypotheses and potential undesired changes in the modified plant, and by privileging the local context through not using surrogate species. As outlined in section 4, those supporting the eco-toxicological approach argue that the additional information gained by the ecological approach is not necessary for adequately assessing risks in non-target GMO ERA, while those supporting the ecological approach believe it is necessary.

1.5.2 Implications of conflicting approaches: GM plant environmental decision making

As national governments are faced with decisions about whether and under what conditions to allow for the cultivation of GM plants, they will need to decide upon, and reexamine, processes for characterizing the potential for environmental harm from such plants. And in order to be deemed legitimate under WTO agreements, such processes will need to be based in risk assessment (Bonneuil and Levidow 2012). Multiple risk assessment guidelines with their constitutive judgments clearly identified and described can inform relevant agencies that there are choices to be made and potentially help them make such choices.

For example, environmental agencies with existing risk assessment guidelines for GM plants, like the European Food Safety Authority (EFSA) and USEPA, can draw upon insights from both approaches for non-target GMO ERA if and when they revisit their guidelines. The more the distinct approaches publicly air their differences and deliberate about the implications of these differences, the more insights these environmental agencies will have to build on. At this point in time, the United States environmental agencies seem committed to an approach built upon the eco-toxicological approach for the risk assessment for non-target impacts of insect-resistant GM plants (EPA 2007), but EFSA has revisited their non-target GMO ERA building partially upon the ecological approach (Devos et al. 2012). For example, a recent scientific opinion from EFSA states that when exploring potential indirect effects from undesired changes within the GM plant, there is a need to go beyond the compositional and agronomic testing that normally informs substantial equivalence testing. Specifically they call for an extended compositional analysis "which focuses on plant parts (e.g. pollen, nectar, leaves, stem, roots) that are consumed by NTOs and which are not always considered under food/feed safety assessments" (EFSA Panel on Genetically Modified Organisms 2010, 33). This scientific opinion also calls for the study of "plant-environment interactions" that focus on examining how non-target organisms are impacted by the GM plant material itself (EFSA Panel on Genetically Modified Organisms 2010, 33–34). Both these proposals can be seen as efforts to address the concerns raised within the ecological approach, that the traditional compositional and agronomic substantial equivalence testing is not adequate to examine unintended changes in a GM plant. Another area where this EFSA scientific opinion drew upon the ecological approach was in their guidance on species selection. Instead of using a standard set of surrogate species as promoted in the eco-toxicological approach, it calls for a prioritization process with ecological and practical considerations to select the most suitable non-target organisms from the specific ecosystem under consideration. The EFSA example demonstrates that a diversity of articulated approaches to ERA can help call attention to judgments that need to be made and highlight new risk hypotheses in need of consideration in order to inform decision making.

1.5.3 Challenges when seeking to change risk assessment guidelines

Even if the potential for a multiplicity of legitimate risk assessment guidelines is realized, there remain challenges facing efforts to change risk assessment guidelines. I explore these issues in three parts: guidelines deemed inadequate, establishing alternative guidelines, and the normative assumptions that delimit the scope of the assessment. First, once a set of guidelines is established, the burden of proof to demonstrate that the guidelines are in need of change generally falls to those critiquing them (Demortain 2013). Once in use, many are reluctant to change them without strong evidence that they could be problematic. Proof of possible inadequacies – e.g., the potential for significant unassessed adverse effects – can be difficult to garner when, as shown in this study, the judgments within risk assessment guidelines delimit what type of science is completed. Put differently, you cannot find empirical evidence that risk assessment guidelines are not assessing a significant adverse effect if no studies look for such an effect. You cannot find what you do not look for. For example, if there were indirect effects on beneficial predators from an insect resistant GM crop, yet there were no studies conducted that could reveal these effects, it would be impossible to gather evidence that these effects should be examined. Furthermore, I found that justifications for the status quo ERA guidelines often relied upon arguments focused on "practicality" and "reasonableness". This leads to the tension that without strong evidence of an unassessed adverse effect, it appears unreasonable to change approaches; yet, you can only find such evidence of an unassessed adverse effect by changing approaches.

Second, changes to risk assessment guidelines can be done in an incremental or foundational fashion. Incremental changes (e.g., increasing the number of non-target species tested or increasing study length (see Marvier 2002)) may be straight forward, but changes involving foundational assumptions of existing guidelines (e.g. incorporating indirect effects or not relying upon substantial equivalence testing) can involve developing a coherent set of alternative risk assessment guidelines and may require a significant amount of time and resources. Although not the focus of this article, conversations with those who developed the ecological approach revealed that it took years of work and significant funding to develop the alternative risk assessment guidelines they support. And this competing approach helped make explicit the judgments that delimit the study of risk, their implications, and how they could be made differently. Given this investment level, it is unclear if, and how, current risk assessment guidelines will come under critical review. A final impediment to change involves the foundational assumptions about the status quo that inform judgments used within the guidelines. Disagreement may not center on the potential for adverse effects, but instead, on whether adverse effects are significantly worse than the status quo. Judgments about the status quo can influence whether particular potential changes to risk assessment guidelines are deemed as necessary and, as a result, should be rigorously scrutinized.

1.5.4 Scholarship on guidelines and risk assessment in environmental decision making

Insights from this study of risk assessment guidelines and their constitutive judgments contribute to the current conversations about risk assessment and decision making. In particular, I focus on two recent discussions, one involving whether the European Union should move the assessment of environmental risk from member states to the European Food Safety Authority (Wickson and Wynne 2012a; Perry et al. 2012; Wickson and Wynne 2012b) and another about what constitutes relevant and quality scientific studies for GM plant ERA (Romeis, McLean, and Shelton 2013a; Wickson et al. 2013; Romeis, McLean, and Shelton 2013b). In both cases a key component of the disagreement revolves around differing understandings of risk assessment and risk assessment guidelines.

In the first case, Wickson and Wynne (2012a; 2012b) argue against a proposal by the European Commission to separate the environmental and health risk considerations from socio-economic considerations when member states make decisions on whether to cultivate GM crops. The European Commission's proposal, Article 26b in directive 2001/18/EC, would allow member states to make their own decisions on whether to cultivate GM crops, but only based on socio-economic considerations. The European Union's scientific advisory body, the European Food Safety Authority (EFSA), would evaluate the environmental and health risks. The desire to separate the scientific assessment of risk from the normative socio-economic arguments around GM plants was part of an effort to help reduce the conflict and controversy surrounding GM plant decision making. Wickson and Wynne argue that by choosing to see risk assessment as a singular and objective process that could be adequately completed by EFSA for all member states is to neglect how "the processes of scientific RA [risk assessment] are inevitably shaped by normative commitment, which as a matter of institutional, policy and scientific integrity must be acknowledged and inclusively deliberated" (2012b, 483). Perry et al., a group of current or past members of the EFSA GMO Panel, respond to Wickson and Wynne by defending the approach used by EFSA for assessing the risks of GM plants (2012). They argue, for example, that concerns about the ability of EFSA to address the specific conditions within member states are already covered by the existing ERA guidance document that mandates they address separate receiving environments. In addition, Perry et al. (2012) defend the process used to assess risk, pointing out that comments from stakeholders and representatives from member states are included.

Finally, they reassert the distinction between risk assessment and risk management, arguing that risk assessment and not risk management is the responsibility of EFSA.

As Wickson and Wynne explore in their rebuttal to the response, although Perry et al. defend EFSA's approach to risk assessment, they do not address the "normative commitments inevitable in risk assessment" (2012b, 482). Perry et al. argue that the local conditions can be considered within a risk assessment and even that stakeholders can be allowed to comment on the risk assessment itself, but these types of reassurances do not acknowledge that there exists foundational values-based judgments within risk assessment that influence how the potential for harm is examined. Yet, as my findings show, judgments that delimit how the potential for harm is studied are present as risk assessments are conducted but also initially in the risk assessment guidelines, themselves. These findings help make explicit where such judgments exist and begin a conversation about the implications of differing judgments. These results reinforce the argument made by Wickson and Wynne concerning the importance of highlighting the existence of values-based judgments in risk assessment and, in addition, show the need for scrutiny to extend to risk assessment guidelines themselves. These guidelines should be openly discussed, debated, and ultimately decided upon by individual member states that will use the resulting risk assessments to inform their decision on whether and how to cultivate GM plants.

The second case I examine involves contestations about which scientific studies are legitimate and relevant for decision making surrounding GM plants (Romeis, McLean, and Shelton 2013a; Wickson et al. 2013; Romeis, McLean, and Shelton 2013b).

Here I specifically focus on the role of risk assessment guidelines within this exchange. Romeis et al. (2013a), including at least some authors who have expressed support of the eco-toxicological approach, argue that scientific studies that gain attention in the media are often not well designed and many times largely irrelevant to risk-related decision making. They argue that more attention must be paid to whether the studies are relevant, saying:

> "it is essential that regulatory authorities, or the scientists that evaluate data on their behalf, be discriminating about the legitimacy of the studies that they consider during the evaluation process, irrespective of their source. This evaluation should include both the quality of the study itself as well as *its relevance to the risk assessment process as described in the regulations and associated guidance*" (Romeis, McLean, and Shelton 2013a, emphasis added).

In response, Wickson et al. (2013) argue that determination of what constitutes relevant scientific studies for risk assessment will influence the outcomes of a risk assessment and is dependent upon values-based assumptions. Therefore, this decision should not be made by a group of experts but should be open to wider scrutiny and deliberation. What neither side acknowledges, however, is that the "associated guidance" that Romeis et al. (2013a) refer to as criteria for narrowing the desired set of scientific studies would include risk assessment guidelines, such as those I studied. And given the values-based judgments within risk assessment guidelines that delimit how the potential for harm is studied, these risk assessment guidelines also need to be scrutinized. In other words, there are judgments in both risk assessment guidelines and in the conduct of risk assessment itself that determine what scientific studies are relevant and how risks are characterized. If one is committed to critical examination of the values-based judgments that influence how risks are studied to inform decision making, it is necessary to consider both risk assessment guidelines as well as the conduct of the risk assessment, itself.

1.6 Conclusion

> "Guidelines very different from the kinds described could be designed to be devoid of risk assessment policy choices. They would state the scientifically plausible inference options for each risk assessment component without attempting to select or even suggest a preferred inference option. However, a risk assessment based on such guidelines (containing all the plausible options for perhaps 40 components) could result in such a wide range of risk estimates that the analysis would not be useful to a regulator or to the public. Furthermore, regulators could reach conclusions based on the ad hoc exercise of risk assessment policy decisions" (National Research Council 1983, 77)

This statement from the 1983 National Research Council report on risk assessment emphasizes the importance of judgments made within risk assessment guidelines by articulating how problematic guidelines would be without them.[1] This statement supports the argument that if important risk assessment policy choices are identified and established within risk assessment guidelines, then it reduces the possibility that those conducting the risk assessment would inadequately make such choices. In this way, risk assessment guidelines have the potential to ensure that the foundational judgments in risk assessment are recognized as values-based judgments, reflected upon, and made in a deliberate, defensible way. This NRC statement aligns

[1] It is questionable whether it is useful to frame this question in terms of being able to remove all risk assessment policy choices or being able to drastically reduce the number of risk assessment policy choices by making explicit all of the possible options for many of these choices. It seems possible to argue that if you remove all risk assessment policy choices completely, there is nothing of significance remaining. Or at the very least you will be left with needing to create a distinction between what is innately essential to risk assessment and what aspects of risk assessment are choices that could be made in different ways.

with the idea that those concerned with risk assessment guidelines should not try to make them devoid of risk assessment policy choices, but should help ensure that the guidelines, and judgments within them, are interrogated and take the best form possible.

My results confirmed the importance of judgments in risk assessment by finding that differing judgments exist within conflicting risk assessment guidelines and that these judgments delimit, or determine the boundaries of, the study of potential harm to the environment. Specifically, I found that judgments about hazard identification and substantial equivalence testing, species selection, and indirect effects delimited how each set of guidelines examined the risks from insect-resistant GM plants. In addition, I found that judgments within risk assessment guidelines also influenced what science was called for to inform the risk assessment. In other words, risk assessment guidelines influence not only how scientific studies are synthesized for decision making, but also what scientific studies are conducted and how they are conducted. Furthermore, these judgments that delimit the study of potential harm cannot be avoided; they are a necessary condition of empirical studies to inform decision making. It is not possible to study all the potential ecological entities that could be adversely impacted by a GM plant, or other potential stressors. Judgments are needed to focus scientific studies and to ensure they provide useful information for risk assessment and decision making. Recognition of the importance of risk assessment guidelines and the judgments that constitute them is vital for risk assessment-informed decision making. Without open scrutiny of risk assessment guidelines and their constitutive judgments, decisions could be made through an unquestioned faith in the status quo, could privilege the interests of powerful actors over those of the public good, or could be arrived at in an unsystematic, ad hoc manner. To ensure the integrity of environment-related decision making and science, then, risk assessment guidelines must be a site of critical inquiry.

This study also revealed potentially fruitful areas for future research. First, there is a need to better understand the factors that influence efforts to retain or challenge existing risk assessment guidelines. Beyond the assumptions about agriculture and risk assessment policy that I documented in this study, how do other policies or priorities influence what form judgments within risk assessment guidelines take? For example, how do institutional priorities, disciplinary norms, or personal interests lead scientists, decision makers, and risk assessors to defend or challenge particular risk assessment guidelines? Second, there is a need to further examine the limitations of current judgments within risk assessment guidelines, even those that are not challenged by a competing set of guidelines. I examined several of the key judgments in non-target GMO ERA by exploring two competing sets of guidelines, yet one can also question the role of judgments in any set of risk assessment guidelines. What judgments within risk assessment guidelines limit certain risks, or potential harms, from examination? How do these judgments influence what scientific studies are completed and how they are completed? What justifications are used for why those risks shouldn't be examined and for why those studies shouldn't be used? One can use these insights on the limitations of current risk assessment guidelines to inform incremental change within them and to make decision makers and society more broadly, aware of the fundamental limitations of how we currently make decisions.

As risk-based approaches continue to be privileged within science, technology, and environment-related decision making, it is important for scholars to study how risk assessment delimits the study of potential harm. Studies, like the kind I conducted here, can identify judgments in need of reflection and deliberation, and help foster a greater societal awareness of the processes used to inform decision making and the limitations of these processes. Awareness of how sometimes seemingly minor judgments within risk assessment guidelines can consequentially influence science and decision making processes, makes it possible to better understand how risk-related decisions are made and how they could be made in light of different values-based judgments.

Chapter 2 – Conflicting Futures: Environmental Regulation of Plant Targeted Genetic Modification[2]

2.1 Introduction

Plant targeted genetic modification (TagMo) is a term we use to describe a variety of emerging technologies that are poised to significantly change plant genetic engineering. Targeted genetic modification, also called "targeted genome editing" and "new biotechnology-based plant breeding techniques," refers to techniques that create more precise changes in DNA than the relatively random changes made in the first generation of plant genetic engineering (Figure 3). TagMo techniques will likely improve the efficiency of plant genetic engineering and increase the number of traits and plant species that can be engineered (Porteus 2009; Bogdanove and Voytas 2011). In addition, because TagMo techniques fall outside existing United States (US) regulatory definitions for genetically engineered plants, it is uncertain how US regulatory agencies will handle plant TagMo products. The US Department of Agriculture has already ruled that certain TagMo-derived plants will not be regulated as genetically engineered organisms in the United States (Waltz 2012). Many other regulatory agencies across the world are also grappling with how they will address plant TagMo products (Podevin et al. 2012).

[2] This chapter was submitted as a journal article co-authored with Professor Jennifer Kuzma.

First generation techniques for plant genetic engineering randomly insert DNA sequences containing desired traits into plants using Agrobacterium or biolistics-based methods. The random nature of this insertion means that many insertions are needed to arrive at a plant that expresses the desired trait. As a result, much effort is required to determine when the inserted DNA leads to the successful expression of the desired trait within the transformed plants. The plants expressing the desired trait then needed to be bred with conventional plant varieties to produce plants suited for commercial use. First generation modification techniques are the dominant methods used to create herbicide tolerant and insect resistant traits used in existing genetically modified crop varieties that in 2013 made up 90% of cotton, 93% of soybean and 90% of corn grown in the US (USDA 2014).

We use the term plant TagMo to represent a set of genetic engineering techniques, such as those using zinc-finger nucleases, meganucleases, olionucleotides, and transcription activator-like (TAL) effectors, that all rely upon similar mechanisms for creating changes in a plant's genome. These techniques use molecules that read DNA sequences and that create double-strand breaks at precise places within DNA (Townsend et al. 2009; Shukla et al. 2009; Gao et al. 2010; Bogdanove and Voytas 2011). The double-strand breaks within a plant's DNA activate the cell's own repair mechanisms that can then be used to alter the targeted gene within a plant's DNA. If a DNA fragment is provided that shares sequence similarity with the broken site in the DNA, the cell repair mechanism will use this fragment as a template for the repair. This can allow for the insertion of foreign DNA in a similar yet more precise and efficient way than the first generation of plant genetic engineering. More specific changes, down to a single nucleotide, can also be made with TagMo techniques. These changes can be used to create small insertions or deletions that can alter or delete gene function.

Figure 3: Plant targeted genetic modification and its relationship to first generation plant genetic engineering

Plant TagMo is still in the early stages of development and basic understandings of what plant TagMo is, plant TagMo's potential future, and how it should be governed are being established and contested (Podevin et al. 2012; Lusser et al. 2012). As part of a larger project examining plant TagMo oversight, we explored differing ways of understanding how plant TagMo should be addressed by environmental regulation. We gained insights into the possible futures of plant TagMo environmental regulation through in-depth individual interviews with thirty-one expert-stakeholders from academia, industry, government and non-governmental organizations. In designing and conducting this work we drew upon governance approaches developed at the intersection of the fields of science and technology policy and science and technology studies (STS), including upstream public engagement (Wilsdon and Wills 2004) and anticipatory governance (Barben et al. 2008). Much of the scholarship on anticipatory governance has focused on how to move societal engagement with technology beyond the regulatory realm by, for example, encouraging societal deliberation on emerging technology during the initial stages of technological development (Selin 2011). We believe, however, that the principles of anticipatory governance can also inform efforts to improve environmental regulation itself.

In this paper, we begin by reviewing the tenets of anticipatory governance and exploring their implications for our analysis of plant TagMo's environmental regulation. We highlight the importance of the concept of reflexivity in anticipatory governance and draw upon the STS subfield of future studies in exploring how to engage with futures in a way that contributes to reflexivity. Building upon these ideas, we contribute to a reflexive engagement with the environmental regulation futures of plant TagMo, as articulated by expert-stakeholders, by exploring how they conflict. We outline how these futures are built upon contrasting understandings of what constitutes environmental risk and of the adequacy of existing genetically modified (GM) plant regulation in the US. We conclude by exploring the implications of our findings for the regulation of plant TagMo and for anticipatory governance.

2.2 Anticipatory governance

Anticipatory governance is an approach to technology development and governance that builds upon the principles of foresight, engagement and integration. It seeks to insert reflection into technological development in an upstream manner so as to guide development towards desired societal outcomes and away from undesired ones (Barben et al. 2008). At their most basic, anticipatory governance's three founding principles can be summarized as follows:

- Foresight describes the process of developing plausible and evolving scenarios of possible futures that can be the subject of the public deliberation
- Engagement encompasses the suite of activities that stimulates public deliberation
- Integration brings the engagement and foresight activities into the domain of scientific practice in order to enhance reflexiveness (Sarewitz 2011, 103)

Anticipatory governance builds upon critiques and ideas developed within the field of STS, and has informed how science and technology policy scholars engage with emerging technologies such as biotechnology and nanotechnology (Karinen and Guston 2010; Kuzma et al. 2008). To better understand anticipatory governance and the intervention it is making within science and technology policy, it is helpful to take a closer look at two of its foundational principles: foresight and engagement. Both ideas emerge from a lineage of scholarship and critique developed at the intersection of STS and science and technology policy.

2.2.1 Foresight

The critiques built upon in the principle of foresight involve moving technology assessment from a reactionary position to a proactive one (Guston and Sarewitz 2002). Within the classical paradigm of technology assessment, technology development is largely unquestioned and takes place outside of the realm of societal influence. Instead of substantively influencing a technology's development, technology assessment is used only to advise society how best to react to the consequences of technology. Some of the initial critiques of technology assessment emerged from scholars developing constructive technology assessment and real-time technology assessment (Schot and Rip 1997; Guston and Sarewitz 2002). They argued for incorporating technology assessment activities into the research and development decision making processes to proactively improve technology. Instead of reacting to technologies already developed and on the market, they proposed generating knowledge concerning the potential societal impacts of potential technologies and pursuing mechanisms to incorporate that knowledge into existing decision making concerning research and development. Schot and Rip (1997) locate constructive technology assessment within a trajectory of thought that has challenged the "two-track" regime of societal technology management that separates promotional activities from control and regulation. They see constructive technology assessment as critiquing the "sequential approach of optimizing the technical before considering uptake, use, and effects" (Schot and Rip 1997, 263), creating and maintaining a space for sociotechnological criticism, and challenging the conflation of social progress and technological progress.

Although the scholarship surrounding constructive technology assessment, real-time technology assessment and anticipatory governance share an interest in "foresight", they do not share a clear definition of its meaning. One concept essential to the meaning of foresight is "reflexivity". Barben et al. (2008) argue that anticipatory governance's foresight principle "aims to enrich futures-in-the-making by encouraging and developing reflexivity in the [decision making] system." Genus (2006, 18) states that a central characteristic of constructive technology assessment is that "actors should be 'reflexive' about the processes of co-evolution of technology and society, of technology and its impacts" and that without such reflection stakeholders will be "reluctant to accept close scrutiny of their positions by others, or themselves to probe the assumptions which underlie their own viewpoint." Sarewitz, writing about the experience with real-time technology assessment and nanotechnology, argues that

> "reflexivity moves innovation towards more socially desirable outcomes and away from undesirable ones, as diverse decision makers reflect more deeply on the context of their decision. And this of course can happen either through a change in innovation paths, or through a change in the conceptions of desirability, or, more likely, through the interaction of both" (2011, 103).

These articulations of anticipatory governance share the idea that revealing and scrutinizing previously uninterrogated assumptions concerning the future of technologies will improve technology related decision making. Engagement is integral to an anticipatory governance based approach to reveal and scrutinize such assumptions.

2.2.2 Engagement

The principle of engagement builds upon the vast scholarship developed on participation in science and technology policy (Jasanoff 2003; Hagendijk and Irwin 2006; Lengwiler 2008). In anticipatory governance, engagement, or participation, is an essential part of critiquing and reflecting upon the development of technology. We see two distinct goals for participation within anticipatory governance, exemplified in the following quotation:

> "The aim of such [anticipatory governance] exercises [is to]… *[a]* increase dialogue about and current understanding of the range of possible technological trajectories and respective alternative governance frameworks, and to *[b]* elaborate how these two future projections should develop interactively" (Karinen and Guston 2010, 228, emphasis added).

The first goal (part *(a)* above) is to expand the number and type of potential futures taken into consideration. Underlying this goal is the belief that by broadening the discussion of possible futures, potential technology and governance options will be better understood and the best possible future will be articulated and thus potentially achieved. Involving stakeholders with a diverse set of values, worldviews, and epistemologies will help achieve this. Explicit conflict here is minimal in the sense that the goal is not to narrow or distinguish desired futures, but only to gather and better understand possible futures.

The second goal (part *(b)* above) is to determine what types of futures are desirable. Underlying this goal is the idea that in order to influence technological decision making in a positive way, there must be discussion and discrimination between the types of futures that are desired and those that are not. This goal is fraught with conflict-prone normative questions concerning the desired state of the world. If the first goal produces a variety of possible technological and governance futures, with some of them undoubtedly resembling the course of technological development initially critiqued by anticipatory governance, how does anticipatory governance ensure better societal outcomes? The anticipatory governance literature relies upon the idea of reflection, including critique and the interrogation of assumptions, to ensure that a better decision is arrived upon. So there is a close relationship between foresight, participation, and reflexivity. Without foresight, there is no way to leave reactionary technology assessment. Without participation, there is no way to ensure that a sufficiently broad set of futures and concerns are available for consideration. Yet without reflexivity, there is no way to ensure that participation and foresight will lead to better technology-related decisions. And it is in thinking about reflection, critique, and the interrogation of assumptions in futures that we find it useful to turn to insights from future studies scholarship.

2.3. Future studies for emerging technology

Building upon the STS work examining the role of expectations and promises in technology development (e.g. Van Lente 1993; Brown and Michael 2003), the STS subfield of future studies has produced a wealth of recent work examining emerging technologies. Many insights have been made concerning how to understand and interrogate the potential futures of emerging technologies through the study of expectations (Borup et al. 2006), legitimacy and narrative (Lopez 2008), hopes and affect (Anderson 2007), utopian dreams and apocalyptic nightmares (McGrail 2010), and futures more broadly (Selin 2008; Venkatesan 2010; Tutton 2011). This is in addition to the vast literatures developed by other social science disciplines on related topics, including, for example, technological futures and computing (Kinsley 2011) and potentiality in biomedicine (Taussig, Hoeyer, and Helmreich 2013).

As Groves states, "that the future is uncertain is a precondition of both political and ethical action" (2009, 1). If the future was given, there would be no need or ability to discuss and influence how the future should be. Our ability to influence the future invites, and perhaps obliges, us to consider what type of future we want to live in, with respect to technology or otherwise. A foundational assumption of future studies is that how we think about, discuss, and give meaning to the future influences how it materializes. In other words, how we envision what will happen to an emerging technology substantively influences what will become of this technology; such discussions legitimize, inspire, enroll actors, mobilize resources, dampen dissent or force silences concerning a technology (Anderson 2007; Selin 2008). In addition, futures not only influence how things will be, but also how things are in the present moment. Futures assign relationships among actors that mediate across scales, levels, times and communities (Borup et al. 2006). So when we talk of a possible "future" of a technology (or multiple possible "futures" of a technology) we are referring, broadly, to the understanding of how a technology could influence, and be influenced by, the social and natural world.

To elaborate upon what constitutes futures, why they are consequential and how we should study them, we highlight two insights developed by the futures studies literature. First, futures do not emerge from nothing but are partially constituted through already existing discourses and narrative strategies (Lopez 2008). Lopez states that, "approaching an emergent technology in this way allows us to understand how the not-yet-materialized (which all emergent technologies are) becomes not only thinkable but also invested with cultural authority and social legitimacy" (2008, 1269). Analyzing the narratives and meanings used to construct futures provides a way to see how futures build upon and challenge particular understandings of the past and present. For example, for hype to exist around the future of a new technology, both the contingencies that may disrupt its development and the continuities tying the technology to past technologies need to be marginalized (Borup et al. 2006). In the context of environmental regulation, one can explore how a certain approach to regulation comes to be seen as appropriate for an emerging technology by studying what meanings are privileged and marginalized within a particular future.

Second, conflict is an essential part of futures. As Tutton argues, "every future is predicated on others to be avoided" (2011, 412). Furthermore, Lopez (2008) emphasizes that it cannot be assumed that differing narratives concerning the future will easily converge in a complementary way. Venkatesan (2010) emphasizes the importance of considering the diversity within society and social existence when determining the desired form of emerging technologies. People are influenced by and desire technology differently and it is important to consider what values, meanings, and assumptions are privileged in particular futures. These values, meanings, and assumptions within futures will influence what forms the future will and will not take. By calling attention to these values, meanings, and assumptions and what is at stake in them, we can move from merely listing the potential paths a technology could take to interrogating and reflecting upon them. For example, in making sense of nanotechnology and its role in the world, one can draw upon a variety of meanings concerning the desired state of nature and how nanotechnology influences it (Wickson, Grieger, and Baun 2010). Whether one draws upon a narrative that sees nanotechnology as threatening or treating nature will influence how one considers nanotechnology, including how it should be governed. Furthermore, each narrative supports and is supported by a set of beliefs, assumptions and values. By examining and making explicit the implications of these beliefs, assumptions and values, it is possible to highlight the underlying issues and to pursue a more transparent deliberation about technology development (Wickson, Grieger, and Baun 2010).

2.4 Reflecting upon the environmental regulation futures of plant TagMo

Insights from the anticipatory governance and futures studies literatures informed our study of plant TagMo regulation futures. First, the articulated futures of plant TagMo environmental regulation will influence current and forthcoming decision making, and it is therefore desirable to study these futures and their implications. Second, these regulatory futures will conflict in that each will privilege certain understandings and assumptions at the expense of others. Third, to study the breadth of possible futures (with their differing implications and assumptions) it is necessary to engage with people holding a diversity of views, beyond those views that are most prevalently held. In our case we did this by conducting interviews with a diversity of expert-stakeholders knowledgeable of plant TagMo and genetically modified plant environmental regulation. Finally, reflection on plant TagMo's environmental regulation futures can be fostered by exploring the understandings and assumptions they privilege and their implications.

Our in-depth interviews with expert-stakeholders were guided by two overarching questions: How do expert- stakeholders provide meaning to the future of plant TagMo and its environmental regulation? How do the articulated futures of plant TagMo regulation conflict? Given that we wanted to examine the diversity of plant TagMo futures that exist, we selected expert-stakeholders from a diversity of backgrounds and disciplines to represent the breadth of possible understandings. Conducting individual in-depth interviews also facilitated uncovering this diversity as each interviewee could articulate his or her specific understanding of plant TagMo's future. We conducted thirty-one qualitative, semi-structured interviews with expert-stakeholders knowledgeable of the technical, environmental, social, and/or governance aspects of TagMo and first generation GM plants. Interviewees included TagMo scientists, GMO policy expert-stakeholders, social scientists and natural scientists from the affiliations of academia, industry, government and non-governmental organizations.[3] These interviews took place

[3] Affiliations of our interviewees (with frequency in parentheses) included: NGO (3), Law (1), Industry (3), Government (5), Academia – TagMo researcher (5), Academia – other (14). Primary area of expertise included: Biology (3), Biosafety (2), Ecology (2), Economics (1), Entomology (1), Genetics (1), TagMo researcher (5), Genome engineering (1), Molecular Biology (3), Public policy (7), Risk assessment (3), and Social Studies of Science (2).

between October 2010 and February 2011 and averaged about one hour each. To help interviewees understand how we defined plant TagMo, in advance of the interview we provided interviewees a document outlining the methods we considered TagMo (based on Kuzma and Kokotovich 2011, Figure 1) and an article from the journal *Nature* discussing zinc-finger nucleases, one type of TagMo (Porteus 2009). To elucidate interviewees' understandings of plant TagMo's future we discussed their definition of plant TagMo, key concerns and opportunities surrounding plant TagMo, the potential impact of plant TagMo, and their desires for plant TagMo regulation (Appendix B). We transcribed and coded the interviews using Atlas.ti and guided our analysis with insights provided by our review of the fields of anticipatory governance and future studies, as described below.

First, we identified the overall differences in how interviewees thought plant TagMo products should be addressed by environmental regulation. From interviewee's responses we were able to identify 5 types of suggested changes to the existing environmental regulatory system in the US to make it adequate for plant TagMo products (Table 1). We classify these 5 suggested change into the three categories: *pragmatic* that sought to address plant TagMo products with the existing environmental regulatory paradigm with possible minor changes; *optimistic* that sought for plant TagMo products to be regulated as conventionally bred plant products rather than as GM plants; and *critical* that sought to reconfigure and strengthen the existing regulatory paradigm to make it adequate for plant TagMo products. Drawing upon the insights from the anticipatory governance and future studies literature, we sought to further explore how

Table 1: Summary of the optimistic, pragmatic and critical environmental regulation futures of plant TagMo.

Plant TagMo Environmental Regulation Futures		*Plant TagMo environmental risk*	*Existing environmental regulation*
Optimistic	***Govern as non-GM plants***	Plant TagMo products are more natural than first generation GM plants and are significantly less risky	Adequate; tiered approach needed to not over regulate
Pragmatic	***Incrementally ease*** ↕ ***Keep status quo*** ↕ ***Incrementally strengthen***	Risks surrounding plant TagMo lessened due to increase insertion precision	Adequate but tiered approach needed to not over or under regulate
		Increased precision will not reduce risk	Adequate: No major issues have emerged
		New traits and species will pose new risks	Inadequate: Coordinated Framework lacking
Critical	***Reconfigure, increase rigor***	New traits and species and increased ease of production will worsen risks from 1st generation and pose new risks	Paradigm inadequate: Not capturing harm & not independent

these futures conflicted by examining how the assumptions and understandings they were built upon differed. For example, we looked for how interviewees drew upon differing understandings of past and present events, and how they understood what constituted harm to the environment. We found two key underlying understandings that noticeably differed between the optimistic, pragmatic and critical categories: how the environmental risks associated with plant TagMo products differ from those associated with first generation GM plants and the adequacy of current GM plant regulation in the United States (Table 1). We examined the differing assumptions across these underlying understandings and their implications for environmental governance. Finally, we identified the institutional affiliation and area of expertise of interviewees to better understand the contexts that influence particular futures.

2.5 The conflicting futures of plant targeted genetic modification environmental regulation

2.5.1 Pragmatic environmental regulation future

The vast majority of interviewees, representing a diversity of affiliations and areas of expertise, believed that to best address plant TagMo environmental regulation, existing GM plant environmental regulation should be kept the same, incrementally strengthened, or incrementally eased. We classified these futures as pragmatic because they generally viewed the existing regulatory paradigm as sound and argued for incremental changes to the existing GM plant regulation to best address plant TagMo products. Interviewees articulating pragmatic regulation futures held a diverse set of views concerning the environmental risks associated with plant TagMo products. One group of interviewees viewed plant TagMo as providing increased genetic engineering precision but not decreasing the environmental risk of plant TagMo products compared to first generation GM plant products. They viewed plant TagMo as one of many techniques for plant improvement, all of which can cause adverse environmental effects. They diminished the role of genetic engineering technique for environmental risk and instead focused on the plant's resulting phenotype. As one natural scientist in academia said,

> “Traditional crop improvement occasionally leads to weedier weeds, evolution of new invasives, and the endangerment of species at risk of extinction, and there’s no reason to assume genetically engineered organisms would be any different. There’s no reason to assume that species improved through targeted modification would be any different. I mean, they’re the techniques but they are not the phenotypes. So these sort of risks depend on phenotypes and - yeah, the risks depend on the phenotype, not on the technique.”

Other interviewees viewed plant TagMo as increasing genetic engineering precision and incrementally reducing the environmental risk from GM plants by lowering the likelihood of off-target effects during the genetic engineering process. As an academic in trained in public policy explained, “By reducing some of the uncertainty associated with traditional recombinant DNA engineering, I think [TagMo] helps to remove some of the concerns that have been raised about the potential risks of the technology by allowing us to be more comfortable with predictions about how the plant will in fact behave and perform in the environment.”

Finally, others believed that plant TagMo would facilitate the creation of new traits and species and, as a result, would pose new risks. For example, one plant TagMo researcher in academia stated with regard to environmental risk,

> “As we’re able to modify plants more and more… essentially, we will be able to modify these plants more and more from their standard configurations. Especially with gene addition, we can completely rewire a number of these plants. So I guess the one concern I have is that if we’re creating plants before we really know what the sort of products are…we really could rewire these to the point that they’re not really the same plant anymore. Is it going to be toxic to insects that are still going to recognize it as a food, but it’s no longer really a food for them?”

Even within this pragmatic category, we see a variety of differing understandings concerning how plant TagMo will influence environmental risk. A tension emerged in the pragmatic futures with regard to environmental risk between plant TagMo's ability for increased insertion precision and its ability to produce new phenotypic traits. Some justified their view that plant TagMo would reduce environmental risk by arguing that plant TagMo's increased insertion precision would reduce the off-target effects of genetic engineering. With fewer unpredicted changes in plants as a result of their genetic engineering, the potential for significant environmental risk will be reduced. Others within this category argued that it is the resulting phenotypic traits, and potential new phenotypic traits, that are more of a concern for environmental risk than imprecise genetic engineering. They believed that plant TagMo should be scrutinized because of its potential to create new phenotypic traits that may negatively impact the environment.

Interviewees articulating pragmatic futures viewed the regulation of first generation plant genetic engineering as successful or as adequate and in need of only incremental adjustments. Those who viewed it as successful believed that there had been no major problems resulting from the existing regulation, as this academic in public policy said,

> "I think if you look at the record to date, we clearly have in the United States, we've clearly witnessed the introduction of a widely adopted technology without any apparent health or environmental problem, so to that extent, you can argue that the regulatory system has been adequate and has worked well, because we've had the benefits of the technology, and we've avoided any potential risks."

Those who viewed existing GM plant regulation as adequate but in need of incremental change cited a variety of existing problems within the regulatory system. These changes sometimes were framed in terms of increasing or decreasing the stringency of the regulatory system and sometimes simply framed in terms of correcting existing problems. One frequent suggestion, for example, was to implement a tiered approach to regulatory oversight that would allow products similar to those already deemed safe to move through regulatory review with less scrutiny, allowing more attention to be placed on newer and potentially more risky products. Another set of suggestions involved addressing the regulatory gaps and other issues resulting from the United States Coordinated Framework for Regulation of Biotechnology that divided the responsibility for regulating biotechnology between the Food and Drug Administration, the Environmental Protection Agency, and the Department of Agriculture (Office of Science and Technology Policy 1986).

2.5.2 Optimistic environmental regulation future

A smaller subset of interviewees, mostly consisting of researchers in the plant TagMo field and members of the plant TagMo-related industry, stated optimistic futures for plant TagMo and its environmental regulation. We identified these futures as optimistic because they foresaw plant TagMo leading to drastic improvements in plant genetic engineering including not being able to distinguish between plant TagMo products and those derived through conventional breeding. We see this view articulated in the following quote by a plant TagMo researcher:

> "As long as you're able to keep the [TagMo agents] from actually integrating into the genome, there is no evidence as to how that particular mutation was made. So in that sense, when people get worked up about that type of genetic engineering, it's largely unfounded because you've just sped up what was essentially a natural process. If you can't distinguish between the natural product and the unnatural product, there really isn't any basis for concern between the two. Or at least any

> additional concern than what we've been accepting as standard practice for the last thousand years."

When describing the implications of plant TagMo for environmental risk, these interviewees describe the modifications from plant TagMo techniques as being more natural, and therefore less risky, than first generation techniques. These views emerge from seeing plant TagMo techniques not as a new form of first generation genetic modification, but as a new form of mutation breeding. Mutation breeding, also known as induced mutagenesis or classical mutagenesis, creates improved plant varieties by exposing plants to radiation or mutagenic chemicals and developing the resulting plants that contain random genetic mutations (Shu, Forster, and Nakagawa 2012). Thousands of plants with these random mutations are grown to screen and select for those that may contain desired traits. The vast majority of these plants will contain undesirable changes, but a small number may, by chance, result in desirable traits. Naturally occurring random genetic mutations occasionally result in desired traits in plants, and selecting plants with beneficial natural mutations is the foundational way to pursue improved crop varieties. Mutation breeding, then, can be seen as a way to induce random genetic mutations in plants instead of waiting for natural mutations to occur. The first plant variety created by mutation breeding was released in 1936 and the use of mutation breeding took off worldwide in the 1960s, including in Europe, Japan, India, and China – areas that have been much more skeptical of GM plants than the United States. To date, over 3,000 varieties of plants across 190 plant species have been created through mutation breeding (Shu, Forster, and Nakagawa 2012).

Although genetic mutations are artificially induced in plants using radiation and chemical mutagens, mutation breeding never received the regulatory scrutiny that genetically modified plants have. In the United States and many other countries, plants derived from mutation breeding are not differentiated from plants derived from conventional breeding. In the United States plants derived from conventional breeding, and as a result mutation breeding, fall outside of regulatory scrutiny. As McHughen and Smyth explain, "the US does not routinely regulate safety of new crop cultivars, relying instead on breeders and developers to exercise due diligence and prudence in their evaluations" (2012, 37). McHughen and Smyth go on to argue that this system has worked remarkably well because so many mutation breeding derived varieties have been made "none of which have had the relevant DNA mutations fully characterized, and none of which have had to be removed from the market for safety reasons" (McHughen and Smyth 2012, 37). Others, however, have argued that this exclusion of all conventionally bred crops from regulatory oversight is questionable since the broad set of plant breeding techniques that are considered conventional can produce crops that have substantial negative environmental impacts (National Research Council 2002, 86).

Since plant TagMo techniques can create desired traits by creating changes in a plant's own DNA, without the insertion of foreign DNA, this optimistic group of interviewees argued that TagMo techniques should be seen as a better, more deliberate, more precise form of mutation breeding. With this understanding, plant TagMo is an improved version of mutation breeding, which itself is a process to speed up naturally occurring mutations. First generation genetic modification is a more risky and less natural plant breeding technique because it relies upon the insertion of DNA from other species to obtain desired traits. Within this line of thought, the long precedent of regulatory acceptance and environmental safety for plants resulting from mutation breeding provides a clear justification for treating TagMo-derived plants as conventional plants.

Interviewees in this category largely viewed the existing environmental regulation for first generation GM plants as being adequate. A few echoed the sentiment that a tiered approach to regulation should be implemented to prevent products from being over-regulated. Interestingly, regulation of first generation GM plants was not as important to their understanding of the desired regulation for plant TagMo products, because they viewed plant TagMo products outside of the lineage of first generation GM plants. As one interviewee from the plant TagMo industry said, "Anything that is similar to products that can be obtained by mutagenesis or tilling, should be considered as a non-regulated article. If the product is similar to what can be obtained by other methods which are non-regulated, I don't see why this product should be [regulated as a GM plant]." In other words, if regulatory agencies have trusted breeders to ensure that only safe products from mutation breeding are released, and if certain applications of plant TagMo are similar to versions of mutation breeding, shouldn't certain regulatory agencies treat products from plant TagMo in a similar way?

2.5.3 Critical environmental regulation future

Interviewees stating a critical future of plant TagMo and its environmental regulation made up the smallest group of interviewees and were affiliated with either academia or a non-governmental organization. We classified these futures as critical because they were based on understanding plant TagMo as a continuation of first generation GM plants, which were seen as both inadequately regulated and causing significant adverse effects. They viewed the existing regulatory paradigm as not adequately independent and not adequately assessing the environmental consequences caused by GM plants. As one natural scientist in academia described,

> "Well, there's not enough testing, there's definitely no independent testing, the testing that is done is really voluntary and done by the same people who stand to profit from the application of these things. The testing that is done is also inadequate, even if it was done properly and independently… there are molecular, ecological, social, economic consequences that are specific to the transgenic manipulation that are really excluded from the testing that happens and the regulations that are in place."

This future stems from the belief that the first generation GM plants provided few benefits while producing many negative environmental effects such as the development of herbicide tolerant weeds, adversely affecting non-target species, and the impacts from the increased application of the herbicide glyphosate used with herbicide tolerant crops. Plant TagMo is seen as not addressing the negative impacts of first generation genetically modified plants and as likely leading to further risks and negative impacts through the creation of new plant traits.

The existing regulatory paradigm was deemed inadequate because of how regulatory agencies operate and what type of testing is completed. As an interviewee affiliated with an NGO explained,

> "They [the USDA] are not properly assessing environmental impacts… And I know in my own interactions with them over the years that it's - my saying is pretty much that they haven't met a genetically engineered plant they wouldn't approve… the agency, the scientists, many that I've talked to, are proponents of genetic engineering. They think it's good, think it's good for U.S. agriculture, and their biases inform their analyses… I pay close attention to risk assessments, the environmental assessments that they do, and I still am amazed that they cannot see where their assurances are not supported by data."

One set of concerns expressed by these interviewees involved the influence of industry on US regulatory decision making. As examples of this, interviewees cited the lack of independent analysis resulting from the acceptance of industry's safety data in regulatory review as well as the conflicting priorities that arise from the USDA's role as both regulator and promoter of US agriculture. The interviewee above argues that the USDA and its employees have such convictions of the safety and benefits of first generation GM plants that it biases the assumptions and interpretations of their analyses. Another set of concerns involved the types of tests completed for environmental safety testing. The lack of long-term and post market safety studies were deemed part of a wider decision not to look for and therefore not to possibly find potential negative impacts from first generation GM plants. An additional example given of this inadequacy was the failure to comprehensively examine how GM plants differ from other plants by, for example, conducting proteomic profiles to examine how a genetically modified plant's entire set of proteins may have changed through the modification process. Interviewees articulating these critical futures felt that the fundamental problems they saw would not be addressed by plant TagMo, and therefore they viewed plant TagMo and first generation GM plants as similar in all consequential ways.

2.6 Discussion

In line with the future studies literature (Tutton 2011; Lopez 2008; Borup et al. 2006), we found that conflict was central to the plant TagMo futures, as demonstrated by differences in the interviewees' desired forms of environmental regulation and in the related understandings and assumptions concerning risk and existing regulation. With regards to environmental regulation for plant TagMo products, futures varied from calling for incremental changes to existing regulations, to calling for significant strengthening of existing regulations, to calling for plant TagMo products not to be regulated as genetically modified plants. We helped reflect upon these futures by analyzing the understandings and assumptions that these perspectives were built on. For example, we examined how diverging understandings of what constitutes environmental risk (captured in how risks associated with plant TagMo would differ from those associated with first generation GM plants) and of the adequacy of existing GM plant regulations aligned with desires for plant TagMo environmental regulation (Table 1). These findings can help focus and refine discussions about the future of plant TagMo environmental regulation because they identify the consequential understandings and assumptions that plant TagMo regulatory futures are built upon.

2.6.1 The regulation of plant TagMo

With the exception of the interviewees articulating optimistic futures – who were all plant TagMo researchers or in a plant TagMo related industry – our interviewees largely believed that all TagMo-derived plants should face no less regulatory scrutiny than first generation GM plants. Recent decisions by US regulatory authorities, however, are not in line with this belief. The United States Department of Agriculture gains its authority for regulating genetically engineered plants from the federal Plant Protection Act (PPA) of 2000 which states that a plant should be regulated as a GMO if recombinant DNA (rDNA) from a listed "plant pest" organism is used in the process of creating the modifications or inserted into a plant to achieve a desired trait, or if the USDA administrator has reason to believe the resulting genetically engineered plant is a plant pest. Most first generation genetic engineering both uses such rDNA in the process of creating GM plants and inserts this rDNA to confer a particular trait (e.g. promoters with viral genes or constructs with bacterial genes). TagMo techniques, however, do not need to do so (Podevin et al. 2012; Kuzma and Kokotovich 2011). Plant TagMo techniques can be used to insert rDNA from a differing species, but they can also be used to create genetic modifications that do not use rDNA and therefore fall outside the existing regulatory definitions within the United States. This may lead to the situation where certain TagMo derived plants will only be regulated by the USDA when the administrator decides the resulting GM plant poses a significant risk.

Since our interviews took place, documents released by the USDA through a Freedom of Information Act request demonstrate that, in at least two instances, the

USDA has in fact excluded TagMo derived plants from regulatory scrutiny because of a lack of reason to believe that they are or were created using plant pests (USDA 2011; Waltz 2012).[4] In the first instance, the company Cibus was told by the USDA in 2004 that their products created by the TagMo technique olionucleotides would not be considered GM plants. Cibus is currently using the technique to create herbicide-tolerant canola. In the second instance, DOW AgroScience created a corn product containing less phytate, an anti-nutritional component of feed grain, using the zinc-finger nuclease TagMo technique. This product was deemed to be non-GM by USDA in 2010. In both examples, products derived from plant TagMo techniques will be allowed onto the market as conventional varieties, without the regulatory review typically given to genetically engineered plants. USDA justified these decisions by saying that the techniques fell outside of their regulatory definitions. In the case of Cibus, USDA called the technique in question a "mutagenesis technique" to explain why it has no authority to regulate the products. Therefore it seems that the USDA is considering certain plant TagMo techniques to be equivalent to mutation breeding. Although we began this project seeking to help proactively begin and advance a conversation about how plant TagMo should be regulated, the regulatory decisions treating plant TagMo as a form of classical mutagenesis began, without transparency, as early as 2004. This lack of openness surrounding regulatory decision making demonstrates how anticipatory governance-based engagements with regulation are impeded by a lack of transparency and a lack of opportunities for stakeholder participation. Without transparency and an opportunity for participation, the assumptions and potential implications of these decisions cannot be

[4] This decision by USDA was revealed after our interviews and was not discussed within our interviews.

exposed to scrutiny, eliminating the potential for an anticipatory governance-based approach.

Our examination of plant TagMo's environmental regulation futures also highlights some of the broader issues surrounding the regulation of crops in the US. To begin, it emphasizes the tensions concerning how to differentiate GM and non-GM plants, and how to regulate the environmental risks of GM and non-GM plants. In the United States regulatory system, whether a product is classified as genetically modified or not has important consequences, as it will, in most cases, determine whether the product comes under expensive regulatory scrutiny. Yet in the era of plant TagMo techniques that can create novel traits without the use or insertion of rDNA, the existing Untied States regulatory definition of what constitutes a GM plant seems arbitrary. If plant products with novel traits of similar significant risk to those created from first generation genetic modification can also be created from mutation breeding or plant TagMo, how can the differing levels of regulatory scrutiny be justified? This point speaks to previously raised concerns about the regulation of conventional plants in the United States (National Research Council 2002). The United States regulatory system provides extra attention to the environmental risk associated with the use of rDNA in the plant modification process, yet, as has been convincingly argued, significant environmental risks can emerge from phenotypic traits resulting from conventional or genetic modification based breeding (National Research Council 2002). Other regulatory systems, as a point of contrast, are structured to address some of these concerns –

Canada's, for example, regulates plants based on whether they contain novel features, no matter the technique used to create them.

If plant TagMo products fall outside of existing regulatory definitions and the USDA administrator's judgment becomes the only way for a plant TagMo product to receive regulatory scrutiny, it is unclear how these judgments would be made or whether they would be made in a transparent and participatory way. The recent example in which regulatory decisions concerning plant TagMo products only became public in response to a FOIA request is not encouraging in this regard. Finally, and building upon the concerns articulated by those interviewees supporting the critical future, one may ask how consequential it is for TagMo derived plants to fall under regulatory scrutiny if the regulatory process is currently inadequate. A more important initial goal would be to address existing inadequacies within GM plant environmental regulation in the United States. We believe that the attention given to whether products from plant TagMo techniques should be regulated as GM should not draw attention away from highlighting and addressing the inadequacies of the existing GM plant environmental regulation (e.g. Jasanoff 2005; Snow et al. 2005; Kuzma, Najmaie, and Larson 2009).

2.6.2 Anticipatory governance and regulation

We conclude by discussing the potential for anticipatory governance and future studies based insights to inform the study of environmental regulation. Such an approach, as we demonstrated here, is based on the notion that how future regulations are discussed and argued for influences existing thought as well as present and future decision making. As a result, it is important to garner and scrutinize these "futures" and the understandings and assumptions that they are built upon. To garner these futures involves reaching out (e.g. through public or stakeholder engagement exercises, focus groups, or interviews) to the diversity of people holding differing views about the regulation in question, not only those holding the most prevalent views. This will help ensure that the breadth of current thought is well represented. Scrutinizing the diversity of ways people imagine these futures can take multiple forms. Certain scrutinizing, or reflection, can be completed through scholarship that systematically analyzes the assumptions and understandings that underlie differing futures. This type of work can be informed by the future studies literature and can help comprehend what understandings and assumptions inform stances on regulation, where conflict exists concerning regulation, and where consequential assumptions reside that should be subject to further societal reflection. Designing engagement exercises where stakeholders and the public can scrutinize the gathered futures and their implications can foster further forms of reflection.

Our findings were put to use during a follow-up stakeholder workshop on plant TagMo oversight that took place in June 2013 (Korslund et al. 2013). Insights from this study helped identify specific questions and tensions that were then further examined and reflected upon by expert-stakeholders at the workshop. By revealing some of the differing assumptions concerning risk and the adequacy of existing regulation found in the plant TagMo environmental regulation futures, this study introduced some foundational, perhaps previously unconsidered, tensions to the workshop participants that they were then able to grapple with. These included, for example: how plant TagMo's increased insertion precision may or may not be seen as decreasing environmental risk depending on how risk is conceived; how plant TagMo is similar to and different from classical mutagenesis, and whether this should influence decisions about regulation; and how unresolved questions about the inadequacies of current genetically modified plant regulation complicate considerations of how to regulate plant TagMo.

Through studying the potential futures of plant TagMo environmental regulation we sought to demonstrate the promise of anticipatory governance principles for engaging with regulation. This work contributes to efforts to expand the use of anticipatory governance and related principles beyond the laboratory (Stilgoe, Owen, and Macnaghten 2013). As Wynne argues, "there are significant actors and conditions in the external context of laboratory science which shape those scientific practices themselves, and the innovations which come from them" (2011, 793). As one of the factors shaping what form innovation takes, regulation will continue to be an important site influencing emerging technologies. And as regulatory systems change to address these novel products, anticipatory governance-based approaches, like the one outlined here, will be vital for ensuring the efficacy and integrity of regulatory decision making.

Chapter 3 – Protecting Wild Rice from Harm: A Collaboration to Reconceive Scientific Research – The Case of Genetic Engineering

3.1 Introduction

Public scientific research has long been subject to deliberation concerning what ends it should work towards and what considerations should inform it (Kevles 1977; Kleinman 1995; Sarewitz 1996). Recent scholarship has crystalized a set of concerns and questions that are well situated to contribute to this continuing deliberation. This scholarship has emerged from a variety of trajectories, but shares a common goal of examining the values-based judgments and assumptions that influence science, risk assessment, and environmental decision making. This work – including literatures regarding anticipatory governance, critiques of risk assessment, and indigenous studies – scrutinizes these assumptions to help inform how they are decided upon. Anticipatory governance builds upon an acknowledgement of the values-based judgments that inform scientific research and technology development and argues that they should be informed by a consideration of their impacts. The literature critiquing risk assessment demonstrates how risk assessment is built upon values-based judgments that need to be questioned and decided upon. And the indigenous studies literature argues that the assumptions built upon in scientific and environmental agencies are often not informed by, or compatible with, indigenous worldviews. I begin by reviewing the three areas of scholarship.

First, scholarship on anticipatory governance (Barben et al. 2008; Sarewitz 2011) and responsible research and innovation (Owen, Macnaghten, and Stilgoe 2012; Stilgoe, Owen, and Macnaghten 2013) has, at its broadest, argued that science should be informed by the consideration of its potential societal impacts. These literatures build upon work that questions the distinction between basic and applied science and the ability of science to be self-governing (Jasanoff 2003). Because science is increasingly tied to technological application and societal influences, it is important to examine factors that influence the direction of science and to engage in deliberation about which potential paths for science and technology are desirable.

The literature on anticipatory governance develops the principles of foresight, engagement, and integration to help direct science and technology towards desirable outcomes and away from undesirable ones (Barben et al. 2008). This work seeks to critique the paradigm of technology governance where the potential environmental, human health, and societal impacts of a technology are not considered by stakeholders, regulators, and other parts of society until a technology is going through regulatory review, long after its research and development process is complete. Such a reactionary paradigm eliminates the potential to substantively impact the technology development process itself through upstream discussions about the potential impacts of a technology. At their most basic the three principles of anticipatory governance can be summarized as:

- Foresight describes the process of developing plausible and evolving scenarios of possible futures that can be the subject of the public deliberation

- Engagement encompasses the suite of activities that stimulates public deliberation
- Integration brings the engagement and foresight activities into the domain of scientific practice in order to enhance reflexiveness (Sarewitz 2011, 103)

The principle of engagement recognizes that people will differ in their judgments of how a technology may develop and impact the world, in addition to differing over which of those potential paths is desirable. Involving a diverse set of participants in well-designed anticipatory exercises can help ensure a broad and adequate set of a technology's potential paths are envisioned and rigorously critiqued. In recent years, this literature has established a substantial focus on governance efforts around emerging technologies such as biotechnology and nanotechnology (Karinen and Guston 2010; Kuzma and Tanji 2010).

The literature from the related area of scholarship known as "responsible research and innovation" shares with anticipatory governance the desire to engage stakeholders in deliberations over the desirability of potential research and innovation and their impacts, and to insert these considerations into design and development processes (Von Schomberg 2012; Van Oudheusden 2014). Two particular ideas that are further developed by scholars working in the area responsible research and innovation, however, are reflexivity and responsiveness (Owen, Macnaghten, and Stilgoe 2012; Stilgoe, Owen, and Macnaghten 2013). First, the argument is that there is a need to reflect upon not only the potential unintended and intended impacts of science and technology, but also on the underlying purposes and motivations associated with a technology. It is important to keep the purview of anticipatory efforts on science and technology open to broader questions such as, “why do it, who might benefit and who might not” (Owen, Macnaghten, and Stilgoe 2012, 754)? Second, there is a need for institutional reflexiveness and responsiveness regarding the anticipatory efforts themselves, ensuring that they are open to change and critique. Stilgoe et al. define reflexivity as “holding a mirror up to one’s own activities, commitments and assumptions, being aware of the limits of knowledge and being mindful that a particular framing of an issue may not be universally held” and argue that institutional efforts to engage in anticipatory governance efforts need to be subject to reflexive scrutiny (2013, 1571). Therefore, there is both a need for anticipatory and participatory efforts to inform science, while at the same time being reflexive concerning the commitments and assumptions utilized and their limitations. Third, building individual and institutional reflexivity around science and innovation can change how scientists view their moral responsibilities. Reflexivity can challenge “assumptions of scientific amorality and agnosticism. Reflexivity asks scientists, in public, to blur the boundary between their role responsibilities [as scientists] and wider, moral responsibilities” (Stilgoe, Owen, and Macnaghten 2013, 1571). As scientists become aware of the implications of their work through formal and informal practices of reflexivity, they may realize that it is both undesirable and impossible to see their responsibilities completely outside of the moral and ethical realm.

A robust literature critiquing practices of risk assessment offers a second avenue into examining the dilemmas of evaluating the potential impacts of scientific research or technology. Scholarship developed in public policy and the social sciences has shown how the assessment of risk is a values-based process dependent upon the judgments utilized within it (Holifield 2009a; Jensen et al. 2003; Kokotovich 2014; Thompson 2003). Authors working in this area argue that there cannot be an objective or values-free way to assess whether a potential technology is likely to cause harm. In the context of environmental risk assessment, judgments such as which risk pathways are examined, the desired state of the environment, and what testing protocol are utilized all influence what form the final characterization of risk will take (Meyer 2011; Kokotovich 2014). To produce empirical knowledge on the potential adverse effects from a particular technology, certain normative judgments and assumptions must be made. And how these judgments are made will delimit how the potential for harm is studied and what information is produced to inform decision making. The bottom line is that efforts to explore the potential impacts of a technology also need to consider issues of public or stakeholder participation when determining how to make the judgments consequential to the assessment of risk for a technology. So there is a need for participatory deliberation on the desired paths for science and its technological applications, as well as on the methods used (e.g. risk assessment) to examine the potential for significant harm from such technology.

The third area of literature supporting the analysis emerges from the field of indigenous studies and has shown how the decision making processes utilized in scientific and environmental agencies and institutions often are founded on worldviews and epistemologies that are not compatible with Native American worldviews and epistemologies (Arquette et al. 2002; Richmond et al. 2013; Smith 2012). Worldview refers to the basic beliefs and assumptions that inform one's understanding of the world and epistemology refers to theories of knowledge including what counts as knowledge (Hassel 2006; Ogawa 1995). This rapidly growing domain of indigenous studies scholarship emphasizes that careful attention must be paid to the worldviews and epistemologies that are privileged within any research affecting indigenous peoples, including the design of anticipatory governance and risk assessment processes (Holifield 2009b). Awareness that anticipatory governance or risk-based paradigms are themselves grounded in specific worldviews and epistemologies becomes problematic when these foundational assumptions are not opened to scrutiny. There is a need, therefore, for scholarship that explores how anticipatory processes for science and technology can be informed by indigenous worldviews and epistemologies not compatible with those normally taken-for-granted in a western science context.

When placed in conversation, these three bodies of scholarship offer insights that inform both public scientific research and the analysis within this paper. First, a clear foundation of research has been built that supports the notion that scientific research should be informed by the consideration of its impacts and implications in an anticipatory, participatory, and reflexive way (Barben et al. 2008; Owen, Macnaghten, and Stilgoe 2012; Stilgoe, Owen, and Macnaghten 2013). Second, once the need for an anticipatory approach to public scientific research is realized, there are challenges posed by the values-laden nature of anticipatory efforts and decision making frameworks like risk assessment (Holifield 2009a; Jensen et al. 2003; Kokotovich 2014). Because efforts to study the potential impacts of a technology or to design an anticipatory process to inform scientific research will always be based upon particular assumptions, how these processes are designed and who is involved in determining such assumptions will influence their outcome. Third, those holding differing worldviews and epistemologies can be marginalized when foundational assumptions within anticipatory and participatory processes used to inform scientific research remain presupposed and not subject to conscious attention and scrutiny (Arquette et al. 2002; Richmond et al. 2013). At the intersection of these literatures lie a host of critical questions and tensions in need of study, including the overarching questions I use to guide this study: 1) how can different worldviews inform anticipatory processes for public scientific research? and 2) how does scientific research need to be understood in order to require consideration of different worldviews?

3.2 Wild rice and the genetic engineering issue

To contribute to this literature, I study a collaboration formed in response to issues concerning wild rice and the potential for its genetic engineering. Wild rice is a plant of great cultural, spiritual and economic importance to the Anishinaabeg (Ojibwe) of North America. Wild rice, known by the scientific name *Zizania palustris* and in the Ojibwe language as *manoomin*, is an aquatic grass that produces an edible grain and grows naturally in lakes and slow moving rivers in Minnesota, other parts of the upper Midwest, and Canada. An annual plant that develops each spring from seeds that fell into the water the previous fall, ecologically, it provides a key source of nourishment and shelter for many fish and wildlife species (Minnesota Department of Natural Resources

2008). Wild rice is an especially sacred plant to the Ojibwe, as demonstrated in the following statement from six of Minnesota's Ojibwe Nations:

> "Manoomin is an inherent part of being Ojibwe. Our lifestyles and cultural identity are intimately bound to manoomin, spiritually, physically, and economically. The importance of manoomin to the Ojibwe people cannot be overstated as it holds a central position in the lives and rich history of the Ojibwe people. It is more than just another grain or crop; it is a cultural resource of indescribable importance. It is a sacred gift from the creator to our people and is used for sustenance, ceremonial and commercial purposes" (Bois Forte Band of Chippewa et al. 2008)

Many Ojibwe see the need to protect wild rice as not only a sacred moral obligation, but as a matter of cultural existence as a People. Accordingly, the right to wild rice on ceded lands outside of reservations was protected in the treaties of 1837, 1854, and 1855 and recently reinforced by the United State Supreme Court (Walker and Doerfler 2009; *Preserving the Integrity of Manoomin in Minnesota* 2011; Minnesota v. Mille Lacs Band of Chippewa Indians 1999). This type of sacredness may be hard to comprehend from a Western context, but a starting point can be thinking in terms of key religious practices and relics.

A major change in the relationship with wild rice came in the late 1960s and 1970s when the first successfully cultivated varieties were developed. This push for cultivation was driven by cultural norms and values including economic development, productivity, efficiency and human control over nature (Oelke 2007). Cultivated varieties of wild rice were produced using conventional breeding techniques that developed traits so that wild rice could be grown in drainable paddies similar to white rice varieties. Cultivated varieties have been developed with a range of traits that allowed for easier, more bountiful harvesting in paddies, such as increased yield, uniform ripening, and disease resistance (Oelke 2007). Efforts to successfully develop cultivated wild rice varieties were initially conducted by small-scale European-American farmers working to grow wild rice as a commodity crop in northern Minnesota. The University of Minnesota became involved after these farmers requested help. The University responded as it had with other commodity crops by conducting research and creating many distinct cultivated wild rice varieties from the 1970s to the 2000s (Oelke 2007).

The impacts of cultivated varieties on the wild rice market were not favorable for Ojibwe hand-harvesters of wild rice. By 1990, large-scale production of cultivated wild rice had reduced natural-stand wild rice harvests to just 10% of the global market supply (Minnesota Department of Natural Resources 2008). Before 1970, Minnesota provided half of the global supply of wild rice and the majority was produced from hand harvested natural stands. Now California, where wild rice does not grow naturally, is the largest producer of wild rice in the country due to its favorable weather for cultivated wild rice (Minnesota Department of Natural Resources 2008). One critical concern is the economic impact this had on wild rice harvested from natural-stands. Whereas an unprocessed pound of wild rice in the 1960s before the rise of cultivated varieties could at times garner upwards of $13 (adjusted for inflation), by 2008 the price per pound was closer to a tenth of that (Minnesota Department of Natural Resources 2008).

In the late 1990s, scientists at the University of Minnesota embarked on a research agenda to map the wild rice genome to aid in its conventional breeding (Kennard et al.

2000; Kennard, Phillips, and Porter 2002). No attempts were made to either inform or consult Tribal Nations or their community members as the mapping work was proposed and implemented. Once the Ojibwe nations learned of the research taking place, the President of Chippewa Tribe (an overarching tribal government for 6 of the 7 Ojibwe Nations in Minnesota) wrote a letter to the President of the University of Minnesota expressing their concern, saying in part:

> "We object to anyone exploiting our treaty wild rice genus for pecuniary gain. The genetic variants of wild rice found naturally occurring on the waters in the territories ceded by the Minnesota Chippewa Tribe to the State of Minnesota are a unique treasure that has been carefully protected by the people of our tribe for centuries. Rights to the rice has been the subject of treaty, and is a resource that enjoys the federal trust protection… We are of the opinion that the wild rice rights assured by treaty accrue not only to individual grains of rice, but to the very essence of the resource. We were not promised just any wild rice; that promise could be kept by delivering sacks of grain to our members each year. We were promised the rice that grew in the waters of our people, and all the value that such rice holds… We are prepared to undertake every legal and lawful measure to protect our interests in this matter. I hope you do not feel we do so merely to stop the progress of our general society. (We are all too aware of the historical outcome for Indians when the general society feels we are in the way of their progress.) I assure you, our interest is only in protecting the few rights and advantages that we have granted at such great costs" (Deschampe 1998).

Although the University of Minnesota researchers involved expressed no desire to pursue a genetically engineered variety of wild rice, the development of a genomic map that could be the basis for pursuing an engineered variety raised a host of concerns about the relationship between the University of Minnesota and the Ojibwe and the potential impacts of a future engineered variety (Laduke and Carlson 2003; Noll 2005; *Preserving the Integrity of Manoomin in Minnesota* 2011). First, as a public land-grant institution, the University of Minnesota arguably has a responsibility to the people of Minnesota, including the Ojibwe, to act for their benefit when conducting research and teaching.[5] After the negative effects of wild rice cultivation and the disregard of the Ojibwe with regards to the genetics based work on wild rice, it was clear the Ojibwe were not fully recognized for either the sacredness of their relationship to the *manoomin* or for their standing as a People with a right to be informed and consulted regarding the University of Minnesota research agenda. Such a stance by University of Minnesota researchers and administration precluded any consideration, inclusion, or respect within research related decision making. There is no evidence that there were any institutional efforts within the University of Minnesota to engage with these issues, and certainly none based on principles consistent with those espoused by the literatures of anticipatory governance, responsible research and innovation, or indigenous studies.

This continued neglect within University of Minnesota decision making from the early days of cultivated wild rice to genome mapping in the late 1990s led to further mistrust between the University of Minnesota and the Ojibwe. The poor quality of this relationship was displayed by the University's lack of response to a request by members of the Ojibwe community for information on the on-going wild rice research (the plant they held as sacred and had treaty rights to). After not responding to the request for multiple years, in 2003 the Dean of the College of Agricultural, Food and Environmental Sciences provided the community members a box of unsorted documents. There were also concerns about the potential impacts on natural wild rice stands from a genetically

[5] As stated in University of Minnesota Board of Regents policy, one part of the University of Minnesota's mission is "To generate and preserve knowledge, understanding, and creativity by conducting high-quality research, scholarship, and artistic activity that benefits students, scholars, and communities across the state, the nation, and the world" (University of Minnesota 2008).

engineered variety. Gene flow between an engineered variety and natural stands could introduce a trait that might be beneficial within the context of cultivated wild rice grown for commodity production, but could be harmful to natural stands. Given the sacredness of the natural stands of wild rice that the Ojibwe have tended and relied upon for centuries, this would be not only unacceptable, but an affront to cultural integrity and survival (*Preserving the Integrity of Manoomin in Minnesota* 2011). Finally, the patenting of an engineered variety would appropriate indigenous knowledge and practices that had successfully cared for natural wild rice stands for centuries.

Within the University of Minnesota a disparity of reactions and perspectives existed regarding how to approach the complex issues surrounding wild rice and the relationship between the University of Minnesota and the Ojibwe of Minnesota. In 2006, a leadership change within the college most centrally involved with the wild rice issues previously described allowed for an ad-hoc committee to coalesce from pre-existing relationships between a few Ojibwe community members and several empathetic faculty and staff employed at the University of Minnesota (for part of this backstory see Clancy and Adamek 2005). This ad-hoc committee gained further institutional support when the new Dean of this college traveled to one of the Ojibwe reservations to meet with and hear the concerns of the Tribal community firsthand. The committee grew to be comprised of Ojibwe elders and community members, University of Minnesota faculty, staff, and students empathetic to Ojibwe perspectives, and non-Ojibwe community members. Over the years the faculty spanned a range of disciplines from the natural sciences to the humanities, including those who had worked with wild rice. From 2011 to 2014, there were approximately one dozen core members of the committee who regularly attended meetings, and closer to 20 people who were involved with the committee at some point. The commonly agreed upon goals guiding the committee include: to protect natural stand wild rice and to improve the relationship between the University of Minnesota and the Ojibwe of Minnesota and the upper Midwest. The committee began work to pursue these goals through a variety of means, including regular meetings to develop relationships and explore potential courses of action for pursuing policy changes at the University of Minnesota.

3.2.1 Underlying historical context: University science and the Ojibwe

Although the wild rice collaborative committee formed in response to the contemporary issues surrounding wild rice and genetic engineering, the importance of the underlying historical context cannot be ignored. Members of the Ojibwe community viewed the issues concerning wild rice and genetic engineering not as an isolated incident, but one more example of a pattern of behavior characterized by arrogance, an inability to understand or appreciate Native worldviews, and negative effects from University activities on Native life (Laduke 2005; Laduke and Carlson 2003). One example of this conflict-laden history was the cultivation of wild rice. The drive to cultivate wild rice was based upon: 1) a perspective that considered wild rice a commodity crop to be improved upon while disregarding the Ojibwe's view that it is a sacred gift from the creator, perfect in its current form, and 2) disregard for the impact of domestication research on Ojibwe natural-stand wild rice harvesters. The arguments for cultivating wild rice also built upon notions that the Ojibwe's use of wild rice was inadequate and that the Ojibwe would not be adequate contributors to the Minnesotan economy until wild rice was exploited as a commodity crop. This notion was captured most directly in a report conducted by the Minnesota Resources Commission for the Minnesota Legislature in 1969. As part of a statement included as the only Appendix to this report, the Iron Range Resources & Rehabilitation Commission argued the following (Edman 1969, vii):

> "There is no doubt that this grain which long was a staple of the Indian diet is being exploited by the white man. To take the attitude of some sociologists and welfare agents that "the rice should be left to the Indian" is to close the eyes to the facts. Once the white man tasted the grain it was no longer left to him – it became a delight of anyone's diet. So the white man will eventually domesticate the grain! To curb the trend by stubborn, lethargic, do-nothingness will be to lose the business to another state with vision and the will to prosper its agricultural community.
>
> If the Indian is to be raised to a level of equality, respectability and become a self-supporting part of the Minnesota economy, it is a criminal neglect to let him waste his heritage and make no effort to better the one natural resource that is uniquely his. The Nett Lake tribe, to take one area as an example, could with proper management of their lands, be a proud asset of the State, totally self-supporting, and devoid of any reason to fear the cultivation of wild rice by their neighbors, whose skins are prone to sunburn!"

Here, the desire to modernize is extended both to the wild rice and to the Ojibwe themselves. In addition, the implied rationale is that the one way the Ojibwe can avoid the negative impacts of treating wild rice as a commodity crop is to cultivate wild rice and treat it as a commodity crop before and more efficiently than those around them. Modernization and commoditization cannot be questioned within this understanding; rather, they must be exploited for one's own gain. Other arguments existed at the time, however, that pointed out the likely negative impacts from the cultivation of wild rice on

Minnesota harvesters of wild rice. The report recounts one such argument made at a hearing in 1967 (Edman 1969, 76):

> "If there is developed a [cultivated] shatter-proof agricultural species of wild rice, I think there is every reason to believe that much of it will be grown in other parts of the nation and other parts of the world… For the Legislature of the State of Minnesota or any agency of the State of Minnesota, to appropriate money to develop a product which would deprive us of almost a monopoly, seems to be a little less than idiotic."

Another important historical context that influenced the relationship between the University of Minnesota and the Ojibwe was the role of Anthropology Professor Albert Jenks during land dispossession in the early 20th century. Albert Jenks was a physical anthropologist and a professor at the University of Minnesota from 1906 to 1938. He founded and served as chair of the University of Minnesota's Anthropology Department for its first twenty years of existence from 1918 until his retirement (Soderstrom 2004). He believed, as was accepted by his discipline at the time, that it was possible to make judgments about race by measuring and observing physical characteristics and by scratching people's skin and hair (Beaulieu 1984). He also believed in a racial hierarchy, arguing that certain races were more primitive, and that physical anthropology could help improve the American race (Soderstrom 2004). As one University of Minnesota newspaper article highlighting his research stated:

> "[His] researches are continued among primitive peoples, mainly for the purpose of getting at human cultural beginnings: never before has the student of present social conditions so appreciated the necessity of starting at the bottom of the ladder of human culture, if he would understand the social life, at any of the higher steps of the ladder… He believes that when the scientific facts of human heredity become common knowledge (such facts as are known of plants and animals) such educated public opinion will gradually impel people toward a rational improvement of the race of man" (*The Minnesota Alumni Weekly* 1909, 4).

Although ideas concerning a racial hierarchy, measurement of physical characteristics to determine race, and the improvement of the American race through eugenics were widely shared throughout his discipline and with many key administrators at the University of Minnesota at the time (Soderstrom 2004), they have since been widely rejected. Yet their "truth" at the time allowed Jenks to use these ideas in the name of University of Minnesota scientific research for ends detrimental to Minnesota's Ojibwe.

Earlier in Minnesota history, in 1889, US Congressman Knute Nelson, a representative from Minnesota and a Regent at the University of Minnesota, secured passage of the "Act for the Relief and Civilization of the Chippewa Indians of Minnesota" or what came to be known as the Nelson Act. In addition to calling for relocation of Minnesota's Ojibwe people to two reservations in western Minnesota and for the elimination of all other reservations, this act called for the allotment of the remaining reservation land to individual Ojibwe and for the selling of excess tribal lands (Beaulieu 1984; Doerfler 2009). As Beaulieu (1984) describes, the intention of this act was to benefit individual settlers and speculators in land and timber, but also to increase the property values of non-Indian lands surrounding reservations and to increase tax revenues through elimination of reservation lands and through improvements to the land by European farmers. The sale of Ojibwe land was heightened by further legislation in 1906 and 1907 that removed restrictions to the sale, incumbrance or taxation of allotments held by "mixed-blood" adults, those having partial European ancestry. Although all of this legislation was created to help further the interests of timber and land speculators, there was massive fraud in deals that were made with “mixed bloods” and with illegal purchases from “full-bloods” and minors. This led to an investigation in 1909 by a special representative of the United States Attorney General and a resulting lawsuit involving 142,000 acres of land (Beaulieu 1984). Those who had purchased the land defended themselves by saying that all the land they bought had been sold by “mixed bloods”.

The initial investigation by the United States Attorney General had difficulty establishing who of the Ojibwe in question were “mixed blood” because the idea of a blood quantum-based notion of race and identity was not used or accepted by many Ojibwe (Doerfler 2009). As a result, in 1915 Professor Jenks and Dr. Ales Hrdlicka, from the Smithsonian Institute, were called in to use their methods to scientifically determine who was “mixed blood” and therefore outside of official concern for how their land was obtained. Jenks was sure that he could definitively identify whether someone had any white blood in them by sampling hair, rubbing skin, and measuring faces, noses, and heads (Beaulieu 1984; Soderstrom 2004). Through his examinations based on the scientific paradigm he was steeped in, he found that over 90% of the people examined were “mixed-blood” and therefore outside of concern for how their land was obtained. The implications of these findings were disastrous for the Ojibwe and beneficial for those who gained from these lands, as highlighted by a University of Minnesota newspaper article:

> “90% of the 300 Indians examined show unmistakable evidence of mixed-blood. The results of the government suits so far tried with aid of anthropological evidence are decidedly favorable to the citizens of Minnesota; if the defendants

> continue to win their cases, farming lands now valued at more than $1,500,000 will, it is conservatively estimated, within ten years increase in value by improvements four hundred percent. They will be worth $6,000,000 and taxable by the state" (*The Minnesota Alumni Weekly* 1916).

As a result, scientific anthropological evidence, since completely discredited, was used by a University of Minnesota professor to contribute to the dispossession of thousands of acres of land from the Ojibwe.

This historical context was foundational to the common understandings that the collaborative committee was seeking to establish. How could one begin to comprehend the Ojibwe's understandings of the University of Minnesota, academic science, and the issues around wild rice and genetic engineering without becoming aware of and acknowledging the Ojibwe's past experiences with the University of Minnesota and its science? Whether the legacies of an anthropologist poking and measuring or a plant breeder seeking to improve through cultivation the use of a plant that was used successfully for centuries was deemed perfect and a gift from the creator – many Ojibwe have experienced University public science as something that is not universally beneficial. Rather, they experience it as a colonizing and disrespectful force based upon racist presuppositions used by authoritative outsiders to: inform people of their "correct" ancestry, justify the dispossession of land, and disrespect a sacred plant in the name of efficiency and progress. This history helps make clear the tensions and histories of conflict that served as the background for the wild rice collaborative committee's actions. It took the committee about three years of meeting 2 to 3 times a year before sufficient trust had been built to plan and organize a large three day cross-cultural symposium held in August 2009 at White Earth Nation, one of the Ojibwe nations and reservations. This 2009 symposium was sufficiently successful that the committee continued to organize symposia that were held in 2011, again at White Earth, and in 2013 at Mille Lacs Reservation.

3.3 Methods: Studying the wild rice collaborative committee

The wild rice collaborative committee, heretofore referred to as the committee, continues to work proactively to protect natural wild rice from genetic engineering and to improve relationships between the University of Minnesota and the Ojibwe. Arguably then, the committee is pursuing an anticipatory process to influence scientific research policy at a public research institution. And given that a key aspect of the process it follows involves acknowledgement and engagement with different worldviews and different understandings of science and harm, the committee's experience can contribute rich insights to the scholarship on scientific research and anticipatory governance.

My engagement with and study of the committee took place in many parts. First, I attended the 2009 symposium organized by the committee as a trainee in the University of Minnesota's National Science Foundation Integrative Graduate Education and Research Traineeship program on Risk Analysis for Introduced Species and Genotypes (IGERT-ISG). Graduate students from this program were invited to participate in the 2009 symposium because of its relevance to the study of risk concerning genetically modified organisms, a theme of the IGERT-ISG program. After that symposium and subsequent conversations with members of the committee, I expressed interest in becoming involved with the committee and in studying the committee as a case study for my dissertation. Over several months in the spring of 2011, I worked with a couple of committee members to determine an appropriate process to join the committee. As part of this process, I attended a committee meeting to share why I wanted to join the committee and how I planned to draw upon my experience to inform my dissertation research. I also obtained a letter of support from one of the tribal governments actively involved with the committee. As further described below, my methodology for studying the committee lasted from 2011 to 2014 and involved participant observation in the committee's meetings, in-depth interviews with committee participants, and document analysis of relevant documents concerning the committee and the history of the issues surrounding wild rice.

As I worked with and observed the committee, I refined and narrowed my research questions based upon what I learned. One benefit of using participant observation to engage with a group over a long period of time is that it allows a researcher to adjust their study's direction as they learn more about the group, helping the researcher formulate sensible questions (Bernard 2013). I had a broad interest in how the committee dealt with different understandings of harm and risk that exist around the wild rice issue. But during my time working with the committee, I became more interested in foundational questions concerning the committee's anticipatory approach to wild rice governance and the reconceived notion of scientific research that informed it. The committee's process of reconceiving scientific research required bringing into the foreground certain questions and concerns. Examining the understanding of scientific research that the committee questioned and the one that emerged through its work was a useful way to explore the committee's specific anticipatory approach to engaging with the issues around wild rice and genetic engineering. This reconceived notion of scientific research emerged from the committee's specific critiques of science and risk and from its particular approach to collaboration. The specific research questions for this paper include: How did the committee reconceive scientific research? What particular understandings of science and risk did it critique and draw upon as it reconceived scientific research?

The methodology I used to complete this study had three components: participant observation as a member of the committee, in-depth interviews with 14 committee members, and a document analysis of relevant materials. First, I completed participant-observation as a member of the wild rice collaborative committee for three years, from 2011 to 2014. During this time I regularly took part in committee meetings and contributed to planning efforts for the symposia in 2011 and 2013. The committee met between 6 and 12 times a year with more frequent meetings surrounding symposia planning. Bernard (2013) cites 5 reasons why participant observation is a particularly valid method for studying groups of people. First, participant observation enables the collection of different kinds of data than interviews or surveys – primarily observed behavior rather than self-reported behavior after the fact. Second, participant observation over a long period reduces reactivity, or the likelihood that people will change their behavior around a researcher. With regards to these two points, participant observation allowed me to witness firsthand, and repeatedly, discussions taking place within the committee. I was able to experience how certain ideas influenced the discussions within the committee and reactions of committee members to discussions over time. Third, because it allows for an extended interaction with a group, participant observation can help formulate sensible questions for inquiry. Through my work with the group I was able to determine the key tensions the committee faced, how to ask about them in formal interviews and informal conversations, and how to look for them within meetings. Fourth, participant observation helps facilitate sound interpretation of observations. For example, the backstories and context that I learned through my work with the committee informed my interpretation of what I experienced and the committee's actions. Finally, participant observation is often the only method well suited to address certain research problems. While participant observation is time-consuming, it yields knowledge captured in real time that cannot be gained through any other method, and any method coming close to allowing the garnering of such knowledge would be even more time consuming and thus prohibitive. In my case, it would have been prohibitively time consuming to try to use personal interviews to keep up with the committee's process, ideas, and outcomes over the course of three years.

I conducted the participant observation as an "overt full member" of the committee (Bryman 2012, 441), as I informed other members of the committee of my research and I participated as a full member of the committee. I was, however, acutely aware of the tensions and limitations within this method such as ensuring anonymity and considering that participant observation research to some extent changes the situation being studied (Platt 2004; Cook 2005). I was mindful of the potential impact of this research itself on the committee when I was choosing my specific research questions. In both research design and my participation on the committee I sought to act in ways that were both beneficial for the committee and for the areas of scholarship I sought to contribute to. By focusing on the overarching process of the committee in my research questions, I was able to better ensure the anonymity of the data I collected and conversations I had. With regard to my actions on the committee, in addition to contributing to the committee through organizational tasks such as a post-symposium survey of participants, I sought to contribute conceptually through verbal comments and feedback on written documents: clarifying when issues or perspectives were not clear, making explicit where sources of conflict or divergence were among committee members, and highlighting points from previous discussions when they were relevant for current discussions. This conceptual work aligned well with my concurrent goal of learning about the committee's functioning and its reconceiving of scientific research. As part of the participant observation I conducted at committee meetings and the symposia in 2011 and 2013, I took notes, paying particular attention to discussions and interactions having to do with research, risk, and science. As part of my analysis and reflection on these experiences I regularly reviewed these notes. I describe the analysis process below.

To complement the participant observation, I also conducted semi-structured interviews and a focused document analysis. I conducted in-depth, semi-structured interviews (Bernard 2013, 189) with 14 of the most active members of the wild rice collaborative committee. These interviews, conducted in the summer of 2011, were broad in scope, and lasted from 2 to 4 hours. Longer interviews were conducted in two sessions. In addition to providing specific insights for my research questions, these interviews served to inform my participant observation. In particular, these interviews helped me learn about the committee's work, key issues, and tensions that existed up until I started participating in 2011. This helped me better understand what I experienced on the committee, especially at first. During the interviews, I asked committee members about: the history of the committee and the issues around wild rice, their experience with the committee, the committee's process, challenges faced by the committee, key actions of the committee, the understandings of harm that exist around the wild rice issue and the impacts of the committee (Appendix C). These interviews were transcribed to aid in my analysis, described below.

Finally, I analyzed documents relevant to the wild rice and genetic engineering issue. Specifically, I obtained literature that provided insights on the following historical periods: 1) Prof. Jenks and the University of Minnesota's role in land dispossession; 2) the context surrounding wild rice cultivation; 3) the reactions to the genomic work on wild rice – both from the University of Minnesota administration and from the Ojibwe tribes; and 4) the committee and its activities and process. I found these documents through previous literature that cited them, discussions with those currently involved with wild rice related issues, internet searchers, and scholarly search engines. These documents, as cited in my results, included previous historical studies, a report published by a state agency, and newspaper articles and editorials. The documents informed both my discussion of the historical context and my analysis of the differing understandings of scientific research that existed around wild rice and genetic engineering.

My analysis of information from these sources supported two goals, one specific to learning about the committee and one specific to my research questions. The first goal was for this information to inform my foundational learning about the committee so that I could better participate with and study the committee. By reflecting upon the data, whether from participant observation, interviews, or documents, I was better able to contextualize and interpret the actions of the committee and their significance. For this end, I analyzed the committee as a whole, including its process, its goals, and the key tensions it dealt with. When I wanted to confirm my emerging understanding of an aspect of the committee or gain further insight on a question that persisted for me, I would seek out members of the committee for further conversations.

The second goal was for this information to help address my research questions. For this end I followed a formal process of analysis that contained two parts. The first part involved analyzing the understandings of science and risk that supported the University of Minnesota administration's position on wild rice research and those that the committee built upon in reconceiving scientific research. I focused on science and risk because these concepts were significant to the positions articulated by the University administration and the committee, and because the meanings provided for these concepts differed greatly. This focus also allowed me to examine the understandings of science and risk that were compatible with the anticipatory approach developed by the committee and those that stood counter to it. I drew upon insights developed by the literature on discourse analysis to inform this examination (Phillips and Jorgensen 2002; Fischer 2003; Hajer and Versteeg 2005). First, discourse, as "a particular way of talking about and understanding the world (or an aspect of the world)," is important to study because our ways of talking "do not neutrally reflect our world, identities and social relations but, rather, play an active role in creating and changing them" (Phillips and Jorgensen 2002, 1). Furthermore, discourses, "by representing reality in one particular way rather than in other possible ways,… make certain types of actions relevant and others unthinkable" (Phillips and Jorgensen 2002, 145). In studying understandings of science and risk, then, I am examined the specific meanings provided to these concepts and their implications. For example, by drawing upon certain understandings of science and risk, the University administration made certain actions towards wild rice research and the Ojibwe in Minnesota possible and other actions inconceivable. The committee, in offering a different set of meanings to science and risk, made possible a different set of actions towards wild rice research and the Ojibwe in Minnesota.

Finally, I identified the instances where science and risk were discussed within the documents I examined and within the interview transcripts. I explored how the understandings of science and risk informed a particular understanding of scientific research that then influenced how the administration and committee sought to address the issues and research surrounding wild rice. This analysis also revealed how the committee worked towards institutional change by challenging particular understandings of scientific research. As Fischer argues,

> “At the micro level of analysis, the focus turns to the relationships between discourse and the specific institutional practices. The goal… is to uncover the ways that discourses embedded in institutional practices function to reproduce the existing power-structure relationships from the bottom up” (Fischer 2003, 89).

I examined if, and how, the understandings of risk, science, and scientific research reinforced by the responses offered in support of the University administration’s position reproduced understandings that excluded the concerns of the Ojibwe from being considered. I also explored if, and how, the understandings reconceived by the committee opened new questions to consideration and supported the anticipatory approaches they developed. In the second component of this analysis, I examined the processes that supported the committee’s anticipatory efforts and its reconceived notion of scientific research. I drew largely upon my participant observation, which involved reviewing my notes and reflecting upon my experiences and observations. In particular, I analyzed the actions that helped foster the particular type of scientific research supported by the committee. As part of the overall analysis process, I reviewed my findings with a key long-time member of the committee that I worked closely with to provide a check on my interpretation.

3.4 Findings: Reconceiving scientific research

By reconsidering and reconceiving notions of scientific research, the committee confronted the institutionalized understanding of scientific research that was the foundation of the University of Minnesota administration’s position on issues concerning wild rice and genetic engineering. After reviewing this institutionalized understanding of scientific research, I explore how the committee reconceived scientific research in a way that contributed to its anticipatory approach. First, I review key aspects of the process used by the committee in developing its anticipatory approach, specifically focusing on its utilization of the conceptual frame "bridging worldviews". Second, I review the understandings of scientific research arrived at by the committee through its process and approach. Finally, I elucidate the distinct ways the committee's anticipatory approach fostered change in relation to scientific research on wild rice at the University of Minnesota.

3.4.1 Institutionalized understanding of scientific research

The institutionalized understanding of scientific research articulated by those within the University of Minnesota concerning wild rice perpetuated the historical tension and conflict with Ojibwe Nations. This understanding of scientific research was articulated by certain members of the University of Minnesota administration and faculty and contributed to the justification of the University's response to issues surrounding the genetic mapping of wild rice. These ideas were made public through documents produced during the late 1990s and early 2000s when the Ojibwe first learned of and responded to the genetic mapping research and the committee was first formed. Core to the University's understanding of scientific research were particular understandings of science and of risk. First, science was seen as creating universally beneficial knowledge in the most defensible fashion possible due to its methodology based on repetition and peer review. Because of this presupposed unbiased and universally beneficial nature, the right to create this knowledge is seen as protected by academic freedom, a values-based construct fundamental to 20th century academic institutions (Menand 1996). The Dean at the time articulated this view in an op-ed piece, defending the University's position on wild rice genetic mapping:

> "In the Ojibwe culture, wild rice is central to the origin stories of the Ojibwe and to traditional rituals, feasts and ceremonies. Wild rice is the sacred gift from the Creator. The Ojibwe know this to be true. They need not question. Alternatively, the culture of Western science is based on questioning. Those who enter fields of science, medicine and engineering are educated, trained, evaluated and rewarded on their ability to successfully pursue the unanswered question. Nothing is accepted without the proverbial "defense" and replication of methods that are published for all to challenge. In addition, the academic culture upholds the right of an individual scientist to pursue his or her interest, as long as that effort is consistent with procedural and ethical guidelines of the university, national accreditation requirements and federal requirements. This 'academic freedom' ensures that the pursuit of knowledge is not hampered or subverted by political, ideological or other special interests" (Muscoplat 2004).

One can see in this statement how science is constructed in such a way so as to subjugate the concerns and viewpoints of the Ojibwe. Implicit in this op-ed column is the value that Western science has a right and/or obligation to study all unanswered questions, except for (and without consideration of) questions about the potential impacts of such research. As long as basic institutional procedural and ethical guidelines are followed, the right to conduct this research subordinates any need to further contemplate how this research will be taken up and used in the world. From the author's perspective, taking impacts beyond basic procedural and ethical guidelines – which do not currently capture within their purview the concerns of the Ojibwe – into consideration would compromise academic freedom. There is no conceptual space in this understanding for consideration of the potential negative impacts of science that the Ojibwe articulate. There is no possibility that scientific integrity could be reconsidered and improved by giving serious consideration to the Ojibwe's relationship to wild rice. Here, such reconsideration of science can only be understood as an act that will hamper and subvert the pursuit of knowledge by "political, ideological or other special interests".

Another pivotal aspect of the understanding of scientific research articulated by the University of Minnesota involved risk. At one level, the understanding that science should exist and progress for its own sake, outside the consideration of its potential impacts (other than basic ethical and procedural guidelines) eliminates the need for the consideration of risk. Science produces knowledge that, due to its method, is presupposed as beneficial to all; issues concerning technology and its impacts are seen as outside of the realm of science. A more explicit understanding of risk that emerges from the University of Minnesota institutional perspective acknowledges that scientific research may indeed have negative impacts, but that any potential risk can be assessed by experts without a need to engage those impacted by or concerned about potential harms. The potential harm to wild rice, with this view, could be examined without reference to how the Ojibwe understand and relate to wild rice. In the context of using the genetic mapping of wild rice to improve cultivated varieties, University of Minnesota President Yudof could assert in his 1998 response to the Chippewa tribes' initial letter:

> "As you are already aware, our researchers are working on ways to improve certain qualities of cultivated varieties of wild rice...the intention is to make the plant more adaptable to agricultural practices common to cultivated wild rice, such as mechanical harvesting techniques. They have assured me that there is virtually no risk to the wild rice stock native to the reservations. Thank you for letting me know of your concern on this issue, and please contact me if you feel that there is not good progress on resolving it" (Yudof as quoted in *Anishinaabeg Today* 2002, 18).

Yudof assumes that he can assert, based on the researchers' assurances, that there is "virtually no risk" from the research being completed. Risk, here, is understood as something that can be assessed objectively by expert scientists doing the genetic research and situated outside of the worldview and values of those who are impacted by it. In addition, "risk to the wild rice stock native to the reservations" is taken as something that adequately encompasses all of the possible concerns of the Ojibwe, or, at a minimum, legal responsibilities of the University. Implicit here is a commonly held institutional presupposition that research not only extends the pursuit of scientific inquiry but carries with it an absolute validity that transcends culture and trumps any need for participation by Ojibwe people.

A more nuanced view concerning the ecological risks from the genetic mapping and its potential impact on cultivated varieties was provided by Professor Ron Phillips, one of the researchers who contributed to mapping work. In discussing the issues around the mapping he states:

> "It depends on what you're willing to accept as a threshold [of risk]… The possibility of a trait coming in from one of the bred varieties that would significantly alter the wild type is probably not very great. But it is possible. So you can't guarantee [that it won't happen]. You can't guarantee that a bird won't pick up a seed and take it 20 miles away. So that's where you have the conflict. . . You've got to agree on some threshold, and in our discussions [with the Anishinaabeg], some people said, 'Well one in a million is too great a risk'" (Phillips in Clancy and Adamek 2005).

This articulation acknowledges some of the values-based judgments inherent in the assessment and management of risk, such as the need to determine what level of risk is acceptable and envision different pathways that could lead to an adverse effect. It also makes apparent how certain values or worldviews can be seen as almost nonsensical when placed within a risk analysis context. The inference of this statement is that not accepting a risk with a probability of one in a million is unreasonable. Yet, because risk is a product of probability and consequence (referred to as exposure and effect in risk analysis), the severity of the consequence in this risk equation needs to be considered and can only be fully understood by involving the Ojibwe. Given that natural stand wild rice is sacred and an essential part of cultural survival for the Ojibwe and given that genetic mapping research was conducted with the aim to create improved cultivated varieties – which do not protect natural stands of wild rice – then it would make sense that even a one in a million chance of harming natural stands of wild rice could be seen as undesirable. Therefore, it is important not to conflate probability with risk and not to ignore the values-based judgments informing considerations of consequence (e.g. What is put at risk? For what reason? Who would benefit from certain actions and who would risk greater harm?).

3.4.2 Reconceiving scientific research: Process & Understandings

In this section I describe key attributes of the process used by the committee to reconceive scientific research. These findings provide important insights on how the committee pursued an anticipatory approach that could attend to differing worldviews. This process helped challenge the understanding of scientific research that the administration built upon. I focus on two attributes of the committee's process: 1) the specific actions that constituted the majority of the committee's work – meetings and symposia, and 2) the core concept that informed these actions – bridging worldviews. After outlining this process I describe how it allowed the committee to arrive at contrasting understandings of science and risk as compared to the institutionalized understanding of the University.

3.4.2.1 Process: Bridging at Committee Meetings

First, the committee meetings were moments for committee members to interact with and learn from one another, set goals for the committee, plan for the symposia events. The meetings that took place before the planning of the first symposia in 2009 involved a small group of initial committee members and primarily focused on establishing common understandings of the issues which then created a platform for shared language from which to build. These meetings involved discussions about the different ways of understanding wild rice and the issues surrounding it, including the historical context described previously (section 2.2), as well as exploration about what the committee could do to improve the situation. After many meetings, over multiple years, the committee wrote a document articulating a shared understanding that was then used to plan the first symposium (Appendix D). This document explained how the committee was formed and set forth the guiding philosophy that interaction and dialog could facilitate learning and change that would help address the issues around wild rice. It described the sacredness and importance of wild rice to the Ojibwe, outlined the conditions that led to the cultivation of wild rice, described the conflicting interpretations of what the wild rice genetic research signifies, and concluded with the charge:

> "Must these diverse worldviews stand in opposition and conflict or can they be bridged by listening and learning, by mutually respectful conversation and discourse? Recent developments at the University of Minnesota indicate a willingness to shift away from a culturally exclusive approach embedded in conflict toward one that embraces this dissonance as a healthy opportunity for understanding and growth. Native American reservation communities and faculty at the University of Minnesota have embarked on a path to build increased cultural understanding and a broader range of scholarship generated by the interactions of opposing worldviews as held by community-based elders and knowledge-holders and agricultural research scientists" (Appendix D).

The initial concept that the committee worked with was "bridging worldviews". This concept allowed the committee to establish and emphasize that there was more than one legitimate way of relating to and studying wild rice. Furthermore, that there was more than one way of understanding what form scientific research should take. The committee was explicit in their desire to shift away from an understanding of wild rice and scientific research they regarded as "culturally exclusive" and toward an approach that would acknowledge and take seriously Ojibwe teachings and worldviews. Thus, the bridging worldviews concept, as used by the committee, implied a commitment toward maintaining scientific integrity while transforming or abandoning the ideal that good scientific practice is "hampered or subverted" by serious consideration of views from the Ojibwe community.

A host of noteworthy implications emerged from the bridging worldviews concept that the committee members worked with in their meetings. First, to better comprehend the Ojibwe's worldview as it relates to wild rice and scientific research, it was necessary for committee members to engage with the complex and conflictual history that the Ojibwe have had with the University of Minnesota, including those surrounding land dispossession and wild rice cultivation. This helped make explicit the historical injustices that inform the current situation and how the interests and worldviews of the Ojibwe had been marginalized over time. As one of the committee members reflected upon,

> "I think commonly shared is this idea that we want to protect the *manoomin*. I also think there's a growing interest and, probably pretty widely shared assumption that we want to protect, to the extent we can, protect the interests of American Indian communities and reservation communities and that the university has not paid attention to the interests of Indian people to the extent that it could have or should have. There's this common understanding of a legacy of the past relationships that is not something that people within the university are necessarily proud of and people beyond the university have had to deal with or put up with. I think there's a common commitment to trying to improve that."

Second, the concept also allowed the committee to facilitate a space for acknowledging the existence of worldview and culture-related background assumptions within the University of Minnesota, and specifically within its agricultural science disciplines. Within a culture of no culture (Traweek 1988) that can be present within scientific research institutions, assumptions can remain subconscious or unacknowledged, and as a result uncontestable. Within the intercultural working context of this committee, assumptions are frequently acknowledged as value-laden and become contestable in terms of how the University approached wild rice and scientific research. By drawing attention to these assumptions and how they differ from an Ojibwe worldview, the committee encouraged questioning of what was at stake in certain conceptions of wild rice and scientific research. In moving past the idea that there is a single way to approach these topics it became possible to contemplate what is at stake in differing assumptions.

Third, in creating the space for exchange and learning, it allowed committee members who came from differing backgrounds and worldviews to learn more about each other and to challenge established stereotypes of each other. For example: the University as a monolithic institution that universally supported viewing wild rice as a commodity; the Ojibwe as anti-science, nature loving luddites; and scientists as amoral, profit seeking, power hungry technocrats. It allowed people to work towards knowing and respecting each other, instead of seeing only nameless threats to their wellbeing. It also helped all involved learn about the complexities and tensions existing on many sides of this issue. Fourth, the framework of bridging worldviews placed the emphasis on achieving change by establishing long lasting relationships between individuals based on common understanding instead of acting only from temporarily aligning self-interest. This particular approach was seen as a way to help address the problems that had emerged from the lack of trust and understanding that had characterized past interactions between the University and the Ojibwe communities. As explained by one committee member,

> "Well it wasn't in the interest of the tribal side of it to get it done quickly, to be task driven and to be oriented along those lines. It was: why should we trust you? We can accomplish this task together today, sure… But what happens when next week things shift for whatever reason and the university administration doesn't like what you're doing and we don't have a relationship? You're just as likely to shift on a dime again because we're focused on tasks. And what the tribe wanted to see was a real commitment, so in other words to build a trusting and working relationship based on authentic mutual shared understanding. And that was going to be more important than a task-based focus for early committee effort."

So although the committee certainly worked on tasks, such as those involved with organizing the symposia, there was also a widely supported acknowledgement of the importance of building trust and relationships.

3.4.2.2 Process: Bridging at Symposia

The symposia represented a way for the committee to further their goals of establishing communication and bridging across the larger University and Ojibwe communities. These three day events served as a larger macrocosm for the processes the committee was working through. The symposium in 2009 focused on protecting natural wild rice and bridging worldviews. The symposium in 2011 added the theme of water, or *nibi* in Ojibwe, in addition to wild rice and bridging worldviews. The symposium in 2013 shifted to "building lasting relationships" as an additional focus and sought to establish working groups that could carry on the priorities and strategies identified in the first two symposia. People from both the University of Minnesota and from all of Minnesota's Ojibwe communities were invited to the symposia, which were planned by the collaborative committee. Speakers included both scientists and representatives from the University of Minnesota and academia more broadly as well as Ojibwe community members and elders. Further descriptions and outcomes from these symposia can be found online[6], but with regards to the committee's reconceiving of scientific research a few parts stand out from the first two symposia that emphasized bridging.

[6] The following website contains the documents from all three symposia. The concept note created before the first symposium is not included on this website, so it is included as Appendix D. https://www.cfans.umn.edu/wildrice

First, there was a conscious effort to emphasize both speakers informed by Western scientific worldviews and those informed by indigenous worldviews. Ojibwe elders, tribal community members intricately involved with ricing and managing stands of wild rice, scientists from the University of Minnesota, and other scientists from the western science tradition all spoke about wild rice. They raised the questions they thought were important to consider and, implicitly or explicitly, highlighted the ways of knowing and ways of relating that they used for engaging with wild rice. Given that the Ojibwe worldview and histories have been largely marginalized with respect to wild rice and within the University, the committee privileged them within the symposium. Many Ojibwe speakers helped articulate the importance of wild rice to the Ojibwe and the limitations of the dominant worldview and Western scientific approach. Scientists informed from a Western scientific background discussed their research exploring different aspects of wild rice and issues concerning plants and the impacts from genetic engineering. This served as an opportunity for the attendees from Minnesota's Ojibwe tribes to learn about and reflect on the issues and scientific research concerning wild rice. By exposing symposium attendees to different worldviews and the questions and approaches that emerge in each, the committee explicitly built the tension of differing worldviews into the symposium. As a result, the attendees were able to see and grapple with what was at stake with differing worldviews and their related assumptions.

Yet even as the differences between the two worldviews became apparent, so did the diversity within the two worldviews. This further complexity helped make the existence and implications of differing assumptions more apparent. Symposium participants were faced with needing to understand and contemplate the differences between not two neatly defined and contained worldviews, but between distinct worldviews and assumptions with nuanced differences within them. Scientists informed by the Western science tradition came from different disciplines, examined different research questions, and related differently to wild rice, their role as an expert, and their research. For example, one Western science trained presenter from the first symposium who was particularly well received by attendees spoke as a concerned individual who was open to learning, appreciative of the teachings that had been shared by the Ojibwe elders throughout the symposium, interested in protecting wild rice, and able to share knowledge that may be useful to efforts to protect wild rice. This was very different from speaking as a disinterested expert attending the symposium to educate the audience with authoritative knowledge.

Second, for one entire afternoon and evening of the 2009 and 2011 symposia, attendees were invited to attend a traditional wild rice camp. The wild rice camp provided an opportunity for bridging by allowing those unfamiliar to better understand wild rice and the Ojibwe's relationship to it. This included a chance to learn about and experience how wild rice is gathered and processed. For example, during the 2009 symposium attendees were provided an opportunity to gather wild rice in a canoe and see rice in the different stages of processing – drying, parching, hulling, and winnowing. Members of the Ojibwe community also shared traditional stories and their experience with ricing. These teachings and the invitation to the camp were offered by members of the Ojibwe community who were willing to share these experiences with symposium attendees, including members of the University community, in the spirit of bridging, protecting wild rice, and fostering improved relationships. The rice camp was an opportunity for experiential learning that had the potential to foster bridging and understanding in ways different from listening to speakers in a conference center. Especially for the participants who had not previously experienced a wild rice camp, these activities provided another way to comprehend just how different wild rice is from other commodity crops for the Ojibwe.

Third, the symposia also included many hours for small group talking circles – opportunities for further discussion, sharing, learning, and bridging that generally took place after the formal presentations. As the program from the 2011 symposium explains,

> "The traditional "talking circle" is a very old Native way of bringing people of all ages together in a quiet, respectful manner for the purpose of teaching, listening, learning, and sharing. The talking circle is a traditional way for Native American people to solve problems. It is a very effective way to remove barriers and to allow people to express themselves with complete freedom."

Each circle contained approximately 6 to 8 people, had a facilitator, passed a bundle of wild rice to indicate whose turn it was to speak, and followed five simple guidelines: only one person speaks at a time, introduce yourself during the first round, speak from the heart, listen with respect, and what is said in the circle stays in the circle. Although participants could speak on any topic that was real for them, a guiding prompt for each circle was provided based on the symposium themes, such as: "How do you feel about the collaboration between the University of Minnesota and the Tribal Nations on manoomin?" These talking circles provided an opportunity for attendees to become individually involved with other symposium participants coming from a different background than their own. In personal conversations and in a post symposium survey that was conducted after the 2011 symposium, many symposium attendees spoke highly of these talking circles and cited them as a place where bridging took place. One member of the organizing committee explained the transformation possible through these encounters, "I come as a person with some understandings and expertise in my way of knowing the world but I need to learn here as much as you need to learn from me and I have to be open to being transformed in that." So the talking circles offered an interpersonal opportunity for bridging in addition to those that emerged from the formal presentations and the wild rice camps. Overall, these differing moments for bridging at the symposium – formal presentations, wild rice camp, and talking circles – provided opportunities for attendees to reflect upon their own assumptions and grapple with the implications of differing worldviews and related assumptions for the issues around wild rice.

3.4.2.3 Understanding of scientific research from committee

As I observed the collaborative committee, I found the processes utilized and the ideas built upon could be seen as supporting a reconceived understanding of scientific research. This understanding supports participatory and anticipatory principles and questions the institutional understanding put forth by those supporting the University administration's position, as described in section 4.1. This understanding was not formally articulated by the members of the committee itself, it emerges from my own interpretation of the committee. The first part of this understanding is that scientific research is not universally beneficial and is based upon particular values-based assumptions. Such assumptions can be exposed to scrutiny; therefore scientific research can take different forms based upon which assumptions inform it. In addition, academic freedom does not remove the responsibility individuals and institutions have to consider the impacts of their work. With regards to wild rice this means that it cannot be assumed that all scientific research taking place on wild rice will be of a beneficial nature. Once this is acknowledged, it becomes necessary to explore what potential paths for science are most and least desirable.

To explore what paths for science are desirable, the second part of the understanding becomes necessary: the impacts of science and its products can only be understood by engaging with those who are impacted by and have a close relationship with the topic in question. Part of this involves considering impacts from the worldviews of those impacted, not assuming a similar set of assumptions or values. As part of this, it is necessary to consider the history that shaped the present moment, once again from the perspective of those impacted. So, inherent to scientific research is a commitment to consider the impacts of such research, which needs to involve engagement with those who will be impacted by it. Of special importance, in this regard, is engaging with peoples who hold an extraordinary relationship to the topic at hand. With regards to wild rice, this means that Ojibwe nations, due to their treaty protections and sacred connection to wild rice, would be critical to engage when determining the direction of research.

3.4.3 Reconceiving scientific research: Pathways to change

Another arena for the committee's approach to bridging and reconceiving scientific research can be seen in their work to influence scientific research at the University of Minnesota. The major strategies pursued were articulated in a white paper that was presented on behalf of Minnesota's Ojibwe tribal nations to the University of Minnesota at the start of the second symposium (*Preserving the Integrity of Manoomin in Minnesota* 2011). Pursuing these strategies has been a key part of the committee's work since the second symposium in 2011. These strategies work from the status quo at the University of Minnesota and suggest pathways for change based on the process and understanding of scientific research supported by the committee. The strategies were placed under three topics: respect, reciprocity, and policy and regulation.

First, under respect were a host of desired changes at the University concerning transparency and communication. Without knowledge of what research being conducted at the University, tribal communities cannot respond to it and cannot begin to influence it. Therefore transparency and communication in the form of annual disclosures, a website for reporting, and the symposia were identified as key needs. Second, reciprocity involved creating opportunities for collaboration around research. This first part of this collaboration involves a way for Ojibwe nations to determine which research is undesirable and a mechanism for them to be able to prevent research that is objectionable. The second part of collaboration involves creating opportunities for collaboration around research deemed desirable by Ojibwe nations. This involves pursuing a formal process for engaging with tribal communities as well as identifying funding for collaborative research between researchers at the University of Minnesota and tribal colleges. Once scientific research is opened to considering its potential impacts, both desirable and undesirable, then there is a natural need to determine opportunities to pursue one and prevent the other. The third strategy involved changing research policy through a formal memorandum of understanding between key organizational units at the University of Minnesota and tribal nations. The white paper makes the following request to the University of Minnesota (*Preserving the Integrity of Manoomin in Minnesota* 2011, 10):

> "We request the University of Minnesota acknowledge and agree that:
> 1. Anishinaabe nations have the authority to prohibit scientific research about wild rice within their treaty territories. All wild rice research proposed to take place on Tribal lands and ceded territories must be approved by the Anishinaabe nation(s) before it can begin.
> 2. Genetic engineering of wild rice shall be prohibited."

The genetic engineering of wild rice is widely agreed upon by the Ojibwe to be undesirable, so in addition to having the ability to prohibit future research on a case by case basis, there is also a desire to pass a formal agreement to prohibit wild rice genetic engineering. Such a memorandum of understanding on the prohibiting genetic engineering has had a harder time gaining traction within the University than the first two strategies. One major reason for this is that the University administration is unwilling to agree to permanent formal policy changes that may be seen as setting a precedent for prohibiting research based on the views of a particular group. If they were to restrict research in this case, they feel they would be more susceptible to being forced to restrict research because of the views of other interest groups. Yet, as many member of the committee pointed out during the interviews, the Ojibwe are not just another interest group as they are a sovereign nation with treaty rights. This sets them distinctly apart from other interest groups.

A final, less formal strategy that integrates respect, reciprocity, and policy involves changing how individual researchers and administrators think about wild rice and the relationship between the University of Minnesota and the Ojibwe. This bridging work helps make explicit how the desired forms of scientific research and the understandings of harm surrounding wild rice differ based upon the assumptions (including those based on worldviews) that inform them. Furthermore, this work makes explicit that the relationship the Ojibwe have to wild rice is not compatible with treating wild rice as a commodity crop. For those who have chosen to take part in the committee's work or in the symposia, it becomes clear that certain scientific research is harmful to and undesired by members of the Ojibwe community. Since there are so few University of Minnesota researchers working on this plant, influencing them individually can be an effective way to change research policy from the ground up at the University of Minnesota. One of the only researchers at the University of Minnesota who has worked on wild rice and genetics was invited to become involved with the committee and accepted. Although even before participating with the committee this researcher agreed with the widespread sentiment that there is no current need or desire for a genetically engineered variety of wild rice, this researcher's involvement with the committee has increased the transparency around wild rice research. It has also helped advance research directions based on genetics-based work that are more desirable to Ojibwe communities such as understanding the genetic diversity of natural wild rice stands and why some are in decline.

3.5 Discussion

How does scientific research need to be understood in order to require consideration of different worldviews? And therefore, in relation to governance, how can different worldviews inform anticipatory processes for public scientific research? I discuss how this study informs these questions in three parts. First I review the implications of the differences between the two understandings of scientific research. Second, I discuss the specific anticipatory approach fostered by the committee and the insights that emerge from it for the anticipatory governance and responsible research and innovation literatures. Finally, I review some of challenges faced by the collaborative committee and the tensions they point to.

There are foundational assumptions that differ between the two understandings of scientific research I examined. The assumptions informing the institutionalized understanding of scientific research are incompatible with the approach fostered by the collaborative committee. For example, if there is only one expert-derived, objectively correct way to conduct scientific research and assess the potential for harm then there is no reason to request input from communities, stakeholders, or other non-experts. This is reinforced by the idea that the potential negative impacts of scientific research are sufficiently avoided by basic ethical guidelines and government regulations. If scientific research and risk assessment are not built upon contestable assumptions, then trying to question the assumptions informing scientific research and risk assessment can only ever be seen as detracting from their integrity. If there are values-based assumptions present within scientific research and processes to assess the potential for harm like risk assessment, then it becomes necessary for the integrity of scientific research and risk assessment to consider the impacts of such assumptions. In this way, the question of examining the implications and desirability of these assumptions cannot be raised when the institutionalized understanding of scientific research is imposed on the wild rice issue. Part of the work of the committee, therefore, can be seen as helping open up science and technology governance to broader deliberation, a necessary requirement from the view that science is built on values-based assumptions (Stirling 2008). The committee challenged an understanding of scientific research that marginalized the consideration of worldview and assumptions and replaced it with an understanding that made such considerations essential. It therefore challenged an Enlightenment notion of science, replacing it with one that emphasized the values-based assumptions in scientific research (Sarewitz 1996; Jasanoff 2003; Barben et al. 2008; Owen, Macnaghten, and Stilgoe 2012).

These values-based assumptions within scientific research and risk assessment in the wild rice case lead to the emphasis of key questions such as: For what ends is this research being completed? Who is likely to benefit? Who is likely to be harmed or put at risk? What is the desired state of the environment being worked towards? What understandings of harm should be examined? How should the relationship between humans and the natural world be envisioned? And since these questions are likely to be answered differently based one's worldview, values and life history, it is important to gather such reflections from the people who will be impacted by such scientific research and risk assessment. It is especially important to consider the assumptions that fall outside of the established societal norms because they will be excluded if the status quo goes unquestioned (Harris and Harper 2011; Holifield 2012). In the case of wild rice, it is clear that this necessitates engaging with the Ojibwe who hold wild rice to be sacred and who have watched after wild rice for centuries. And once the diversity of assumptions are gathered and reflected upon then one can consider what is at stake if one set of assumptions is privileged over another. Reflecting upon the implications of certain assumptions can help contribute to better scientific research and risk assessment as, for example, Arquette argues in the case of risk assessment for toxic substances in Native American communities (2002). Yet as long as the default institutional view that claims to question everything does not question the ends that scientific research is working towards, academic and publically funded research will continue to produce intended and unintended negative impacts for native communities and others whose interests and concerns fall outside the scope of institutional ethical guidelines and regulations. The committee's work, then, can be seen as supporting Smith's argument that the knowledge production taking place at public research institutions needs to be decolonized (2012).

In addition to working to establish an anticipatory approach for wild rice research, the committee's process revealed many insights for the anticipatory governance and responsible research and innovation literatures. A key concern for these literatures is how to pursue an anticipatory approach that is informed by different worldviews, or different assumptions concerning the desired state of scientific research and technology (Stilgoe, Owen, and Macnaghten 2013). The findings from this study of the wild rice collaborative committee provide an example of how a non-privileged worldview can inform an anticipatory approach to influence scientific research at a public research institution. The committee's approach had a couple noteworthy steps. First, it supported a conceptual framework of "bridging worldviews" that made explicit the worldview-based assumptions within scientific research. It acknowledged that compared to university scientists a community holding a marginalized worldview could legitimately embrace different understandings of the desired process for and ends of scientific research. Bridging work was explicitly incorporated into committee meetings as well as into organized symposia. The committee's approach recognized the potential that learning about different worldviews has for helping people critically examine their own worldview. The design of the symposia and the committee process emphasized an explicit, yet productive and respectful, engagement with the tensions that form across different worldviews. Second, the approach followed by the committee was not a top-down anticipatory process initiated by the institution to inform its decision making. Rather, it was a bottom-up, less formal process that focused on the involvement of willing participants in bridging work and the propagation of certain understandings of scientific research and wild rice. This fact allowed the committee to move at a pace that it set, and allowed it to emphasize relationships and mutual understanding.

Despite the insights gained, the committee faces a variety of challenges. First, changing the University's official position and actions was and continues to be a slow process, whether the focus is transparent reporting of research activities or pursuing a memorandum of understanding on wild rice research. Even when the University administration supported the symposia with significant funding, there was little further support for moving quickly to accomplish other desired goals. Second, the committee faces the challenge of gathering support for protecting natural stands of wild rice from genetic engineering by influencing the University of Minnesota, while facing the realities of industry funded scientific research and technology development. Even as the committee seeks to influence university research policy, there are many institutions outside of the university who could conduct research to develop an engineered variety. Even if current University of Minnesota researchers do not pursue a genetically engineered wild rice variety, there was no way to insure that large agricultural biotechnology companies could not take the existing publically available research on wild rice genetics and pursue an engineered variety, if it ever became profitable to do so. Therefore, it is important for the committee to realistically state its potential ability to influence research policy as well as the limits given the current research environment. At the same time, however, by spreading the idea that certain types of research on wild rice are undesirable and not responsible research, the committee could indirectly help establish norms about what type of research is desirable. If it became well accepted that research on this sacred plant is undesirable, then perhaps companies would be less likely to pursue such research if only to avoid the negative public relations issues.

3.6 Conclusion

This study examined the issues concerning wild rice and genetic engineering and the collaborative committee that formed to help address these issues. This committee challenged the institutional understanding of scientific research that was used to justify the initial reaction by the University of Minnesota to the issues concerning wild rice and genetic engineering. By making visible the assumptions that are built upon in conducting scientific research and by showing the necessity of a participatory approach to deciding upon such assumptions, this committee fostered an anticipatory approach to address the issues around wild rice and genetics research. Key to the committee's approach was exploring how differing worldviews led to divergent views about the significance of wild rice and how and to what ends it should be researched.

Although this case was specific to a collaborative effort taking place at the University of Minnesota concerning wild rice, lessons from it are broadly applicable elsewhere. First, it speaks to the importance of challenging objectivist notions of scientific research that negate the constitutive role of assumptions and worldview. Without challenging the understanding of scientific research that erases assumptions and impacts from consideration, it is hard to foster a process for reflecting upon such assumptions and impacts. Second, once it is realized that scientific research can take differing forms with differing impacts based upon the assumptions and decisions that inform it, it becomes possible to highlight and reflect upon these assumptions and how they should be arrived at. Furthermore, it becomes possible to see how certain paths for scientific research and how certain ways of assessing the potential for harm may be at odds with particular communities, worldviews, or values. Given the importance of scientific research and risk assessment in decision making surrounding technology and the environment, the potential significance of this type of work is apparent. Consequential assumptions are being made, many of them unacknowledged, and it is through identifying them and calling attention to their implications that they can be improved upon. As we look at the major decisions based on assessments of environmental impacts and investments in scientific research, from invasive species and emerging technologies to fracking and mining, it behooves us to open the processes to scrutiny to ensure that the assumptions being built upon are just and in the interest of those communities who will be impacted by them. Finally, given the declining role of publically funded research in the United States, there is an imperative to ensure that the research that is publically funded is conducted in a broadly ethical and inclusive nature. This involves considering the impacts of research and the assumptions that lead to them and how they could be otherwise.

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Appendices

Appendix A: GMO ERA interview guide

Introduction

1. What are the ways that you been involved with genetically modified crop ecological risk assessment?
    a) *Follow-up: ERA framework, transgenic crop risk science, etc.*

As I said in my initial email to you, I'm interested in the important disagreements or controversies concerning GM crop ecological risk assessment.

2. What are some of the disagreements or controversies in your field concerning the study of the potential environmental impacts of GM crops?
    a) E.g.: Competing ideas of direct & indirect effects (including whether natural enemies are impacted through direct toxicity or prey-quality), proper ways to study non-target impacts.
    b) Controversies, differences of opinion or areas of disagreement

3. Which of these disagreements or controversies have you been part of?
    a) How have you been involved?

I'm interested in these disagreements. I'd like to talk about them in more detail now.

4. Could you describe your understanding of the disagreement, including who was involved, the sides that were established, how it began, and the specific points of contention?
    a) How far back does it go?
    b) Is it scientific? Political? Both?

5. What do you believe to be the differing underlying assumptions concerning ecological risk assessment that influenced this disagreement?
    a) What are the differing understandings of harm influencing the disagreement?
    b) How do others think differently from you?

6. What is at stake in this disagreement?
    a) Why is it important?
    b) What are the potential implications?
    c) What might happen if another way of thinking about ____ were to prevail?

7. How should this disagreement be addressed (or how was it addressed?)
    a) Will they be worked out internally through standard scientific paradigm processes?
    b) Who should be involved? Should stakeholders be involved?

I'd like to return to a couple of broader questions now.

8. What is your overarching objective in your work, what do you strive to achieve, or what do you hope to accomplish?
    a) Who are you responsible to?

9. How do you think GMOs have impacted the world to this point?
    a) Environmentally, socially

10. Who else do you think I should interview to learn more about these issues?

Appendix B: Plant TagMo interview guide

1. What has been your experience with genetically modified organisms? And specifically plant targeted genetic modification?

2. What do you believe are the major differences between targeted genetic modification and standard genetic modification techniques?
    - Where is the line between the two?
    - Probe: technically & environmentally as well as socially, (politically, ethically, legally)?

3. How do you believe the world would change if the targeted genetic modification of plants was technically successful and widely adopted?
    - How would these impacts be distributed? Effects on industry, environment, farmers, society? [Could you elaborate a bit and discuss how these impacts would be distributed…]

3b) How do you feel the world changed with the adoption of genetically modified plants?
    - How have these impacts been distributed? Effects on industry, environment, farmers, society?

4. What concerns do you have surrounding targeted genetic modification?
    - PROBE: Technically, environmentally and socially
    - PROBE (when relevant to interviewee): Intellectual property rights picture

4b) How do they compare to the concerns you have surrounding GMOs?
    - [or, if needing further prompts: What possible risks you are concerned about?]
    - What should be done to address these concerns?
    - Probe: How are these concerns similar/different?

5. What do you find most fascinating about the field of targeted genetic modification of plants? What do you find most fascinating about genetically modified organisms?

6. How would you describe the relationship between public (e.g. academia) and private (e.g. industry) in the TagMo (or GMO) field?
    - What do you believe are some of the effects (both positive and negative) of the current relationship between public and private in the TagMo field?
    - What form should the relationship between public and private take?
    - **IPR** issues
    - (How does this compare to other areas you have studied?)

7. Are the current federal regulations for genetically modified organisms adequate for products resulting from the targeted genetic modification of plants?
    - Are they adequate for GMOs?

- In what ways should they be changed?
- Should **participatory processes** be further utilized within the oversight and development of targeted genetic modification (or GMOs)?
- What are your thoughts or concerns over **international governance issues**?
- What are your key concerns surrounding the regulation of plants resulting from targeted genetic modification?

8. In what ways may targeted genetic modification be less controversial than the first generation of genetically modified organisms? In what ways may targeted genetic modification be more controversial than the first generation of GMOs?

9. What additional opportunities do you see for TagMo (and/or GM plants)?
    - What conditions are necessary to achieve them?

10. What additional concerns do you have surrounding GM plants?
    - How can such concerns be addressed?

11. Do you have any other concerns, comments or issues that we haven't raised that you feel are important?

12. What is your **affiliation** (e.g. academia, NGO, government) and your **area of expertise** (e.g. ecological scientist, biotechnology scientist, social scientist, policy analyst).

Appendix C: Wild rice collaborative committee interview guide

Introduction

1. Could we begin by having you describe how you have been involved with wild rice?

Wild rice committee

2. How did you become involved with the wild rice committee? What were you hoping to accomplish by becoming involved?

Wild rice history

3. Please share with me your understanding of the committee's history(origin, events actors)

4. What conceptual framework (way of thinking about problems, goals and means) has it been working with?
   a) What did this conceptual framework allow the group to do well? Limitations?
   b) What common assumptions do people on the committee share?
   c) How does bridging take place? What is understanding?
5. With regards to the first symposium, what worked well and what didn't work well?

Some broader questions about the committee

6. What are some of the challenges that the committee runs up against? Concerns?
7. What actions by particular committee members are most helpful to the group?
8. What has surprised you most about the committee?
9. In your opinion, what affect has this collaboration had? Accomplishments? Implications?

Wild rice strategy

The wild rice white paper suggests many different actions to achieve its goals, such as communication opportunities (e.g. symposium), research collaboration opportunities (e.g. research protocol, involving tribal communities), and legal & policy options (e.g. U of MN MOU, state law);

10. Which of these do you support most?
11. U of Minnesota policy around wild rice
    a) Ban the creation of GM wild rice products by U of MN researchers?
    b) Ban U of MN genetic research that could help lead to GM wild rice products?
    c) Ban all genetic research on wild rice by University of Minnesota researcher
12. Should the growing of genetically modified wild rice be banned in Minnesota? In the US? Why?

Personal understanding of issues around wild rice & genetic engineering

Better understand the issues around WR and how different understandings come together in com

13. Could you please describe to me your understanding of the conflicts around wild rice and genetic engineering?
    a) E.g. Key actors, interests, etc.
    b) What do you see as the differences that underlie the issue?
    c) How do you think these issues could be addressed?
14. What are the biggest points of misunderstanding?

15. What are your own concerns surrounding wild rice and genetic engineering?

16. What would just outcome look like with regards to the WR and GE issue?

17. What knowledge is needed to help address these issues?

18. How has your thinking change through your involvement with the committee?
    - How has what you are trying to accomplish changed in your involvement?

Broader issues

1. One of the first things that interested me about the conflicts surrounding wild rice and genetic engineering, was the different understandings of harm that existed. Understandings of harm rely upon a desired state of the world, which could be detrimentally affected, knowledge to understand when harm is taking place or when there is potential for it, and a means for addressing the experienced or possible harm.
    a) Do you believe differing understandings of what constitutes harm (or not) underlie the conflicts around wild rice?
        - What are some of the differing conceptions of harm?
        - How are they navigated within the committee?

2. The University of Minnesota and the question of knowledge production have been important to this issue.
    a) How do you see the University of Minnesota's involvement with the issue?
        - What do you mean by the University of Minnesota?
        - Why do you think the University of Minnesota (administration) is now interested in collaborating on this issue?

3. Another set of concerns surrounding wild rice involves questions of Native American sovereignty.
    a) What is at stake in the wild rice issue for Native American sovereignty?
    b) What is at stake in this collaborative effort for Native American sovereignty?

4. What are the similarities and differences between the wild rice and genetic engineering issues and the sulfate and water issues?

5. What would you like me to look at in these interviews, what would you be interested in knowing about the committee?

Appendix D: Concept note from wild rice collaborative committee

People Protecting Manoomin: Manoomin Protecting People

A Symposium Bridging Opposing Worldviews

Context

To the Anishinaabeg (Ojibway), wild rice (manoomin) is a sacred gift from the creator. It was foretold in their prophecies that they would reach their homeland where food grows upon the water. In this sense, the Anishinaabe exist today as living prophecy fulfilled, and the survival of their people is intimately tied to that of the manoomin itself as found in its natural habitats. Anishinaabe lifestyles and cultural identity are intimately bound to the manoomin spiritually, physically and economically. The wild rice in lakes and rivers has been harvested, sustained, cared for and traditionally processed by many generations of indigenous ricers with extensive knowledge of the plant.

About 40 years ago, farmers of European descent approached the University of Minnesota to assist them in developing wild rice as a cultivated crop to be grown in irrigated paddies. University scientists responded in the tradition of land-grant university researchers and began a process to domesticate wild rice. In a short while, researchers had produced varieties that could be cultivated and developed a system of paddy production for these varieties as well. This work resulted in an increase in production and supply of wild rice in the US, and California now is the leading producer of commercial wild rice. Recently, in continued pursuit of agricultural research and development, researchers have begun to map the wild rice genome with the goal of developing genetic markers that will allow selection and development of preferred genotypes.

For the Anishinaabe, manoomin is complete in its natural state, a sacred gift essential to their cultural survival and increasingly threatened by the work of agricultural scientists. University researchers see themselves as fulfilling their public mission of advancing knowledge and creating economic opportunity for the public at large. Does this trajectory of research - domestication, hybridization and genomic mapping - endanger the existence of manoomin in its natural form? Will this lead to the development of transgenic wild rice? What are the risks to the sustainability of manoomin in the lakes and rivers of the region? Does this university research and extension work represent a public obligation, a right of academic freedom, or an inappropriate and disrespectful continuation of over 500 years of destruction and desecration of Anishinaabe culture and identity? These questions span many difficult issues: cultural, scientific, political and legal.

Must these diverse worldviews stand in opposition and conflict or can they be bridged by listening and learning, by mutually respectful conversation and discourse? Recent developments at the University of Minnesota indicate a willingness to shift away from a culturally exclusive approach embedded in conflict toward one that embraces this dissonance as a healthy opportunity for understanding and growth. Native American reservation communities and

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faculty at the University of Minnesota have embarked on a path to build increased cultural understanding and a broader range of scholarship generated by the interactions of opposing worldviews as held by community-based elders and knowledge-holders and agricultural research scientists.

Our Proposal

Reservation communities of the upper Midwest in partnership with the University of Minnesota propose an international symposium as an important initial step toward the emergence of cross-cultural scholarship. The three-day Symposium, planned for 25-27 August 2009 at the Shooting Star Convention Center on the White Earth Reservation, is titled: "People Protecting Manoomin: Manoomin Protecting People".

Desired Outcomes

1. Consensus statements
    a. On the sacredness of wild rice and respect for it for generations to come
    b. On the cultural and sacred significance of wild rice
    c. On the inclusion of the collective voice of the Indian community in wild rice research
    d. On the potential impacts of climate change
2. Experiential
    a. Rice camps
    b. Pow wow
    c. Story telling
3. Building Relationships
    a. Among University scientists, Indians, and rice growers
4. Scientific/information outcomes needed.

Draft Schedule

	August 25, Day 1
9 AM	30 min - Traditional Welcome - White Earth Elders 30 min - Opening ceremony , Various officials including politicians, U of M officials, and Tribal leaders 1 hr - Karl Lorenz presentation, Bridging Communities 30 min - Paddy wild rice history: Paul Bloom ? 30 min - History of Anishinaabeg and wild rice
12:30 -1:30	Lunch
PM	Rice camp
evening	Story telling (international guests invited to contribute)
	August 26, Day 2
9 AM	90 min - Anishinaabeg panel, Michigan, North Dakota, Wisconsin, and Canada.- 2 each?, at least one traditional leader 90 min - Continuation, Minnesota panel, Red Lake, Leech Lake, Fond-du-Lac and others
12:30 - 1:30	Lunch
PM	Scientific section - Intro to biotech; Threats to wild rice; Gene flow; Gene flow panel.
evening	Educational Pow Wow
	August 27, Day 3
AM	Working groups
	Lunch
PM	Consensus statement developed and presented

Organizing Committee

The organizing committee comprises participants from the University of Minnesota and the White Earth Band:

Brenda Child, Associate Professor. Department of American Studies, University of Minnesota, and member of the Red Lake Band of Ojibwe.

Craig Hassel, Associate Professor & Extension Nutritionist, Food Science and Nutrition. Craig has developed cross-cultural engagement practice for scientific professionals, and bridges academic and cultural communities. Co-principal investigator for this proposal.

David Andow, Distinguished McKnight University Professor, Department of Entomology, University of Minnesota, Project Director for this proposal.

David Biesboer, Professor, Department of Plant Biology, and Director, Lake Itasca Biological Station and Labs, University of Minnesota.

Don Wyse, Professor, Department of Agronomy and Plant Genetics, University of Minnesota. Don has been interacting and collaborating with the Ojibwe for over 15 years.

Earl Hoagland, Elder and Cultural Leader, White Earth Indian Reservation. Earl is a leading Elder and cultural authority within the White Earth Reservation community. Earl co-founded Sah Kah Tay with his late wife Kathy Hoagland.

Erma Vizenor, Chairwoman, White Earth Tribal Council.

Joseph LaGarde, Assistant to the Chair, White Earth Tribal Council. Joe is highly regarded as an organizer and activist within the community and was one of the first to begin cultivating positive working relationships with the University of Minnesota.

Karl Lorenz, Director College of Food, Agricultural, and Natural Resource Sciences (CFANS) Student Services, University of Minnesota.

Paul Bloom, Professor, Department of Soil, Water and Climate, University of Minnesota. Paul has been involved in wild rice research for more than 25 years. Co-principal investigator for this proposal.

Paul Schultz, Healer and Spiritual Leader, White Earth Indian Reservation; Board member White Earth Tribal & Community College. Paul is a vital force in the work of bringing science and spirituality together in ways that respect the integrity of each.

Rachel Walker, Water Resources Environmental Scientist, Barr Engineering Company, Minneapolis, MN. Rachel is author of .Wild Rice: the Dynamics of Its Population Cycles and the Debate Over Its Control at the Minnesota Legislature, Ph.D. thesis, University of Minnesota, and several peer reviewed journal articles on ecological and political aspects of wild rice.

William Paulson, Program Coordinator, Sah Kah Tay. Sah Kah Tay is a community-based 501c3 with a mission to reclaim and strengthen traditional Anishinaabe cultural practices. Seasonal camps, including a Traditional Rice Camp are a major focus for Sah Kah Tay. As Coordinator, Bill will organize and oversee the Rice Camp experience proposed for the Symposium.