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Agricultural and Biodiversity Beyond Agricultural Biodiversity

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ABSTRACT OF THESIS submitted by:

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Abstract

This paper critically examines the relationship agriculture has with biodiversity at a conceptual level. I argue that biodiversity as a concept is antagonistic to the concept of agriculture, and that efforts that claim otherwise are misguided, misleading, and not in the best interest of those concerned with either biodiversity or agriculture.

In order to successfully show the antagonistic nature between biodiversity and agriculture this thesis expands upon the questions: ‘what is biodiversity?’, ‘what is agriculture?’, and ‘how are they interrelated?’. The lack of an accepted definition of biodiversity constitutes a significant challenge to such an undertaking, and to overcome this hurdle I develop the concept, ‘the idea of biodiversity’. The ‘idea of biodiversity’ is biodiversity at a conceptual level and is derived from analyzing both the common usage definitions of the term as well as the connotations of how it is used in practice. With the ‘idea of biodiversity’ as my guide I show the relationship between biodiversity and agriculture as fundamentally antagonistic.

Once this is established, I then bring forth and critically examine the term ‘agrobiodiversity’, and use it as an example of the extent to which the relationship between the two concepts is misunderstood in practice. I conclude that the realities of agriculture are so inconsistent with biodiversity that it is superior from both an agricultural and an environmental standpoint to recognize the inharmonious nature between biodiversity and agriculture so that they can be properly considered and managed.

Keywords: <insert key words here: e.g. environment, policy, etc.>

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1 Introduction

Agriculture is one of the defining aspects of our species, and is the cornerstone to what we know as society. More than any other technology it has allowed us to prosper, providing a reliable food, fiber, and fuel source (Zhanga, *et al.*, 2007). It has undoubtedly been of high value to human societies since we first developed it, and our current society is completely reliant on it. As time has progressed our population has grown globally, and while agricultural technologies have continuously improved, we have had to nonetheless cultivate more and more land in order to feed our population (FAO, 2005), (Green, *et al.*, 2005), (Kirchmann & Thorvaldsson, 1999).

Agricultural land currently covers over 38% of global land area¹ (FAOSTAT, 2011). Combining the expanse of current agricultural cover with population growth it is easy to see why non-exploited arable land, much of which is made up of forests, is threatened globally (Despommier, 2010). In addition, population, land change, and sprawl has rendered most alternatives for obtaining food (e.g. foraging and hunting) unviable at a species level.

In recent history the concept of biodiversity has gained increasing interest and value to society. Much of this has to do with an increased awareness of biodiversity loss. In line with this increased awareness many individuals and groups representing different interests have argued for the value of biodiversity. These arguments claim biodiversity to be of value due to it possessing an inherent worth regardless of society, or of it possessing a worth to society (or both) (Angermeier, 1994), (Callicott *et al.*, 1999), (Sahotra, 2005), (Gaston, 1998), (Norton, 1999), (Swift *et al.*, 2004).

¹ Agricultural land is defined as “the sum of areas under ‘Arable land and Permanent Crops’ and ‘Permanent pastures’”

The high value of both agriculture and biodiversity to large portions of modern societies has understandably encouraged individuals to attempt to link the practice of certain types of agriculture with the concept of biodiversity in a positive manner, the goal being to achieve the pinnacle of managerial achievements, the ideal win-win, when past arrangements had produced less than ideal results. In this case the win-win would be where biodiversity is enhanced (or at minimum is non-inhibited) by agriculture. Arguments for a win-win scenario in regards to biodiversity and agriculture is either seen or alluded to in European Crop Protection Association (2010), Henle *et al.* (2008), Quinn (2012), and Thrupp (1998, 2003)

In this paper I will, at a theoretical level, critically examine the relationship agriculture has with biodiversity. I will argue that biodiversity as a non-fragmented concept is antagonistic to the concept of agriculture, and that for a variety of fundamental reasons a “win-win” scenario is far harder to attain than has often been supposed. Through a series of steps I will conclude that the theoretical antagonisms between the two concepts has practical implications, and that for the purposes of optimizing societal desires for both agriculture and biodiversity, it is far superior to recognize them as fundamentally antagonistic rather than compatible values.

1.1 Research Question

To what extent and in what ways are the concepts of agriculture and biodiversity antagonistic?

1.2 Methods

This thesis is a conceptual, non-empirical, analysis of two related concepts: biodiversity and agriculture. As such, my methods have consisted of an extensive review of the literature related to this topic. How biodiversity and agriculture relate to each other has been approached a number of different ways in previous research, and because of this I have read on numerous distinct subjects related to the terms. I have read on: the history of the term biodiversity, the history of the practice of agriculture, discussions involving the definition of biodiversity, papers

on what domestication is and how it relates to agriculture and societal development, debates from a variety of angles on how agriculture relates to biodiversity (e.g. intensive versus extensive, land sparing versus land sharing, the importance of preservation, the relevance of restoration, the pros and cons of the green revolution, the value of wilderness, etc.), philosophical works related to agriculture and biodiversity, the economic value of ecosystem services, sciences role concerning biodiversity, sciences role concerning agriculture, biodiversity conservation, etc. This is a non-exhaustive list, but does cover the major areas that were researched while preparing this thesis.

On this literature I performed a conceptual analysis using a qualitative philosophical research framework focused on definition clarification and conceptual elaboration. This involved close readings of the literature noting any specific definitions, connotations, and contexts. The purpose with every reading was always to delve deeper into the research question, but the approach this took in practice was often dependent on how the the literature in question dealt with either Agriculture, Biodiversity, or their relationship.

1.3 The Importance of This Topic

Environmental concepts have become, “institutionalized in national, international, and multinational policy and law” (Callicott *et al.*, 1999). As Paul Angermeier points out in regards to the problems caused by biodiversity being poorly defined, “Policy built on flawed conceptions could contribute to the erosion rather than the conservation of biodiversity (Angermeier, 1994)”.

In this sense, the importance of better understanding policy adopted concepts and how they relate to our goals and values should not be underestimated. As I will go on to show, many policy makers and academics in the field seem to have warped understandings of the relationship biodiversity has with agriculture. This has the potential to lead to less than optimal decisions when it comes to land, agriculture, and biodiversity management. Not clearly recognizing the fundamental antagonisms between agriculture and biodiversity constrains ones understanding of

an increasingly important area of study, how a society ought best to practice agriculture while simultaneously valuing biodiversity.

1.4 Contribution to the Field

I view my contribution to this field as having three aspects. First, I expand on the relationship that agriculture and biodiversity have to each other on a conceptual level. I take the position that on a conceptual, and by extension practical, level biodiversity and agriculture are antagonistic. This is not a novel thought in and of itself, and aspects of this idea are inherent in many agriculture and biodiversity debates, such as: land sparing versus land sharing, or intensive versus extensive agriculture.

My contribution in this regard is a critique directed towards the modern trend of promoting biodiversity on agricultural land by claiming that agriculture and biodiversity are not necessarily antagonistic. I am critical of this position and argue that it is not only unrealistic given the conceptual realities of the terms, but also is apt to lead to management mistakes that are not in society's interest given overall societal desires and values²

Next, I contribute a distinct conceptual understanding of biodiversity. My conceptual definition of biodiversity is admittedly broad and inclusive in nature, but I defend this understanding of biodiversity nonetheless, arguing that there is value in a well defined conceptual definition of biodiversity (value that has generally been not appreciated to its fullest by many other champions of biodiversity), and that although broad it is not an all-inclusive concept, a critique that has been levied against concepts like 'nature'.³

I do recognize the practical value of 'common usage'⁴ definitions of biodiversity, and I also recognize that these contextual definitions are likely inevitable when concerning a highly

² I would claim that biodiversity can have no interest in and of itself being a distinctly human abstraction, and thus only society's interests are mentioned as relevant in this paper. If we were discussing a particular group of bears, for example, as opposed to the more abstract concept of biodiversity, then the question of the interest of the bears could be an important one and lead to very interesting discussions. As it is though the question of the interest of biodiversity is considered to be null.

³ That is to say that the concept of nature is so inclusive that it means everything and yet nothing (Callicott *et al.*, 1999), (Gaston, 1998), (Swift *et al.*, 2004), (Takacs, 1996).

⁴ 'Common usage definitions' is a general reference to other definitions of biodiversity.

valued yet broad concept such as biodiversity. As Martin Drenthen points out in regards to the term 'nature', and I would argue that nature and biodiversity have a similar high value yet ambiguous quality that is apt to be understood differently by the same individual in different situations, "The problem is that, in the end, we all cling to different concepts of nature on different occasions. We conceive of nature differently when we drive a car or when we go on a hike" (Drenthen, 2005). Likewise I argue that we use 'biodiversity' in an opportunist and contextual manner, which varies not just from person to person, or society to society, but also from situation to situation. My position is that even with the multitude of ways biodiversity is evoked, there is still a general understanding of what biodiversity represents that all of these common usage definitions should, and generally do, reflect, and that the usage of the term 'biodiversity' in ways that do not reflect this general understanding are at minimum misleading and at worst counterproductive to societal desires.

My claim is not that my conceptual definition of biodiversity is unprecedented per se (although my arguments for it may be), for I argue that it is present in most usages of the term, nor that it is the only proper way to use the term 'biodiversity', but that all other reasonable common usage definitions reflect a similar underlying understanding of biodiversity at the conceptual level, even if that conceptual definition had not been fully formed, and that despite disagreements amongst definitions, there is a conceptual understanding of biodiversity that crosses all reasonable uses of the term.

These contributions lead me to my third contribution which is an original critique of a trend to create concepts that claim to connect biodiversity with certain agricultural practices in a mutually positive way. This trend is exemplified by terms like 'agrobiodiversity' being incorporated into the environmentalist lexicon. I make the claim that the use of the term 'biodiversity' in this context does not reflect in a meaningful way the idea of biodiversity and thus is misleading. For reasons I will expand upon in my upcoming text, insinuating that agriculture is focused on the variety of life is for multiple reasons a misrepresentation of the practical and

conceptual realities of agriculture, and this misrepresentation hinders the management of both agriculture and biodiversity.

1.5 Limitations and Scope

While the on-the-ground practical aspects of the relationship between agriculture and biodiversity are unquestionably interesting, it is nonetheless outside my scope to go in-depth into any particular case studies. I take an admittedly utilitarian assumption that a society would like to fulfill its desires in regards to agriculture and environmentalism in a manner that reflects how they value and understand both concepts, and that they would like their actions to produce optimal results given the investments made.

It is important to stress that this thesis is conceptual in focus and distinctly non-empirical. Reflected in the fact that this thesis is not concerned with particular case studies, it also makes no claim of providing original empirical data (e.g. What is the quantity of biodiversity in _____?). I will draw on empirical data, but only to reinforce my position, and never with total reliance on it. I take the position that the validity of a conceptual theory is somewhat immune to empirical data as the latter cannot prove a theory positive but can only support the said theory.

In this thesis I take the a priori position that populations will increase, at least in the near future. I am familiar with theories and projections that argue that at some point the world population may level off (e.g. United Nations Department of Economic and Social Affairs Population Division, 2013)). While population theory and its implications is quite interesting, it is outside the scope of my thesis. It is also irrelevant to my thought at a theoretical level, for while this is of interest to certain practical aspects of my theory, it doesn't actually change any key aspects. The fundamental relationship agriculture has to biodiversity is not dependent on population. This is not to ignore the fact that arguably human population does have effects on both agriculture and biodiversity, but delving deep into this relationship is outside the scope of this paper and non-essential to my work.

Related to population theory, theories that discuss income and its relation to consumption, agriculture, and population are likewise outside the scope of this paper. This includes the profitability of agriculture, farmer income, or equitable distribution of wealth. For example, there is interesting literature that deals with the phenomenon of increased profits for the individual farmer being positively related to increased land conversion in certain circumstances (Godfray, 2011), (Lacher, Slack, Coburn, & Goldstein, 1999), as well as literature that shows decreased profits for the individual farmer leading to increased land conversion in certain circumstances. (Green *et al.*, 2005). Despite its parallels, this and similar topics are outside the scope of my paper, as it is assumed that, ideally, increased land conversion due to opportunistic individuals but not due to a greater societal-level desire for more agriculture land conversion can be handled through societal regulation and management. While I am well aware that this is a very idealistic assumption, it is reasonable enough given the conceptual nature of this thesis. Future work, mine or others', can be focused on examining whether societies have strong agricultural management systems that reflect the desires of the society at large, but it is something I cannot tackle in this paper.

In looking at biodiversity and agriculture I am admittedly deemphasizing the importance of any particular individual farmer as vital to the system. Justifying this is outside the scope of this paper other than my position that a maximally efficient, minimally polluting, high yielding, agricultural system that was mostly automated and required just a handful of human farmers (agricultural experts) to operate and met the desires of society better than other options, would not be opposed, even if this meant massive numbers of individuals were forced into new vocations. This said, if increased numbers of farmers optimized the system, then I would be in favor of that option instead, and this paper makes no assumptions one way or the other as to what is superior for the optimization of societal goals in regards to labor. Ultimately I am concerned with the concepts of biodiversity and agriculture, and those who maintain and manage

these systems are valued (only) up to the point that they optimize the system that serves society's desires.⁵

It should also be noted that due to the variety of authors I am drawing from there may be some confusion at times as to whether I am referring to crop production or livestock production. This paper is interested in both aspects of agriculture. It should also be noted that livestock production is often reliant on crops (although not always), increasing its land requirements in regards to calories produced for human consumption per unit of land significantly. Generally though, the differences between crop and livestock production are outside the scope of this paper.

The question of monocultures, or to be more specific, “do monocultures represent a problem in and of themselves?” is also outside the scope of this paper. This paper is focused mainly on agriculture in the sense of high input versus low input and their relationship to biodiversity. I make no claims as to the theoretical costs or benefits of monoculture, other than pointing out that agriculture historically has not particularly been focused on inter-species diversity but has placed a much higher emphasis on intra-species diversity. It should also be noted that regardless of amount and type of inputs, monocultures are possible. That is to say low input farming can practice monocultures without it being a misnomer.

In this paper I am fairly regularly addressing ‘management and regulation’. The particulars of what this entails in practice however are not addressed, as the paper is not focused on governance issues. Additionally, when I evoke ‘society’ it is often unclear to what scale of society I am referring. This is intentional as I take the position that there is interplay between small groups, large groups, and the ‘global society’. When mentioning ‘society’ I am often referring to all groups simultaneously. Just as I am not focused on governance, I am also not concerned here with sovereignty or politics.

1.6 Glossary of Terms

⁵ Noting that labor, in this example, is both a part of society and is affected by societal desires.

While it is far outside the scope of my paper to claim to offer universal definitive definitions to all the concepts mentioned in it, I will do my best to give clear, and reasonable, working definitions of the key concepts. These definitions I believe reflect the general sense of the terms as I have seen them used in the literature.

Agriculture: is probably the easiest to define. The Merriam Webster encyclopedia defines it as, “The active production of useful plants or animals in ecosystems that have been created by people. Agriculture may include cultivating the soil, growing and harvesting crops, and raising livestock” (Merriam-Webster.com, Retrieved January 8, 2014). It is important to note that foraging and hunting non-cultivated plants and animals would not be considered agriculture under this definition, but almost all other kinds of primary food production is.

Agrobiodiversity (agricultural biodiversity): is generally defined as the beneficial biodiversity found within a specific locus or aspect of agricultural. The FAO defines it as, “The variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel and pharmaceuticals. It also includes the diversity of non-harvested species that support production (soil micro-organisms, predators, pollinators), and those in the wider environment that support agro-ecosystems (agricultural, pastoral, forest and aquatic) as well as the diversity of the agro-ecosystems.” (FAO, [2014?]).

A key component of agricultural biodiversity is that it is human-centric in both theory and practice. The focus of agricultural biodiversity is the variety of *beneficial* life as it relates to agriculture, and by extension humans. An intrinsic aspect of agricultural biodiversity is that life that can be useful to agriculture is promoted, while life that detracts from agriculture is deterred (often intentionally to the point of elimination).

Biodiversity: is probably the most difficult concept to define. It has a tendency to mean different things to different people in different contexts. I find that the definition put forth by E. O. Wilson (1988) to be a very reasonable, non-controversial, working definition of biodiversity. It states that, “Biological diversity is the variety of life at every hierarchical level and spatial scale of biological organization: genes within populations, populations within species, species within communities, communities within landscapes, landscapes within biomes, biomes within the biosphere”.

I should note that there are a spectrum of formal definitions of biodiversity and likewise there are a large spectrum of ways that it is used in practice. While this one by E. O. Wilson appears to a rather highly referenced and centrist definition, it is far from the only definition used in practice, and that both the definition of biodiversity used and how it is interpreted in practical senses are highly contextual.

It is important to stress that many use other definitions of biodiversity (I often refer to these as 'common usage' definitions when referred to in a general sense). In this paper I propose the concept of the 'idea of biodiversity'. This concept is biodiversity in its most general sense, encompassing both the Wilson definition as well as most other definitions. The idea of biodiversity is derived by analyzing what most definitions of biodiversity have in common, as well as how they are generally used in practice. It is useful not so much as a new definition of biodiversity, but as a tool for examining particular understandings of biodiversity, as well as examining what biodiversity is at a theoretical level. For more information on the idea of biodiversity see Chapter 3 where I justify the merit of the idea of biodiversity and explain its value as a concept.

Ecosystem services: is both a broad and vague concept. As its name implies it refers to the services an ecosystem can provide society. These services should theoretically have an economic value, although in practice it is difficult to determine their economic value accurately.

Ecosystem services can be defined as the “goods (such as food) and services (such as waste assimilation)” a well-functioning ecosystem provides to humans (Costanza *et al.*, 1997)

1.7 The Outline of The Chapters

This thesis takes advantage of an approach in which each chapter uses information from the previous chapters to progress the argument to its final conclusion. As smooth as I have tried to make the transitions between the chapters, there are a few shifts that the reader may want to be aware of.

Chapter 2 is the literature review. In this chapter I have attempted to give an overview of many of the issues and debates currently discussed within the literature involving the relationship between biodiversity and agriculture. The most important function of this chapter is that it explains how this thesis fits into the grander discussions and debates within the field.

Chapter 3 outlines the 'idea of biodiversity'. An original concept proposed in this thesis and used both to expand upon what biodiversity is at the conceptual level, and to analyze the relationship agriculture has with biodiversity. The reader should be aware that the shift from chapter 2 to chapter 3 is the most abrupt in this thesis. Noting, that it was necessary to put forth the 'idea of biodiversity' before my analysis of the term 'biodiversity', as this analysis is done with the 'idea of biodiversity' in mind.

Chapter 4 focuses on the question, 'what is biodiversity?'. It starts by going over the origins of the term. It then discusses the issues with defining biodiversity, and the varying ways it has been used in practice. It then discusses issues with science, both in the sense of defining the term, but also in its limitations in regards to measuring biodiversity and its components.

Chapter 5 is a shift in topic, and is concerned with the question, 'what is agriculture?'. It explore the process of domestication, as well as the conceptual issues that may exists between domestication and biodiversity. In doing this it also brings forth the question of genetic alteration, including genetically modified organisms, and how these may related to biodiversity at a conceptual level. Finally this chapter expands upon the debates brought forth in Chapter 2 such

as intensive versus extensive, land sparing versus land sharing, the importance of preservation, etc. and analyzes them considering both common usage definitions of biodiversity and the idea of biodiversity.

Chapter 6 focuses specifically on stressing the antagonistic nature that agriculture has with the concept of biodiversity, a thread that has been advanced throughout the thesis thus far. This chapter stresses that it is more reasonable, and likely a better environmentalist position, to consider agriculture as antagonistic to biodiversity at a conceptual, and by extension practical level.

Chapter 7 is the last chapter before the conclusion. It brings forth all of the arguments made thus far and successfully uses the 'idea of biodiversity' to discredit the term 'agrobiodiversity'. It shows that the use of the term 'agrobiodiversity' and its claim that it is a subset of biodiversity is misleading given both what the term represents in practice. It stresses that the acceptance and usage of the term 'agrobiodiversity' by major international organizations as well as academics is unreasonable given the relationship agriculture has with biodiversity.

Chapter 8 is the conclusion. It wraps up the thesis, reiterating the general arguments found within it. It stresses the fact that both agriculture and biodiversity are concepts to be valued, but that this does not mean that they are complimentary, and that they should be considered and managed accordingly.

2 Agriculture and Biodiversity – A Literature Review

In this chapter I will explore the current ideas, trends, and approaches that are found in the literature dealing with the relationship between agriculture and biodiversity at the conceptual level and how they relate to my thesis. Due to the argumentative style of this work, in many cases it was more practical to give an in depth explanation of particular debates in upcoming chapters. In these cases I will give an explanation of the debate here, including how it relates to this thesis, but save much of my expansions on the debates for the upcoming chapters.

2.1 Agriculture In Regards to Biodiversity

At the broadest level when one examines the topic of the relationship between agriculture in regards to biodiversity, the literature found is often dealing with how biodiversity is beneficial to agriculture. To an extent agriculture relies on biodiversity, or at least particular aspects of it. Some microbes provide decomposition and nutrient cycling services; some insects provide pollination and pest control services; some fungi assist in both decomposition and nutrient uptake; some plants assist in regulating water flows, etc. (Fischer *et al.*, 2008), (Kennedy, 1999), (Schloter, *et al.*, 2003), (Zhanga *et al.*, 2007). These positive attributes, or ecological services, to the agricultural system are well documented and should not be ignored in their current, historic, and likely future importance to agriculture.

What is also noted in the literature is that not all aspects of biodiversity are beneficial to agriculture. There are agricultural disservices that biodiversity can have on an agricultural system. These disservices include pest damage, disease, competition for nutrients (including water and sunlight), and competition for pollination services (Zhanga *et al.*, 2007). All of these can cause lower yields given the area allocated for, and inputs available to, the agricultural system in question.

Ignoring distribution issues (they are mostly outside the scope of my paper⁶), the assumption that the population will continue to increase globally creates a situation where reduced yielding agricultural projects on the large scale will require larger areas of land devoted to agriculture in order to sustain the current populations (Balmford *et al.*, 2012), (Diamond, 2002). This expansion of agriculture puts significant pressure to convert non-agricultural areas, that are often biodiversity rich, to agricultural land (Green *et al.*, 2005).

This discussion is relevant because it shows that when considering the relationship between biodiversity and agriculture any effects that lowers agricultural yields are also likely to have negative effects on biodiversity outside of the agriculture in question. In this way, the lower yields that are caused by certain aspects of biodiversity on agricultural land, are problematic even from a biodiversity centric position. When considering the relationship between agriculture and biodiversity, the issue isn't just how beneficial or damaging biotic elements can be in a given agricultural system. The discussion must also take into account how agricultural productivity in the short and long term affects agricultural expansion as well as biodiversity on non-agricultural lands. Agricultural yields that are less than optimal (the maximum yield that is sustainable for indefinite production and is of high quality) will generally encourage non-agricultural land to be converted to agricultural land. Any agricultural expansion that may arise from lower yields will clearly in turn have significant implications for biodiversity.

The question of the relationship between biodiversity on agricultural lands and biodiversity external to agricultural lands is one of the main areas of discussion in the literature. The discussion of this topic has taken many different forms such as land sharing versus land sparing, extensive agriculture versus intensive agriculture, the pros and cons of wildlife-friendly farming, pro green revolution versus anti-green revolution, etc⁷. Despite each one of these

⁶ Current issues involving failures of food distribution systems are outside the scope of this paper for a few reasons, but most importantly is that even if the distribution of agricultural products were improved it would only streamline the current system and not change the fundamental relationship biodiversity has with agriculture.

⁷ This is a non-exhaustive list, but it names the bigger debates.

debates fundamentally having to do with agricultural yields versus increased agricultural consequences they each have their own subtle deferences.

Land sharing versus land sparing has to do with whether agriculture land should be as hospitable to biodiversity as possible (land sharing), this includes retaining certain non agricultural bits solely for biodiversity habitat (e.g. Shade trees, hedgerows, ponds), but also it involves reducing inputs such as pesticides, etc., versus having agriculture mainly focused on sustainable yields so that other, non-agricultural lands, can be preserved for biodiversity purposes (land sparing) (Balmford *et al.*, 2012). Arguably the way the pros and cons of wildlife-friendly farming has been used in the literature is almost the same as the land sharing versus land sparing debate, with the exception that in the pros and cons of wildlife-friendly farming debates there appears to be an emphasis on wildlife (Green *et al.*, 2005). As will be discussed when I bring up ‘artificial diversity’ and domestication there are distinctions between ‘artificial diversity’, domesticates, and tamed animals that may or may not be of importance when considering biodiversity (Angermeier, 1994).

The extensive agriculture versus intensive agriculture debate is also similar to the land sharing versus land sparing debate minus the fact that it does not necessarily deal with preserving non-agricultural bits on agricultural lands. It is focused mainly on whether agriculture has an increased concern for environmental benefits on the agricultural land (this includes biodiversity as well as ecological services) or whether it is focused on sustainable high yields in an effort to reduces agricultural land conversion in areas other than the agriculture in question (Green *et al.*, 2005). For most intents and purposes this is the debate I look most closely at in this thesis (although I draw on literature from all the debates to explore this concept. In this thesis I favored the terms ‘intensive’ versus ‘less intensive’ (or occasionally ‘high intensive’ versus ‘very high intensive’) because I argue that all agriculture is intensive, and that while extensive versus intensive is a reasonable way of framing the distinctions between the two, it understates the level of intensity represented in extensive agriculture.

The pro-green revolution versus anti-green revolution debate takes a slightly different form in the literature. Few, if anyone, would deny that the green revolution resulted in higher agricultural yields (the yield increase is well documented), but many have noted the costs (often environmental) of these higher yields, some claiming the cost is too high (anti-green revolution). The pro-green revolution arguments are generally focused not so much on biodiversity, but on feeding the world's population. Nonetheless it is rarely noted that increased yields can have beneficial effects in regards to preventing land conversion (this is similar, if not the same, to land sparing) (Angelsen & Kaimowitz, 2001), (Stevenson *et al.*, 2013).

This thesis fits in well with all of these debates as it gives insight into what biodiversity is at a conceptual level, something that is important if one is to conserve biodiversity. Additionally, while my conclusion is not unequivocally in favor of land sparing, pro-green revolution, or intensive agriculture positions in all situations and forms that they are practiced, it is generally very sympathetic to their lines of thought. I would say that my conclusion is a pro pragmatic and well managed intensive agriculture argument.

In this paper I stress that even relatively biodiversity rich agricultural land houses mostly the biotic aspects that are viewed as beneficial, or at least non-detrimental to agriculture. Non-beneficial biodiversity is deterred, often to the point of complete elimination, unless societal rules or relatively strong social norms dictate otherwise (generally speaking); what remains can be considered highly selective and “diversity-diminished” biodiversity. The deterrence of non-desired aspects of biodiversity is a fundamental aspect of agriculture. In this way when one uses the term ‘biodiversity’ in regards to agriculture they are often referring to biodiversity’s value conditionally, contingent on its value to humans outside of agriculture or to agriculture itself, but not to the concept of biodiversity having inherent value on agricultural land.

As will be explained, from the idea of biodiversity perspective the detrimental and beneficial aspects of biodiversity are of tantamount significance in that the repression of either detracts from biodiversity (later I will argue that the willful fostering of aspects of biodiversity is

likewise out of line with the idea of biodiversity). This creates a paradox, for if biodiversity on agricultural land is not managed properly, management including the willful removal of the detrimental aspects of biodiversity and the encouragement of the beneficial ones only to the degree that they are optimally beneficial, then arguably this ‘excessive’ biodiversity on agricultural land detracts from biodiversity on the whole. This is because by encouraging suboptimal combinations of biodiversity on agricultural land in regards to yields, one contributes to the practice of agricultural land conversion,⁸ which often takes the form of deforestation, grassland conversion, or wetlands draining (Despommier, 2010), (Green *et al.*, 2005), (Kirchmann & Thorvaldsson, 1999), (Lacher *et al.*, 1999). The loss of forests and wetlands, from an idea of biodiversity, environmental, and social perspective, are often considered more detrimental to biodiversity than decreases in biodiversity on agricultural land. Efforts to encourage biodiversity on agricultural land for the sake of diversity but at the expense of yields can in this way be seen as a questionable biodiversity position, unless one’s primary concern is biodiversity on the farm and not biodiversity itself (In chapter 4 of this paper I will put forth an argument that it may be reasonable to consider most biodiversity in agriculture of less value generally speaking from the idea of biodiversity position than compared to biodiversity in relatively less altered landscapes.).

This position is quite obviously controversial and there are many who do argue to the contrary (Henle *et al.*, 2008), (Koellner & Scholz, 2008), (Quinn, 2012), (Thrupp, 2000), (Tschardtke, *et al.*, 2005). While I doubt I will end the debate once and for all, I believe that I can contribute to it in a significant way by expanding on how one understands the relationship between the concept of biodiversity and the practice of agriculture.

In the upcoming chapters of this thesis I will further expand upon perspectives that have questioned, often indirectly, the value of biodiversity on agricultural land. I will present a cogent argument that the practice of agriculture should be considered as separate and incongruent with that of the biodiversity, arguing that the practice of agriculture is at the theoretical level, and by

⁸ I am not claiming a 1-1 conversion, but that the general trend of one contributes to the general trend of the other.

extension practical level, antagonistic to that of the idea of biodiversity. Any claims to the contrary confuse the situation, and are a disservice to our ability to understand the terms in a realistic manner. This research, in that it gives insight into biodiversity at a conceptual level, is pertinent not only to the thesis itself, but to the field in general, because without having a clear understanding of the relationship agriculture has with biodiversity it is impossible to give a reasonable assessment of the value of biodiversity on agricultural land. Additionally, misunderstanding concepts that are of value at the societal level, which both agriculture and biodiversity arguably are, can lead to management mistakes, resulting in systematic suboptimal outcomes when compared to the initial desired goals.

To look at the value of biodiversity on agricultural land properly it is necessary to first understand the concepts in a realistic manner. In the next chapter I will present my concept of the 'idea of biodiversity'. This is an analysis at biodiversity at the conceptual level.

3 The Idea Of Biodiversity

Key Points of The Idea of Biodiversity

1. The idea of biodiversity is the theoretical idea of biodiversity in its most general sense.
2. All reasonable understandings of biodiversity can be thought of as having to do with the diversity or variety of life.
3. The idea of biodiversity includes all conceivable levels and scales of life without priority given to one over another (e.g. species diversity is not of more value than gene diversity or vice versa, etc.).
4. The idea of biodiversity is focused on the variety of life, but has no inherent emphasis on any of the particular qualities of that variety (e.g. rarity is not by definition of more value than uniqueness or vice versa, etc.).
5. The idea of biodiversity is neither the active promotion nor hindrance of the elements of biodiversity.
6. The idea of biodiversity does not *only* differentiate based off of the quantity of biological elements and their diversity, but also differentiates based off of the level of intentional human alteration.

* These are my most controversial claims. I recognize this, and while I find my justifications for them to offer some new insight into biodiversity at a theoretical level, I would not expect all of my readers to accept these positions wholeheartedly. In relation to this I would like to point out that neither my critique of agrobiodiversity nor my analysis of the relationship between agriculture and biodiversity hinge on the acceptance of these two points. While I hope my readers find my logic in regards to these points sound, critiques waged solely against them would not cause my larger arguments to unhinge, as they rely on points 1-4 and only are bolstered by 5 and 6.

The first things that must be explained before delving deeper into the ‘idea of biodiversity’ is ‘how does it differ from common usage understandings of biodiversity?’ and ‘what function does it serve, that common usage understandings do not?’. The difference between the idea of biodiversity and common usage understandings of the term is that the answer to the question ‘what is biodiversity?’ changes contextually⁹ with common usage understandings of biodiversity, while the answer to the question ‘what is biodiversity?’ does not change in any significant manner with the idea of biodiversity. The idea of biodiversity is a broad concept, and is generally supportive of most common usages ‘biodiversity’. The concept of the idea of biodiversity was developed by deciphering the aspects that the vast majority of common usages of biodiversity have in common when they are evoked.

The other difference between the ‘idea of biodiversity’ and common usages of the term is also its function. The term ‘biodiversity’ is generally evoked with the purpose of drawing attention to the variety or diversity of life in a particular area with a particular context. The idea of biodiversity on the other hand is not necessarily as useful for this function. Given that the evoker of biodiversity, and their goals, is a major part of the context in which ‘biodiversity’ is commonly evoked, the idea of biodiversity would in this sense lose practical appeal, as the question of ‘what is biodiversity?’ is less subject change due to context.

The main functions of the idea of biodiversity is not to examine the variety or diversity of life per se, but to examine how individuals generally define and use the term, and to determine whether a particular usage of ‘biodiversity’ is reasonable considering how the term is generally used. I am putting forth the argument that reasonable uses of the term ‘biodiversity’ are complementary of the ‘idea of biodiversity’, and that any uses of the term ‘biodiversity’ that are either automatically rejected due to obvious dissidence with what the term generally represents, or that are misleading due to less obvious, yet significant, incongruities, are not in agreement with the ‘idea of biodiversity’.

⁹ This includes the goals of the evoker at the moment, but also with other contextual realities as well.

There are four reasons why developing the concept of ‘the idea of biodiversity’ is relevant to a thesis on ‘the extent and ways the concepts of agriculture and biodiversity are antagonistic to each other’. First, it adds insight to the long history of debates that have dealt with what the definition of biodiversity is or should be. Through the idea of biodiversity I challenge arguments that claim that a single understanding (or even one group of understandings) of biodiversity is correct while most or all others are inferior. I claim instead that most common usages of biodiversity are correct, as is the nature of such a broad and widely used term.

Second, and related to my first point, the idea of biodiversity is quite functional in its ability to give insight into and ammunition against unreasonable uses of the term ‘biodiversity’. Namely uses of the term where it is used in such a way that its positive or neutral relation to the diversity or variety of life is questionable. That is to say, the use of the term ‘biodiversity’ in contexts that may in practice reduce the diversity or variety of life.

Third, it would be difficult, if not impossible, to levy a significant argument regarding the antagonisms between biodiversity and agriculture without understand what biodiversity actually is, not in practice (for its common usages are far too contextual), but in theory. It may be noted that a conceptual analysis of ‘what is agriculture?’ is not conducted to nearly the same extent as ‘what is biodiversity?’. My justification for this is my position that conceptually agriculture is quite straightforward, and it is in practice that agriculture gains its complexity.

Forth, the development of the idea of biodiversity proves to be exceedingly useful in concisely critiquing the concept and practice of ‘agrobiodiversity’. This reflects the idea of biodiversity’s usefulness as a concept that can assist in illuminating instances when the term ‘biodiversity’ is used in an questionable manner.

In deciphering what biodiversity is conveying in this most general sense, I will start with the etymology of the word. Biodiversity was originally a conjunction of the words ‘biological’ and ‘diversity’. The etymology of biological is Greek and broken down translates as: ‘bio’ - life, ‘log’ -

discourse, and 'ical' - "in the manner of, or pertaining to" (Harper, 2014). The etymology of diversity is Latin and broken down translates as: 'di' - asunder, or 'a part from each other in position', 'vers' - to turn, and 'ity' - "the condition or quality of being" (Harper, 2014), ("Merriam-Webster.com," 2014). More precisely diversity can be thought of as the quality or condition of having variety or difference, and biodiversity can be thought of as having to do with the diversity or variety of life. The definition of these words, and to a lesser extent their etymology, may seem obvious to a native speaker, but understanding their origins (scientific, philosophical, and etymological) is important in understanding my case for an idea of biodiversity.

The important bit to take away from the etymology of the word 'biodiversity' is that assuming its name is not a misnomer, it is meant to be focused on the variety of life (Key point #2). This can be seen in most definitions of biodiversity, including the well known and generally accepted CBD definition (representing many political environmentalists), the popular E.O. Wilson definitions (representing many scientific environmentalist)s, as well as most other definitions¹⁰. E. O. Wilson put forth a definition of the term 'biodiversity' that is I believe quite reflective of the etymology of the term and can serve as a reasonable centrist example of how many understand biodiversity¹¹, "Biological diversity is the variety of life at every hierarchical level and spatial scale of biological organization: genes within populations, populations within species, species within communities, communities within landscapes, landscapes within biomes, biomes within the biosphere" (Wilson, 1988).

The idea of biodiversity has many parallels to this definition. First, it is not limited solely to species diversity, but includes all conceivable levels and scales of life without priority given to one over another (Key point #3). The idea of biodiversity would not place species above landscapes, both exist and neither is inherently more valuable than the other within its logic.

¹⁰ There are a large number of definitions of biodiversity in the literature. I believe that Takacs (1996), Gaston (1998), and Callicott *et al.*, (1999) all give distinctly different yet good overviews of how these definitions vary.

¹¹ For practical reasons in practice there is a clear tendency for species diversity to be given emphasis when considering biodiversity.

Second, defining biodiversity as “the variety of life at every hierarchical level and spatial scale of biological organization” implies a stress on the variety of life, but has no inherent emphasis on the qualities of that variety (Key point #4). Third, it does not explicitly discourage common uses of the term ‘biodiversity’ as long as they compliment the logic of the idea of biodiversity. One can decide to value endangered species over common ones, and this isn’t against biodiversity, it is simply adding the values of the evoker to the understanding. In this way the idea of biodiversity is not an affront to other definitions of biodiversity.

This brings me to a tricky and paradoxical aspect of the idea of biodiversity. Humans I believe are part of biodiversity,¹² however our ability to act in a deliberate way puts us in an interesting position concerning how biodiversity is generally understood. I argue that our position is to neither actively promote nor hinder biodiversity deliberately, if we are to maintain the idea of biodiversity in our actions (Key point #5). This is a clear distinction from most definitions of biodiversity in literature, but nonetheless appears to be an aspect of biodiversity given how it is generally evoked.

My reasoning for this qualifier is as follows, and it has to do with the spirit of what is meant by biodiversity, or in other words, what is implied when the term ‘biodiversity’ is evoked in nearly all senses of the word. I believe most would agree that a zoo isn’t the pinnacle of

¹² There is much to say just on this idea. Many would include the human species as part of biodiversity (this isn’t too controversial a position, although it would no doubt spark discussion), yet when common usage definitions are proposed the human species is rarely included in the results, with the exception of somewhat fringe contextual definitions of biodiversity which use the term to benefit what the evoker understands as human cultural diversity. In other words, humans are generally included into the definition of biodiversity, yet when estimates of biodiversity on a plot of land are measured, human presence is rarely taken into account as either biodiversity, or as beneficial to the diversity. In this way calling into question whether humans are actually generally considered part of biodiversity, and whether the commonality of our inclusion in the concept has more to do with a lack of popular rationales for our exclusion (This is not by personal opinion, but it is a question that seems reasonable). There is the practical argument that humans are overpopulated and possibly over dispersed and therefore should be excluded from practical results, but what exactly is overpopulation exactly? Both generally speaking, and within the logic of the idea of biodiversity the term seems a bit sticky. Overpopulated compared to what? And when does overpopulation exclude a species from the results of biodiversity measurements? If this is the reason for our exclusion from the results of biodiversity, should not common species whose range and populations have been radically extended due to human influence also be excluded from the results of practical biodiversity studies?

biodiversity, neither is a genetics lab,¹³ nor an arboretum. The reason for this is that these entities are not what one generally means when they evoke biodiversity.

The question is, why? What is intrinsically different about them, and why, despite them arguably often having significantly higher amounts of the elements of biological diversity than typically found in most other places, is their quality found to be lacking compared to what is generally meant when the term 'biodiversity' is evoked. Yet, the biodiversity found in a relatively pristine¹⁴ desert, or a relatively pristine old growth tropical forest, is exactly the what most envision when they evoke biodiversity.

The reason for the distinction between an arboretum and an old growth forest has a lot to do with their origins and maintenance, this includes a distinction between the varying levels of human influence, both positive and negative (Key point #5). These may be arbitrary and paradoxical human distinctions (especially if humans are considered part of biodiversity yet they are the only species whose alterations of the biotic system are not considered reasonable), but nonetheless human altered diversity consistently appears to have not only diminished value when compared to non-altered diversity, but is also less complimentary to what one generally means when they evoke 'biodiversity', and thus is relative, and should be incorporated into the concept of the idea of biodiversity.

To qualify this point, there is biodiversity in an arboretum, or an genetics lab for that matter, and this biodiversity arguably has value in some contexts similar to that of the pristine forest, but its particular value is highly contextual, and is based on how one understands biodiversity in a particular context, and the value they place on biodiversity in that context. Both of these variables are susceptible to constant change.

The biodiversity of the pristine forest on the other hand is only likely to change in its complementariness to the idea of biodiversity in regards to the amount of human influence that

¹³ I am assuming this lab has a multitude of genetic samples.

¹⁴ When I write pristine I am referring to how closely that which is being described matches the conceptual archetype.

is experienced by it. The quantity of biodiversity in a pristine forest should be theoretically on par to the theoretical archetypal pristine forest, and because the idea of biodiversity does not encourage the promotion of the elements of biodiversity through human intervention (for who else could they be promoted), the pristine forest therefore represents an unimpeachable level of biodiversity. As long as it remains pristine in the sense of minimal human influence then its relation to the idea of biodiversity is beyond reproach.

When expanded upon, this logic leads to the conclusion that the biodiversity of one relatively unaltered biotic hierarchical level or spatial scale cannot fairly be compared to another in regards to it being more complimentary to the idea of biodiversity, even when that other is of the same level or scale of biodiversity (e.g. genes, species, etc.). "Imagine walking through a forest into a grassland or snorkeling across a coral reef beyond the reef edge toward the open sea. The testimony of our own eyes confirms that the biosphere is not organized as a set of smooth continua in space but rather as a complex 'biotic mosaic' of variably discontinuous assemblages of species" (Colwell, 2009). This author focused on the biodiversity of ecosystems in their example, but the reality remains true throughout the practical comparisons of biodiversity at any level. The archetypal amount of biodiversity when considering the idea of biodiversity is the amount present when intentional human influence is at a minimum, but this amount will nonetheless vary from place to place.

From the idea of biodiversity perspective, the biodiversity of the grassland is not more complimentary to the idea of biodiversity than the biodiversity of the forest, despite the grassland having a higher diversity of life (assumed for this example). The qualifier to this is that the level of human alterations is just one of the aspects that can effect the normative value of the biodiversity present, and thus while the pristine forest and the pristine desert may both be equally complimentary to the idea of biodiversity, this does not mean that they are of equal biodiversity value.

I can defend this point two different ways. First, the quantity, rarity, ubiquity, value to humans, etc. of the biodiversity present also effects the value of the biodiversity, both in common usage meanings and from the idea of biodiversity perspective. This is obvious in almost all usages of the term biodiversity, but can clearly be seen when one looks at the obvious value given to areas designated 'biodiversity hotspots'. The flip side to this point is that the biodiversity of the arboretum is less complementary to the idea of biodiversity than the biodiversity of the grassland or forest, despite the arboretum possibly having more diversity of life per area. This is true even though that alterations in this case resulted in the promotion of diversity (Key point #5 and #6). Regardless of quantity of diversity, the level of biodiversity alteration that is inherent to arboretums will quite likely make it of less biodiversity value when considering common usages of the term, as well as to render it of less value when considering the idea of biodiversity.

Second, when biodiversity is evoked its value is generally implied. "For many, the term 'biodiversity' is value laden. It carries with it connotations that biodiversity is per se a good thing, that its loss is bad, and that something should be done to maintain it. This has reached the point where the discussion of biodiversity may often be taken as implying acceptance of these premises, and they have effectively been incorporated into the working definitions of biodiversity which many people use" (Gaston, 1998).

This is reasonable for practical definitions of biodiversity, but it is problematic for the idea of biodiversity. If we accept the previous statement that the "connotation that biodiversity is per se a good thing, that its loss is bad" have been "incorporated into the working definitions of biodiversity which many people use" (Gaston, 1998), then one would assume that more biodiversity is good and less is bad period, but as I previously noted this is not true with either the common usages of the term biodiversity nor the idea of biodiversity. This leads us to the same conclusion as before, that the amount of biological elements and their diversity isn't the only factor of importance when considering the idea of biodiversity. Thus, how complimentary the biodiversity in question is to the idea of biodiversity involves two factors: the quantity of the

biological elements and their diversity, and the level of intentional human alteration (Key point #6).

The idea of biodiversity illuminate parameters already existent within the common usage of the term, but previously not formally addressed. In doing this it not only allows one to contemplate the theoretical concept of biodiversity more easily, but it also recognizes and legitimizes the majority of the contextual common usages of the term.

The idea of biodiversity does not delegitimize the use of reasonable common uses of the term 'biodiversity'. In fact the parameters of the idea of biodiversity are based off of the common uses of the term. A common use in turn is 'reasonable' because it reflects the idea of biodiversity (the aspects that the vast majority of understandings of biodiversity share when evoked). The most fundamental aspect being that all reasonable uses of biodiversity are evoked with the intent of being focused on the diversity or variety of life.

The term is often used in regards to the preservation of biodiversity rich areas, which as shown means in practice those areas with minimal alterations as well as high levels of diversity, and not a particularly diverse zoo. Due to the fact that the idea of biodiversity does not endorse the alteration of the elements of biodiversity, it likewise does not imply the intentional preservation or protection of the elements of biodiversity. This dilemma reflects the main practical limitation of the idea of biodiversity and why common usage, practical, uses of the term are not only common, but also arguably necessary. Efforts that limit the effects of conifer killing bark beetles would not be in line with the idea of biodiversity, for example, but the action would arguably be done with the greater good¹⁵ of the diversity of life in mind, and thus could be said to be an action in line with a reasonable common usage understanding of biodiversity, which is complimentary, but not tantamount, to the idea of biodiversity.

¹⁵ This is true from at least a human perspective.

In this way, this paper is not an argument that one should follow the idea of biodiversity in their social policies or individual practices, but that if one is to evoke the term biodiversity then that contextual usage of the term should compliment the essence of the conceptual archetype of biodiversity, in other words, the idea of biodiversity.

4 Biodiversity

4.1 The Importance of Understanding the Term ‘Biodiversity’

There are plenty of dialogs on this topic, and it deserves a fair bit of attention. Presenting the current and historic understandings of ‘what is biodiversity?’ is necessary in order to claim that my position regarding this question is a reasonable and defensible one.

Many authors have either attempted to give a definition of biodiversity that is contextual to the nature of their work and reflective of their larger environmental position, and or they have attempted to outline why a definition is elusive; they then generally proceed to list many common definitions (Sarkar, 2007), (Takacs, 1996), (Gaston, 1998), (Faith, 2008), (Norton, 2008). This is a non-exhaustive list, but I want to give a sense of how common the question ‘what is biodiversity?’ is in the literature. Even more problematic is when the term without definition, the assumption being that either we all share a similar conception of the term ‘biodiversity’, or that we can construe what they mean by the context in which they write or speak (Gaston, 1998).

As Takacs helped point out, many individuals regardless of background or interest in the term, do not agree on what the definition of biodiversity is (Takacs, 1996). This opens up a world of interesting dilemmas for those interested in biodiversity. Notably, how can something be conserved when it has not been clearly defined? Which then leads to the very important question, ‘is there common ground amongst these definitions?’. These questions highlight the importance of my research area.

4.2 Understanding the Origins of the Term ‘Biodiversity’

In attempting to understand what is meant by ‘biodiversity’, some have first thought it wise to put the term in a historical context. Two of the more developed and yet distinctly different attempts at this can be seen in Takacs’ and Sarkar’s works. Both of these authors are self-identified philosophers of science, and begin the conversation of ‘what is biodiversity?’ quite

effectively. Both authors stress that biodiversity did not spring out of nowhere, and that it has historical roots prior to its first recorded use in 1986 (Takacs, 1996).

Takacs looks at the historical lineage of biodiversity from a philosophical context. That is to say he elaborates on the theorists who he can directly link to the concept that would become biodiversity. Takacs traces the modern origins of the term 'biodiversity' to the conservationist and naturalist movements of the 19th and 20th century, drawing a lineage of consciousness that begins with thinkers such as John Muir, continues on to Aldo Leopold, Charles S. Elton, Rachel Carson, David Ehrenfeld, up until the 1980's with Norman Myers's, Paul and Anne Ehrlich, its first public usage at The National Forum on BioDiversity, and finally the coinage of the term in the literature by E.O. Wilson (Takacs, 1996). The philosophical history of the term 'biodiversity' is important because although the term itself is relatively new, its origins reflect the fact that the concept of diversity of life having value did not begin with the coinage of the term in the 1980's, but has been in discussion in one way or another for a long time before this.

Takacs also notes a tendency for different environmentalists to hold notably different and often polarized definitions of biodiversity. Takacs gives a series of examples of these varying definitions, and while each individual has personal justifications as to how and why they came to their definition, they are surprisingly different from one another. This said, most understandings seem to reflect a few broad lines of thought: whether biodiversity has value in itself, regardless of human utility (biocentrism versus anthropocentric); whether these discussions are of moral concern; and whether the definition proposed is concerned with practicalities, that is to say a definition that is focused on best practices for conservation (e.g. preservation versus conservation).

Related to this; conservationists', naturalists', and conservation biologists' often show another, perhaps more thought provoking dilemma, "How do you convince others to care about what you love?" (Takacs, 1996), while at the same time maintaining the scientific ideal of objectivity (Takacs clearly makes the first point, but does not refer to the second, this is my thought and I do not want to misrepresent him). This is not only a problem of getting an 'other'

to share values with you that they had not previously shared, but additionally, assuming those values are shared how does one deal with the incongruences between the newly valued concept of biodiversity, and the traditionally valued practice of agriculture?

In contrast to Takacs' history of thought approach to determining the origin of the term 'biodiversity', Sarkar looks at the origins of the word from a history of science and politics point of view. He describes a lineage in which the concept of ecological diversity led to the concept of biodiversity, which has now led to the modern conservation biology movement; with many important scientific and political milestones on the path (Sahotra, 2005), (Sahotra, 2007).

Sarkar (2007) also notes that prior to the coinage of the term 'biodiversity', the concept existed in the minds of those who were concerned with conservation. This can be seen in debates over the diversity-stability relationship, the development of differentiations between different scales of diversity (i.e. differentiating α , β , and γ diversity), and political actions such as the U.S. Endangered Species Act, all of which occurred prior to the coinage of the word 'biodiversity'.

The context in which the concept of biodiversity sprung is important for understanding issues involving its definition, or in this case, the wealth of different definitions that exist for the term.

4.3 Issues with Defining Biodiversity

"How should we define the term, 'biodiversity'? There seems to be a near consensus answer: there is no generally accepted definition of the key term, 'biodiversity'" (Norton, 2008). Biodiversity has proven to be an extremely contextual term in practice, and has relatively lax constraints on its usage. That is to say that it has many meanings that are mostly dependent on context, including the background and opinions of the evoker. This has created an impasse in efforts to define the term. In many ways Takacs' largest contribution to this field was his cataloging the wide variety of ways in which conservation biologists define 'biodiversity'. This research is extremely useful in illuminating where the fundamental differences are in

understanding amongst these conservationists as to what biodiversity means for them (something Takacs also did in the book in which this research was originally published).

In the categorization of biodiversity definitions and understandings there have been a few different ways it has been divided, yet one distinction appears to be the most common. A definition of biodiversity generally falls either into the category of ‘inventory’ definitions or of ‘difference’ definitions. Inventory definitions focus on the inventory of life.¹⁶ That is to say that the definition makes no distinction on form, function, rarity, uniqueness, etc. that could be used to otherwise determine diversity of life, but looks at all varying forms of life as separate and unique. Examples of inventory definitions of biodiversity can be seen in Reid (1989), Wilson (1988), Ehrlich (1992) (to name a few examples).

Difference definitions take a different approach, emphasizing difference between biological entities. Biodiversity is “the sum total of differences among biological entities” (Wood, 2000). This is a clear example of an understanding of biodiversity as something related to difference. Whether one understands biodiversity to be a concept defined by it being an inventory of life, or that of it highlighting differences amongst life, may seem minor, but “if applied at the species level, for example, as an illustration for the multiple facets of diversity, a difference definition would emphasize species that are the only one in their genus and would favor genera with no close relatives” (Norton, 2008), where an inventory definition would not show favoritism by definition¹⁷ (although the practitioners may show favoritism).

Some have attempted to research how specific contexts affect the definition of the term ‘biodiversity’. I will focus on one approach that I found helpful in identifying the contexts in which ‘biodiversity’ is often used. Kevin Gaston separated usage of ‘biodiversity’ into four common contexts, each of which has an effect on how the user understands and evokes the term. He recognizes biodiversity as often being understood as: a concept – focused on the

¹⁶ The E.O. Wilson definition is a prime example of an inventory definitions, “Biological diversity is the variety of life at every hierarchical level and spatial scale of biological organization: genes within populations, populations within species, species within communities, communities within landscapes, landscapes within biomes, biomes within the biosphere” (Wilson, 1988).

¹⁷ Although the practitioners of an inventory understanding of biodiversity may show favoritism in their actions, the favoritism is not implicit the inventory definition.

“variety of life”; a measurable entity – something that “can be made operational and reduced to measurable quantities”; a field of study – “biodiversity might perhaps succinctly be defined as the scientific study of the patterns in, and the determinants and consequences of, the variety of life”; or as a social or political construct (Gaston, 1998).

Elaborating on the idea of biodiversity being a social or political construct, Gaston writes, “For many, the term ‘biodiversity’ is value laden. It carries with it connotations that biodiversity is per se a good thing, that its loss is bad, and that something should be done to maintain it. This has reached the point where the discussion of biodiversity may often be taken as implying acceptance of these premises, and they have effectively been incorporated into the working definitions of biodiversity which many people use” (Gaston, 1998). This understanding of biodiversity is similar to what Sarkar is desiring to become more prevalent when he writes, ‘there must be a convincing normative rationale for its greater value’ (Sarkar, 2007). In other words, many individuals use the term ‘biodiversity’ with the assumption that its acceptance as a good thing requires no proof.

The multitude of understandings of the concept of biodiversity is only the tip of the iceberg of what must be overcome if an agreed definition of biodiversity is to be achieved. Most common usages of the term ‘biodiversity’ focus on species-level diversity. Most experts though have defined biodiversity as diversity at all levels of organization. That is to say biodiversity is concerned with the diversity of genes, the diversity of species, the diversity of populations, the diversity of communities, the diversity of landscapes, and the diversity of biomes (Wilson, 1992), but this itself isn’t agreed upon either, and even if a practical definition was agreed upon there would still be the question of what each of these ‘levels of biodiversity’ means in terms of both definition and science.

4.4 Biodiversity and science

Understanding what is meant when biodiversity is evoked is of interest not just to my work, but to most who are interested in conservation, or who self-identify as interested in biodiversity. There has been a particular focus on defining biodiversity in scientific terms. ‘Scientific’ in this sense implies capable of producing non-subjective understandings of diversity (positivistic), or at minimum capable of comparisons where subjectivity is taken into account (post-positivistic).

There appears to be two obvious reasons for an emphasis on science based definitions of biodiversity. First, giving the lineage of biodiversity that Sarkar (2005), in particular, laid out (see above), which seems to be a very reasonable historic analysis of biodiversity, biodiversity has its roots in scientific ideas, and thus is viewed as a concept that should too be ‘scientific’. The term itself is a conjunction of the words ‘biological diversity’, which at the very least alludes to some connection with biology, a well established scientific field. Related to this, is the fact that well respected scientists such as E.O. Wilson (but many others as well) are not only currently using the term in their work, but were the first to use the term.

Second, the concept of biodiversity is of paramount importance to conservation biology and other policy driven environmental fields despite its ambiguity. To have biodiversity viewed as scientific, as opposed to a vague concept like ‘nature’, imbues a degree of legitimacy to those who evoke it. As Sarkar (2007) points out, “Biodiversity conservation does not occur in a sociopolitical vacuum. Rather, conservation must compete with other potential uses of land, including biological and mineral resources extraction, recreation, conversion for agricultural and industrial development, and wilderness preservation. If biodiversity conservation must trump these other claims, there must be a convincing normative rationale for its greater value”. This ‘convincing normative rationale’ ties into the previous point raised by Takacs (1996), “How do

you convince others to care about what you love?” In this case there has been a clear push to claim that ‘biodiversity is good’, as shown by Gaston (1998). The position that biodiversity is both a scientific concept, with all the prestige and command that comes with a scientific concept¹⁸, as well as unquestionably ‘good’, is what I would call a ‘convincing normative rationale’, and is far superior to it becoming a somewhat waffly term (i.e. Nature). I am not claiming that the logic that it took to get biodiversity to the point of being associated with science is itself false, although the limitations of science in terms of biodiversity should be stressed.

4.4a The Scientific Conception of Biodiversity

Despite many interested parties’ desires, biodiversity represents a concept that science generally has some difficulties with. This is not a claim that biodiversity should not have scientific links, I would argue to the contrary, but there should also be recognition of the limitations of science in regards to our understanding of biodiversity. Science would find it challenging to show with any specificity what accrued effects increased biodiversity and decreased yields on farms in country X would have on biodiversity at the world level, and even more difficulty in linking agricultural policies in one area with biodiversity, not on the whole, but in a distant region. For example, how EU agricultural policies affect biodiversity in Borneo is relevant to biodiversity, but is exceedingly uncomfortable for science, because not only is biodiversity currently practically unmeasurable in any reasonable sense at the EU level but the linkage of EU domestic policies to having affects on biodiversity in a specific isolated region on the other side of the world is far past sciences ability to measure.

There is an additional limitation of the term ‘biodiversity’ in regards to the ‘hard sciences’, and that is that the natural sciences have not traditionally been particularly concerned with social or ethical valuation (this ties closely with positivist versus post-positivist debates). Yet as Daniel Faith points out, “Biodiversity is seen by many as a *symbol* for our lack of knowledge about the components of life's variation, and their importance to humankind These arguments suggest that

¹⁸ (To take advantage of one of the newest additions to the OED) Biodiversity is often valued *because* science.

core biodiversity values might be based more on what we do not know than what we do know. Biodiversity can be viewed as primarily capturing the two-fold challenge of unknown variety, having unknown value.”(Faith, 2008). He goes on to write that, “As the post-positivists pointed out, biodiversity pluralism (multiple understandings of biodiversity) exists because biodiversity is inevitably value-laden — there is no one, correct, measure of biodiversity to be discovered but many, each having different values” (Faith, 2008 minor rewording). The idea of biodiversity, as I have defined it, is admittedly and purposefully vague, and in this way not a typical scientific term. Common usage definitions of biodiversity that correspond to the idea of biodiversity are value dependent and indeterminate, and are apt to become lost in translation from one person to another, including scientist to scientist. Value systems are a topic generally outside the field of science, yet are undetachable from that of contextual/practical definitions of biodiversity.

This has certain relevancies when considering environmentalism and science. The field of conservation biology is distinguished from biology and ecology partially because of the overt and inherent connections between science and value systems.¹⁹ Bryan Norton effectively explains this position when he writes, “While much of our conceptual apparatus is adapted from theoretical ecology, we do not consider our work to be scientific in the narrow sense that it consists of value-free descriptions and explanatory hypotheses. We, on the contrary, believe that conservation biology is a normative science — like medicine it is guided most basically by a commitment to important social values” (Norton & Ulanowicz, 1992). He takes the assumption, as a conservation biologist,²⁰ that biodiversity is to be valued and hence conserved. His position is that social values should determine what aspects of biodiversity are to be protected, and a prime example of how one’s value system affects one’s understanding of biodiversity.

On top of all of this, science has not even been able to clearly define what biodiversity is in the specifics. There is certainly diversity within species, but is this diversity of equal importance to the concept of biodiversity as the diversity amongst different species? If focused at

¹⁹ The connections between the natural sciences and value systems are quite interesting, but to expand upon them in detail is outside the scope of this paper.

²⁰ The operative word here is ‘conservation’, which effectively predetermines the normative position, although not necessarily the justification for it.

the species level, which for better or worse most understandings of biodiversity are, then when are two entities the same and when do they represent diversity? When are two very similar entities considered different? The answer is not as simple as one may suppose.

4.4b What is a species, and how many are there?

Let's suppose that we accept the species understanding of biodiversity.²¹ What is a species? This question isn't as easy to answer as one may think. I was always taught the 'capable of viable reproduction' definition in my biology classes, but this doesn't really make sense for an immense number of species. For example, as Stuart L. Pimm points out, "There is no meaningful definition of 'species' for prokaryotes" (Pimm, 2012). With the previous definition, what does it mean to be an a-sexual species? The problem isn't only for prokaryotes, "Strongly divergent groups of plants often maintain some degree of inter-fertility even though they differ at numerous loci and are effectively evolving on their own" (Hancock, 2012). This point becomes significant when looking at what domesticated plants and animals mean for biodiversity.

Even when we decide to use one system for distinguishing species, acknowledging that this system is likely arbitrary and not necessarily idea for distinguishing species diversity in terms of biodiversity in all cases, then the next question is, how many species are there? "Estimates of non-microbial diversity on Earth range from 2 million to over 50 million species, with great uncertainties in the number of insects, fungi, nematodes, and deep-sea organisms" (Scheffers, *et al.*, 2012).

4.4c What is diversity?

'What is diversity?' is an equally enigmatic question as 'what is a species?'. "In measuring biodiversity, almost by definition the breadth of ways in which differences can be expressed is potentially infinite" (Gaston, 1998). This isn't just a question of what is a species, such as whether we should distinguish by biochemistry, biogeography, ecology, genetics, morphology or

²¹ That is to say that biodiversity is concerned with diversity amongst species and is not equally concerned with genes, populations, landscapes, etc.

physiology, but is also a question of whether species combinations, number of functional species, types of genes, artificial diversity (e.g. agricultural land or other maintained landscapes, domesticated crops, or genetically modified crops), etc. should be considered part of the diversity of biodiversity ((Gaston, 1998), (Angermeier, 1994)).

The topic of science's difficulties with the concept of biodiversity has been well discussed in literature. One fact that appears to remain true is that, "The term biodiversity symbolizes biologists' lack of knowledge about the natural world" (Takacs, 1996). This lack of knowledge exemplifies major reasons why specific science oriented definitions of biodiversity have, as of yet, failed to capture universal acceptance.

5 Agriculture

5.1 What is agriculture?

As mentioned in the Glossary of Terms section, the definition of agriculture is far less controversial than that of biodiversity. The Merriam Webster encyclopedia defines agriculture as, “The active production of useful plants or animals in ecosystems that have been created by people. Agriculture may include cultivating the soil, growing and harvesting crops, and raising livestock” (Merriam-Webster.com, Retrieved January 8, 2014). Where agriculture becomes complicated is not in the definition itself, but in the varying practices, and the effects of said practices, that constitute it. In this chapter I will focus on discussions that relate closely to the question of, ‘what is agriculture?’.

5.2 Domestication

Agriculture is more or less synonymous with domestication. “Domestication is a complex evolutionary process in which human use of plant and animal species leads to morphological and physiological changes that distinguish domesticated taxa from their wild ancestors (Purugganan & Fuller, 2009) referencing (Hancock, 2005). Another way to put it is, “A domesticate, is a species bred in captivity and thereby modified from its wild ancestors in ways making it more useful to humans who control its reproduction and (in the case of animals) its food supply. Domestication is thus distinct from mere taming of wild-born animals” (Diamond, 2002).

Domestication, besides being incredibly interesting generally speaking, has a few rather important implications when one considers it with biodiversity. First, it shows that humans’ role as an entity that transforms its surroundings has long historical roots. Agriculture, and with it domestication, is around 13,000 years old (Diamond, 2002). Second, the advent of domestication and agriculture began the Neolithic revolution, marking the beginning of the end of the hunter-

gatherer lifestyle (Purugganan & Fuller, 2009). Third, it allowed (almost required) humans to shift away from nomadic lifestyles, and this led to urbanization. Fourth, domestication has been and continues to be that which facilitates rapid human population growth, a fact that also makes us utterly reliant on it. For humans are, and have been for quite some time, far too numerous in population to revert to pre-agriculture systems at any significant level (Diamond, 2002), (Balmford *et al.*, 2012). Fifth,²² domestication led to not only population growth but also to a rapid increase in the rate of technological innovations. Many non-agricultural technologies were invented in part due to the excess food and lifestyle agricultural societies provided. As Jared Diamond put it, "... Sedentary living permitted the accumulation of heavy technology (such as forges and printing presses) that nomadic hunter-gatherers could not carry, and ... the storable food surpluses resulting from agriculture could be used to feed full-time craftspeople and inventors" (Diamond, 2002).

By 5000 B.C. nearly all of our current major crops had been domesticated (Hancock, 2012). Domestication can be viewed a few different ways. It can be seen as a very successful form of plant-animal or animal-animal mutualism, in that if a plant or animal has been successfully domesticated, altered in ways so that it is superior for human use than comparable plants or animals, then it is likely that this species is currently dominant on many agricultural landscapes worldwide. The benefit for humans is that we obtain a superior and reliable source of calories, and the benefit for the domesticate is highly assisted propagation. Domestication can also be seen as a form of co-evolution. An interesting example is lactase persistence. Lactase persistence is the uniquely human phenomenon of producing lactase post infancy, which allows us to digest dairy products throughout our entire life. This shows that in the evolutionary process of domesticating wild cattle, humans also facilitated an evolutionary change in themselves (Purugganan & Fuller, 2009).

²² There is the question too of 'why would we want to?', but this is a tangent.

5.3 Domestication as Genetic Alteration

Regardless of domestication's status as an example of mutualism and co-evolution, one thing is clear, domestication equates to a form of genetic alteration. "Once plants were domesticated, they were dramatically altered by humans through conscious and unconscious selection" (Hancock, 2012). Many of our current crops are morphologically and genetically radically different from their wild, non-altered, cousins. The wild ancestor of cabbage (*Brassica oleracea*), for example, "was variously selected for its leaves (cabbage and kale), stems (kohlrabi), flower shoots (broccoli and cauliflower), and buds (brussels sprouts)" (Diamond, 2002). In an example regarding genetics, "the number of genes associated with crop domestication and diversification in maize is large, with 2-4% of genes in the genome showing evidence of selection. Furthermore, a recent study of genome-wide nucleotide polymorphism in rice suggests that domestication may have affected the entire genome, possibly because selection acted on a large number of loci" (Purugganan & Fuller, 2009).

It would be beyond this paper's scope to go into extreme depth on this subject, but an overview of the process of domestication and its effects seems relevant. As mentioned, agriculture and domestication go hand and hand. "Once humans began sowing seeds, they began to alter plant species through both conscious and unconscious selection" (Hancock, 2012). The traits that were consciously preferred seem somewhat obvious: larger seeds and fruits, increased palatability, color changes, loss of defensive structures, increased adaptability

(allowing a great number of acceptable conditions for growth and causing dramatic range increases), and so forth.

The unconscious selections of crop traits often resulted in increased yields or ease of harvestability. Unconscious selection favored traits such as: self-pollinating plants, annuals, even and rapid germination, and uniform ripening periods. These were all likely unintentionally favored through human practices, but nonetheless encouraged domestication to evolve in such a way that domesticated crops produced large quantities of food, were easily harvested, and (due to their rapid germination) were resistant to weather and pest devastation prior to harvest (Hancock, 2012).

One of the more important and interesting traits of most domesticated crops is a partial reliance on human intervention for their propagation. This increase in the effort needed for reproduction often took the form of humans favoring the non-shattering trait in seed plants. This trait causes a seeding plant to not disperse its seeds, effectively leaving the domesticated crop in question sterile without outside interference. The reason this trait was favored is due to the fact that it dramatically increased harvestability. It also reduced the likelihood of other non-desirable seeds being collected, for if a seedpod did burst, the seeds would then be collected from the ground. This is not only much more difficult and would result in lower yields due to loss, but it also would have made unwanted seed contamination quite high (Diamond, 2002). The next section will expand on genetically modified crops and how characteristics of domestication parallel

characteristics of modern GMOs. For example, instead of having a low reproduction potential, they are often actually sterile (at least theoretically).

The domestication of animals is likewise interesting. “Individual wild animals also vary in traits affecting their desirability to humans. Chickens were selected to be larger, wild cattle (aurochs) to be smaller, and sheep to lose their bristly outer hairs (the kemp) and not to shed their soft inner hairs (the wool)” (Diamond, 2002). Perhaps most notable is that domestic animals generally have diminished senses and smaller brains than their non-domestic counterparts, traits that, once domesticated, were no longer necessary for survival (Diamond, 2002).

5.4 Artificial Diversity

What is artificial diversity? In this case it is biodiversity that has been intentionally altered at the genetic level.²³ This takes two forms in regards to agriculture: domestication, and laboratory genetic modifications (GMOs or GMs).

From an idea of biodiversity point of view neither are perfect in that they both represent intentionally altered biodiversity, and in practice are designed to be promoted over less intentionally altered forms of diversity. This being said, agriculture is synonymous with domestication and our society is completely reliant on it, and thus when dealing with agriculture it is assumed that one has already accepted this antagonism with biodiversity.

From a practical point of view the case for artificial diversity gets quite a bit more complicated. Given the fact that agriculture has always attempted to improve its crops in terms of what they produce for society, and that domestication represents a form of intentional genetic

²³ I am ignoring artificial at the species or landscape level, which is an inherent aspect of agriculture, but is considered far more innocuous socially (i.e. Describing the presence or absence of species, and the alteration of a landscape, both abiotic and biotic, due to conscious action.).

alteration, and that this genetic alteration often has resulted in increased yields, then it would seem counter to the lineage of agriculture to allow these ‘improvements’ up to but not including GMOs. Domesticates already represent biodiversity of questionable value from the idea of biodiversity standpoint, and as noted agriculture has always been focused on the continual improvement of its few domesticated species.²⁴

Additionally, recognizing that agriculture represents an extremely small amount of biodiversity relative to the plethora of species on this earth, that any effort to further increase agricultural yields without disproportionately high inputs or externalities would likely be a relatively positive thing from both a common usage understanding of biodiversity and from the idea of biodiversity standpoint, in that this increased yield would result in less land conversion.

The focus of this thesis is not to make claims about optimal agricultural management techniques, as this itself is highly contextual regardless of how one understands the antagonisms between agriculture and biodiversity. However, it would be pertinent for a society that values the concept of biodiversity to consider the effects of agriculture holistically. As to the value of biodiversity on agricultural land, diversity amongst different species has never been a notable focus of domestication. Further, diversity within a domesticate species represents diversity of reduced value from the idea of biodiversity point of view. Additionally, domestication, much like GMOs, represents highly altered biodiversity, and much like how a genetics lab isn’t the archetype of biodiversity, neither is a farm. These facts do not change the reality that agriculture is essential to modern society. Given the historic lineage of agriculture, if it is well managed, there is a strong case for the allowance of most, if not all, technologies and practices that advance the field, assuming they involve increased yields with relatively reasonable externalities.

²⁴ ... as well as its technologies. This is not discussed in this paper, but arguably GMOs represent both.

5.5 Domesticates: An Elite and Excluding Club

It should not be overlooked that the notable lack of diversity amongst species (or landscapes for that matter) clearly appears to be incongruent with the concept of biodiversity. Currently “a small number of species of crops, domesticated by a variety of early civilizations,provides the basis of most of our food consumption. Fifteen species of plants, primarily grains, provide over 90% of all human energy needs, and over 98% of all human food is produced in terrestrial habitats” (Lacher *et al.*, 1999), (Paoletti *et al.*, 1992). This raises the question, is this a problem from either an agricultural or a biodiversity perspective? There are an estimated 2 to 50 million non-microbial species and we consume around 20 for practically all of our calorie needs. While agricultural land undoubtedly hosts more species than those we consume, it is still an intentionally simplified system. In addition, given the morphological and genetic changes that have occurred within domesticated plants and animals due to human practices, should they even be considered part of biodiversity? If so then should GMO’s be considered part of domestication and biodiversity as well?

The latter question is quite difficult to answer in definitive terms. Biodiversity may be a bio-centric concept, but it is still a human conception. That is to say it is meaningless outside of the human mind, so it may be simply a question of whether we want to include these species or not, and our justifications for our choice. Regardless, given the current and past realities of domestication and agriculture, it is a bit of a moot point, as even when included, the diversity represented on agricultural land is extremely simplified and diminished as when compared to unique or high diversity areas of the world, and much of the thrust of this paper is expanding on the tradeoffs often ignored between the conservation of non-agricultural biodiversity versus the encouragement of biodiversity on agricultural lands for biodiversity’s sake.

A characteristic of agriculture that does not seem to fit with the concept of biodiversity is the low number of plants and animals domesticated over the millennia. To this day our most important sources of calories come from some of the first few plants to have been domesticated

(rice, wheat, maize, potatoes, yams, millet, etc.). There are 148 species of terrestrial herbivore and omnivore mammals weighing over 45kg, yet only 14 were domesticated. There are around 200,000 wild species of higher plants, yet only around 100 produced valuable domesticates (Diamond, 2002). In these terms, diversity at the species level has never been the focus of agriculture. It would appear that the actual focus has been the continual development of the few domesticate species we have, with a tendency for encouraging human influenced intra-species diversification but almost no inter-species diversification.

Maize offers a good example of the significant changes that occur in the domestication process, as well as an example of the high degrees of intra-species diversification found in domesticates. Teosinte, the true wild relative of maize, morphologically more resembles a tall grass than it does maize, and while different, genetically it has significant similarities (University of Utah - Genetic Science Learning Center, 2014). Despite a connection to teosinte, the vast majority of diversity amongst maize crops is the result of genetic changes due to human intervention through the domestication process.

5.6 Less intensive versus intensive agriculture

Those who are interested in preserving biodiversity often have an opinion as to what is the best way to accomplish this in regards to agriculture. There are two major camps when it comes to this issue, those who believe 'less intensive' agriculture is superior from a biodiversity standpoint, and those who believe that 'intensive' agriculture is superior. The fact that such opposing opinions can simultaneously be seen as reasonable from parties interested in accomplishing the apparent same goal, that is preserving biodiversity, reflect the fact that this is a complicated and multifaceted issue.

Before comparing less intensive and intensive agriculture, it should be noted that there is a spectrum as to how much value one puts on biodiversity, and likewise how one understands the concept of biodiversity, in these different arguments. This paper uses the terms 'less

intensive' and 'intensive'. It could likewise use the terms 'low input' versus 'high input', 'low yield' versus 'high yield', or 'low intensity' versus 'high intensity'.²⁵ Each of these locutions, as is generally the case with language, shows some sort of bias. I choose to use the phrases less intensive and intensive because I believe all large scale agricultural systems to be intensive in that they completely reorganize and simplify the land that they occupy. The question of how much and what inputs are added to these already radically changed systems is more of a question of whether the agriculture in question is highly or very highly intensive: both are intensive relative to a non-agricultural ecosystem in the same area. This is from an environmental point of view and reflects my biases, but I believe that this choice is nonetheless as good, and perhaps better, than other options.

What is less intensive agriculture? Because these are relative terms to each other, the easiest way to define less intensive agriculture is by comparing it to intensive agriculture. Intensive agriculture is characterized by high yields and high inputs. Fertilizers, heavy equipment, pesticides, genetically modified crops, etc. could all be associated with intensive agriculture. Less intensive agriculture on the other hand has less inputs and lower yields (Green *et al.*, 2005). Proponents of less intensive agriculture generally believe it to be superior because from their point of view, "Intensified land use in agriculture and forestry is... the main cause of global change and biodiversity loss" (Tscharntke *et al.*, 2005).

Intensive agriculture is comparatively a more simplified system than that of less intensive agriculture. This generally means that there is less biodiversity on an intensively managed agricultural plot than would be seen on the same plot managed in a less intensive way (Bengtsson *et al.*, 2005). In addition, much of the inputs used in intensive agriculture can potentially disrupt natural systems of pest control, pollination, and decomposition²⁶ (Tscharntke *et al.*, 2005), (Tilman, *et al.*, 2002).

²⁵ 'Low intensity' and 'high intensity' agriculture appear to be the most common terms in the literature, but I find them to be the most misleading, in that I would argue that all agriculture is intensive.

²⁶ Presumably less intensive agriculture has this propensity as well.

Proponents of intensive agriculture appear to accept most of the points put forward by proponents of low intensity agriculture, and to be fair many proponents of intensive agriculture are only proponents situationally, depending on the context. In certain contexts many would feel that even less intensive agriculture would still be too disruptive, and complete avoidance of large-scale agriculture would be ideal. An area of high endemic biodiversity may be an example of this.

When it comes to biodiversity and agriculture, there are certain issues that those in favor of intensive agriculture often stress. First, while it is likely that biodiversity will be higher on less intensively farmed land, some of the biodiversity hosted on less intensive agriculture contributes to yield reductions by competing with, or feeding on, the planted crops (Zhanga *et al.*, 2007). Related to this, proponents of intensive agriculture argue that less intensive agriculture's lower yields is actually worse for biodiversity (as well as other environmental related issues) due to the demand this creates to increase the total global agricultural area. This follows because the world population is not decreasing, so if yields on current agricultural lands are to decrease then our society must find new ways of obtaining food to make up the difference. "Increased production must be met through higher yields because increasing the area of land in agriculture carries major environmental costs. Although land usable for agriculture exists, it consists mainly of forests, wetlands, or grasslands, whose conversion would greatly increase GHG emissions and the loss of biodiversity and important ecosystem services.²⁷ Although less intensive, generally lower-yielding production may generate local environmental benefits, it is critical to consider potential indirect consequences, in particular the risk that land is cleared for agricultural production elsewhere to compensate for locally lower yields" (Garnett *et al.*, 2013).

5.7 The Interconnected Debates Involving Agriculture and Biodiversity

The question as to what is superior, 'less intensive' or 'intensive' agriculture has aligned closely to other environmental debates. There are two in particular which I will speak to in this

²⁷ Ecosystem services are not the focus of this paper, but whether these services are more disrupted through less intensive or intensive agriculture on the global scale is likely highly contextual.

paper, the land sparing versus land sharing debate, and the merits of preservation debate. All three of these debates (less intensive versus intensive agriculture included) relate incredibly closely to each other, and one's opinion towards one will likely affect one's opinion towards the others. The crux that ties these issues together is the reality that the world's human population is increasing yet there is only a finite amount of agricultural land currently in existence, and the conversion of new agricultural lands generally comes at significant environmental costs, as noted in the previous section (Garnett *et al.*, 2013).

Agricultural land currently covers over 38% of global land area (FAOSTAT, 2011): when taken together with areas occupied by human settlements, only a relatively small percentage of non-exploited arable land is available (Despommier, 2010). The exploitation of this potential agricultural land would have dramatic effects on biodiversity. "When forests or grasslands are converted to an agroecosystem, virtually all native species of plants and many of the animals are lost" (Lacher *et al.*, 1999).

It should also be noted that agricultural practices have a clear interplay with not only land sparing versus land sharing type debates (i.e. intensive versus highly intensive), but also effect environmental preservation debates. "In land sparing, agricultural areas are used intensively. This results in a high agricultural yield from a relatively small area of land thereby allowing for the permanent preservation of species rich areas nearby" (Fischer *et al.*, 2008) referencing (Green *et al.*, 2005). This one sentence ties in all three debates. Land sparing is basically the idea that if agriculture is managed in a way that produces a high sustained yield of crops with acceptable externalities, that this will allow more land to be available for preservation.

In contrast to land sparing, land sharing "aims to make existing farmland as hospitable to wild²⁸ species as possible, by reducing inputs of pesticides and fertilizers and retaining on-farm habitat elements such as shade trees, hedgerows and ponds" (Balmford *et al.*, 2012). There is a subtle yet important difference between land sharing and low intensity agriculture. The concept of land sharing generally involves the inclusion of 'non-agricultural' bits of land within the

²⁸ What does 'wild' mean in the context of agriculture?

agricultural system. These bits of land offer habitat for biodiversity outside of the expected agricultural crops and weeds themselves. Less intensive agriculture on the other hand does not necessarily involve land being shared. It simply means that there have been less inputs added to the agricultural system in question as compared to intensive agriculture.

Additionally, in land sharing versus land sparing debates there is much discussion of ‘edge habitats’. This topic is not as prevalent in less intensive agriculture discussions. The edge effect, which is created by edge habitats, is the “tendency for the variety and density of some species of plants and animals to increase at the border between different plant communities. Edges, or ecotones, contain species from both habitat as well as a subset of species considered to be edge specialists” (Lacher *et al.*, 1999). Edge habitats can potentially encourage significantly greater amounts of life to exist on and near agricultural land. This does however come at a cost. The agricultural edge habitats created by land sharing schemes likely involve numerous small habitat reserves, this means that the reserves are not only small, but likely fragmented. While some species thrive in these conditions, many others struggle. Additionally the small reserved habitats are often less rich and complex systems than large preserves, and in some studies are found to be less healthy, with the rate of parasitism and disease being higher within them (Lacher *et al.*, 1999).

There are obvious benefits and costs to all of these biodiversity and agricultural management techniques. It is important to remember that the success of either land sparing or land sharing, or any other type of agriculture for that matter, is dependent on proper management. “Increases in crop yields do not guarantee land sparing, and land sharing schemes do not guarantee benefits to biodiversity on farmed land; instead, both approaches require careful design and implementation to be effective” (Phalan *et al.*, 2011).

6 Agriculture's Antagonisms to Biodiversity

The idea of biodiversity is not always the most useful of terms from a practical point of view and so its definition is often tweaked to form a contextual or practical definition that fits the objective and context at hand. This is an expected practice if biodiversity is to have much practical use as a concept, but it should be understood that these uses of the term will vary from context to context, and that they should all be reflective of at least basic elements of the idea of biodiversity. This is explained in far more detail in the Idea of Biodiversity section, but the most prominent aspect of the idea of biodiversity (although not the only aspect) is that it focuses on a variety or diversity of life, and thus likewise any reasonable common usage definition should do so as well.

To positively associate biodiversity with a concept that inhibits by definition the variety or diversity of life misrepresents biodiversity at its most basic level, and, if not clearly stated as a misrepresentation and bastardization of the concept of biodiversity, has the potential to mislead and create confusion as to what the bastardized term implies. This is unreasonable in regards to a term such as biodiversity, which has in modernity become a highly valued concept, a fact that can be seen in both its widespread use, and by the fact that it has become “institutionalized in national, international, and multinational policy and law” (Callicott *et al.*, 1999).

6.1 Why Agriculture is Antagonistic to the Idea of Biodiversity

Many proponents of both biodiversity and agriculture have attempted to link agriculture (having a predominance in modern society), to having a positive effect on biodiversity (rapidly declining in modern society), and vice versa (this can be seen in European Crop Protection Association (2010), FAO (2005), Quinn (2012), Thrupp (1998 & 2000)). This positive linkage between biodiversity and agriculture does not involve a mere tweaking of the idea of biodiversity, it completely misrepresents it. Agriculture is antagonistic to the idea of biodiversity in nearly

every aspect of the practice. Recognizing the incongruities between the two concepts is essential if society is to understand, and by extension manage, these conflicting yet highly valued concepts simultaneously.

The idea of biodiversity can be thought of: as 'having to do with the diversity or variety of life at all conceivable scales', as 'having no inherent emphasis on the qualities of that variety', as 'not involving the active promotion nor hindrance of biodiversity', and thus as 'not *only* differentiating based off of the quantity of biological elements and their diversity, but also as differentiating based off of the level of intentional human alteration' (A condensation of the key points of the Idea of Biodiversity section). Agriculture on the other hand is the systematic massive alteration and simplification of its domain, and relies on this simplification and alteration for its success, and while biodiversity is of some importance to most modern societies, the success of agriculture²⁹ is of paramount importance to the very continuation of modern society.

While agriculture relies on certain aspects of biodiversity, in that agriculture as we know it relies on life, and to an extent ecosystem services (which can often be linked to biodiversity), it is a huge jump to claim an overall positive relationship between the two based on this fact.

As Zhang *et al.* (2007) points out, agriculture receives ecosystem dis-services from biodiversity as well as benefits. "Crop pests, including herbivores, frugivores, seed-eaters, and pathogens (specifically, fungal, bacterial and viral diseases) decrease productivity ... In fields, weed competition for sunlight, water and soil nutrients can reduce crop growth by limiting access to required resources" (Zhang *et al.*, 2007) referencing (Stoller *et al.*, 1987). All of this unwanted life is both diverse and essential to maintaining the idea of biodiversity, and yet if left unchecked it would dramatically inhibit agriculture. Uninhibited biodiversity cannot coexist temporally and spatially with agriculture (this at most would be foraging and hunting, and not agriculture). The hindrance of many aspects of biodiversity and the promoting of specific desirable aspects is effectively what defines agriculture.

²⁹ Success being the production of a sufficient amount of food.

There is little question that agriculture is a massive alteration of systems with the intent of producing a product. “In agroecosystems farmers take a dominant role in this dynamic by the selection of which organisms are present, by modifying the abiotic environment and by interventions aimed at regulating the populations of specific organisms (‘weeds’, ‘pests’, ‘diseases’ and their vectors, alternate hosts and antagonists)” (Swift *et al.*, 2004).

6.2 Why Agriculture is Antagonistic to Practical Aspects of Biodiversity

The history of agriculture shows quite clearly the tension between agriculture and biodiversity being played out. As I previously noted in Chapter 5, ‘diversity of species appears to have never been of high value to agriculture’³⁰, and for good reason, as much of the diversity present in unaltered biodiversity hinders the productivity of crops and livestock.

Additionally, agriculture early in its history domesticated a few select species (due to a natural propensity for domestication, or luck, or whatever), and those species then were spread throughout the world.³¹ The purpose of these domesticates was to supply a steady and reliable food supply that could support an ever growing population (Diamond, 2002), (Hancock, 2012). Once these domesticates had spread and adapted to all major populations across the world there was no longer a pressing need to create new domesticates (Diamond, 2002). The ones already in existence were serving their function adequately, and the general trend appears to have been to focus on perfecting the already existent domesticates as opposed to searching for possible new ones that would likely be less productive in at least the early stages of domestication with no promise of future superiority.

³⁰ A summarization of the major empirical facts from Chapter 5: Agriculture is around 13,000 years old and yet out of the myriad of species found on the earth over 90% of our energy requirements are obtained from 15 species of plants and animals (Lacher *et al.*, 1999). This is not a new trend either, as by the year 5000 B.C. nearly all of our major crops had already been domesticated (Hancock, 2012).

³¹ It should be noted that different domesticates developed in different locations around the world at different times. The spread of these domesticates varied as well. Crops spread with more ease latitudinally compared to longitudinally most due to similar growing conditions, and the domesticates that were developed in the new world were completely isolated from those developed in the old world up until somewhat modern history (Diamond, 2002).

Although agriculture represents a massive alteration of its domain, there are some situations in which agriculture can be thought of as an improvement to biodiversity in the common usage sense of the word, but only when the land prior to the agriculture was already lacking from a biodiversity point of view more than the agriculture in question currently represents³². These situations can be misleading though because the ‘improvement’ to biodiversity is only relative to the deteriorated state, and even with its improvements to biodiversity it would not imply, nor lend itself towards being, the optimal option from a biodiversity standpoint. In this case, both agriculture and biodiversity would benefit, but with the emphasis always on agriculture. It should be noted that this example does not show that agriculture is sometimes complimentary to the idea of biodiversity, this is because when considering the idea of biodiversity the assumption would not be a degraded state, but one of minimal human alteration; and as shown in this thesis, agricultural systems involve massive human alterations in that they completely reorganize and simplify the land that they occupy.

The practical realities of agriculture are clearly not consistent with a reasonable understanding of biodiversity. If biodiversity on the plot decreases yields then it follows that this will increase the likelihood of agricultural land conversion world wide, assuming that the human population will not decrease in the near future. The areas potentially affected by agricultural land conversion are often much more reflective of the idea of biodiversity than agricultural land. Additionally, they are also far more likely to be of higher value in a common usage (practical) understanding of biodiversity as well. For as previously explained, most of the remaining uncultivated arable land consists of forests, grasslands, and wetlands, all of which would likely have a greater amount, as well as a more diverse selection, of the elements of biodiversity (Lacher *et al.*, 1999). “Hence, although wildlife-friendly farming offers scope to increase the biodiversity value of farmed land on a per unit area basis, this may not result in a net benefit to biodiversity if

³² For example, urban agriculture in a region that use to be a swamp. The transition from parking lot to farm is an obvious improvement to the biodiversity, both to the region and holistically, as it is hard to image the negative external biodiversity effects from such a initiative. But, the biodiversity of the initial landscape (the swamp) would have been optimal.

it reduces crop yield. On the other hand, increasing yield could reduce the requirement for farmland and the rate of conversion of currently nonfarmed land.” (Green *et al.*, 2005). This makes the balance between agriculture and biodiversity that a society chooses exceedingly important because it affects not only the agriculture and biodiversity on the plot, but through a series of steps, it also affects the qualities of agriculture and biodiversity on a global level.

The fact that when agriculture is present biodiversity is limited is indicative of the fact that agriculture and biodiversity as non-fragmented concepts are antagonistic to each other. As Swift *et al.* (2004) pointed out, “An integral part of agricultural intensification at the plot level is the deliberate reduction of diversity”, and as I have pointed out, all agriculture is intensive. Despite some reliance on biodiversity from agriculture, the presence of agriculture implies inhibited biodiversity, and the excess presence of biodiversity (that is to say the presence of aspects of biodiversity that reduce long term productivity) will likewise inhibit agriculture.

7 Agrobiodiversity

The FAO defines agrobiodiversity as, “The variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel and pharmaceuticals. It also includes the diversity of non-harvested species that support production (soil micro-organisms, predators, pollinators), and those in the wider environment that support agro-ecosystems (agricultural, pastoral, forest and aquatic) as well as the diversity of the agro-ecosystems.” (FAO).

The opening sentence of the agricultural biodiversity page on wikipedia reads, "Agricultural biodiversity is a sub-set of general biodiversity" (Wikipedia.org, 2014). Despite stigma over referencing wikipedia, in this case I believe it to be the perfect source, for as a freely editable online encyclopedia it offers some insight into the general understanding of a concept. Additionally the FAO supports this position, they write, “agrobiodiversity is a vital subset of biodiversity, which is developed and actively managed by farmers, herders and fishers” (FAO, 2005). The fact that agricultural biodiversity, a term which has been adopted by well known international organizations and has also appeared in academic literature, has been adopted into the environmentalist lexicon reflects how relatively unexamined the incongruities between agriculture and biodiversity are.

First of all, agrobiodiversity is clearly a subset of agriculture and not biodiversity. When a forest is clearcut in the name of agriculture, even if the agriculture practiced is that of agrobiodiversity, it is not generally thought of as a no lose situation for biodiversity, but rather as agricultural land conversion. The term agrobiodiversity implies agriculture with relatively high degrees of biodiversity for agriculture (technically the definition doesn't speak of the quantity of the diversity, but in practice it is almost always, if not always, used in this way). This is not biodiversity itself, but the elements of biodiversity that relate to agriculture, and as explained in

this paper, these elements are relatively minuscule in terms of diversity (even when purposefully increased), and the domesticated aspects of agrobiodiversity are of questionable value in terms of the idea of biodiversity. Agrobiodiversity being agriculture is still, despite its name, antagonistic to biodiversity, and is in no significant way more complementary to the idea of biodiversity than other forms of agriculture.

My issue with agrobiodiversity is not the concept itself, but its name and what its name implies. Agrobiodiversity is the elements of biodiversity that are beneficial to agriculture, and it carries with it the implication that higher degrees of agrobiodiversity are better for biodiversity. Agrobiodiversity is not biodiversity though, it is either a concept in itself, or when practiced a method of agriculture. This is not to say that what is understood as agricultural biodiversity should never be practiced. The types of conflicts that occur between agriculture and biodiversity, as well as whether society should value biodiversity or agriculture or a balance, considering the realities and viable options on the ground, will differ from place to place. What will not differ is that there will be conflict between the concept of agricultural and that of biodiversity.

There are four problematic issues I perceive in using the term 'agricultural biodiversity'. First, as already mentioned, it represents a conceptual misnomer. Second, and related to the first point, due to the association agricultural biodiversity has with biodiversity, to the point that the word for the former includes the latter, it becomes problematic to argue against agricultural biodiversity, even on environmental grounds. In modernity it can be difficult to argue against biodiversity, and agricultural biodiversity, being falsely associated with biodiversity, is mistakenly given some of that immunity to criticism.

Third, due to the choice to name an agricultural practice 'agrobiodiversity', and the insistence that this agricultural practice is a subset of biodiversity, the term is easily used in ways that assume that this practice is not only beneficial to biodiversity comparative to other types of agriculture, and possibly even other non-agricultural states, but that it is the ideal option by definition for those who are concerned with both agriculture and biodiversity.

Fourth, agrobiodiversity in practice is easily, although likely accidentally, used as a red herring (“something that is used to stop people from noticing or thinking about something important” (Merriam-Webster.com, Retrieved January 9, 2014)). When one uses and or reads a term that is in relatively wide use, including by major international organizations like the FAO, and has become an accepted single word conjunction, it is assumed that the concept is not an oxymoron. Therefore when people use ‘agrobiodiversity’ they can not only do so without having to show that their form of agriculture has a positive relation to biodiversity when compared to alternatives, they, by not using the terms as separate, avoid discussing as to how the three individual concepts of agriculture, biodiversity, and ‘agriculture biodiversity’ relate to each other. This is misleading, and not only sidesteps a debate of importance, but also, due to the value both biodiversity and agriculture have in society, can lead to suboptimal results in terms of both agriculture and biodiversity considering the societal goals regarding the two separate terms.

What is good for agrobiodiversity is not necessarily good for biodiversity. In practice agrobiodiversity is evoked in order to argue for more biodiversity on agricultural land. While this is not negative in and of itself, as this paper shows (as well as other heated debates such as land sparing versus land sharing, etc.), whether increasing biodiversity for the sake of increased biodiversity on agricultural lands is positive or negative for biodiversity is far from obvious. Green *et al.* explain this dilemma quite well when they write, “Evidence that about half of Costa Rica’s native forest species of birds, mammals, butterflies, and moths also occur in agricultural areas has been used to argue that maintaining low- intensity agriculture will benefit biodiversity in developing countries as well. It is clear that adopting farming methods that enhance population densities of wild plant and animal species on farmland is beneficial to biodiversity, provided that the change to wildlife-friendly farming does not require a reduction in crop yield. However, it is frequently observed that the biodiversity value of farmland declines with increasing yield, which suggests that maintaining high wildlife interest on farmland often requires foregoing opportunities for high crop yields. Existing agri-environment schemes depend on farmers

receiving large amounts of financial compensation for lost production, demonstrating that such yield penalties are perceived as real.” (Green *et al.*, 2005).

There are many viable options when considering how best to manage both agriculture and biodiversity. Agricultural biodiversity is one option, but, despite its name, it is not necessarily the optimal option for a society attempting to invest in the aspects of biodiversity and agriculture that they find of value. Allowing land to go feral, intensified agriculture combined with preservation efforts (land sparing), efforts to limit population growth, rooftop farms, vertical farms, etc., are all viable options a society could consider in the effort to satisfy its desires for agriculture and biodiversity. Evoking agricultural biodiversity can mislead one to assume that it is by definition the optimal balance a society can pursue between these two concepts. The reality is that in many situations other options may in fact satisfy societies desires for both agriculture and biodiversity better than agriculture biodiversity.

9 Conclusion

Since biodiversity first gained traction as a concept of societal value, beginning in the mid 1980's, many of the antagonisms between agriculture and biodiversity appear to have gone mostly ignored, the general focus in the literature being the conservation of biodiversity. The term 'biodiversity', with its implied value yet vague definition has been used as a means to that end. Exploring the internal inconsistencies in the logic of how these concepts have been used in conjunction with each other has not been a priority.

In wrapping up this thesis, I will make one last point, by asking, 'which is threatened, biodiversity or agriculture?' Agriculture is a human construct, and modern society is completely reliant upon it. Agriculture is not truly threatened, because it is simply too important to us as a species for us to allow it to be threatened. We drain lakes, reroute rivers, clearcut forests, go to war, etc., all in the name of agriculture and food security. Biodiversity, both the idea and common usage, on the other hand is threatened, and its relationship to agriculture (all types of agriculture), is not positive, but negative.

While I expanded upon a number of reasons why these two concepts have been, and will continue to be, in contention with each other, the over arching reason for this is that by definition, the existence of one implies to at least some extent the detriment of the other. "Biological diversity is the variety of life at every hierarchical level and spatial scale of biological organization: genes within populations, populations within species, species within communities, communities within landscapes, landscapes within biomes, biomes within the biosphere" (Wilson, 1988). Agriculture on the other hand is the "The active production of useful plants or animals in ecosystems that have been created by people (Merriam-Webster.com, Retrieved January 8, 2014).

Agriculture heavily alters and simplifies its domain. The elimination of biodiversity and the promotion of a few highly altered species, that are human artifacts in that they do not appear

as they are in ‘wild nature’ (that is absent from society), is what defines agriculture. All of this unwanted unaltered life is both diverse and essential to maintaining the idea of biodiversity, and yet if left unchecked it would dramatically inhibit agriculture. In the enigma that is intensive agriculture in modernity, practices that consist of utilizing highly altered domesticates and land that is managed as a means to societal ends (in the case of agriculture generally this is food production, but certain ecological services would likely be a consideration as well), would often be the more ‘biodiversity friendly position’ over the decision to use only agricultural methods that ensured greater amounts of biodiversity on agricultural land, yet produced lower yields, which in turn creates a necessity for more land conversion, which is arguably more harmful to biodiversity in a qualitative and quantitative sense than agriculture that has high yields but relatively low amounts of plot-level agricultural diversity.

At a cursory glance it seems reasonable enough that there could be a methodology where agriculture, if practiced in the proper manner, could be beneficial for biodiversity. After all, there is a clear interplay between the concepts of agriculture and biodiversity. Most apparent is that both are heavily associated with biotic systems (although agriculture is in a much more simplified and controlled way), and that they both require the abiotic for their mediums of existence. Nonetheless, biodiversity conservation efforts and agriculture, regardless of how it has been practiced, has been, and will continue to be, in contention with each other. This is not to say that agriculture does not benefit from some aspects of biodiversity in practice, although vice versa is quite a bit harder to argue unless one is referring to a bastardization of the concept of biodiversity. What it is saying is that when agriculture is present, biodiversity is hindered.

Unrealistic understandings of how agriculture and biodiversity related to each other has culminated in terms like ‘agrobiodiversity’ being incorporated into the environmentalist lexicon. As an environmentalist I appreciate the intent and spirit of the efforts to create a win-win scenario involving agriculture and biodiversity; unfortunately however this it is neither

theoretically nor practically realistic. Efforts that attempt to force the conjoining of these two antagonistic concepts can often do more harm than good.

The realities of agriculture are so inconsistent with biodiversity (both the idea and in practice) that it is more helpful to society to recognizing the inharmonious nature of agriculture and biodiversity so that they can be properly considered and managed. This is preferable to the current practice of disingenuously attempting to claim that agriculture itself is not nocuous to biodiversity, and that the problem is simply modern agriculture with its over-use of technology.

A society that values both agriculture and biodiversity has interests in properly managing both. It is important to recognize that world terrestrial biodiversity is something that society manages: humans currently have an effect on every bit of land on the planet. More importantly we have the ability to radically alter all land globally. This makes us managers of the earth whether we would like to admit it or not. Our management decisions should reflect our values, and assuming we value both agriculture and biodiversity, our decisions should reflect this fact as well.

I do not personally care what form of agriculture, if any, a society chooses to pursue, but I am concerned that the logic used to defend certain forms of agriculture is flawed. When looking at intensive versus less intensive agriculture and their relation to biodiversity I believe that there is a strong case to be made for the benefits of intensive agriculture when it is properly managed with society's values and sustainability in mind. This being said, this proper management would be highly context-dependent. Due to agriculture's antagonistic nature to biodiversity I would argue that it is generally best for both if agriculture is managed in a way that is focused on long term yields more than on plot-level biodiversity. The vast majority of arable land that has yet to be cultivated (forests, wetlands, grasslands, etc.) is far more compatible with the idea of biodiversity than agricultural land, and it is likely more inline with common usage understandings of biodiversity as well.

Agriculture is of unquestioned value to human society, and we are completely reliant on its products for our sustenance. Biodiversity is also of value to many, if not all, societies. Modernity has many important choices to make as to how it will manage agriculture and biodiversity. The fact that our population is increasing and that most of the uncultivated arable land left on earth is of high biodiversity value only makes the optimal choices all the more difficult. It is therefore of great importance that biodiversity be viewed in global terms in regards to the effect agricultural policies will have on biodiversity, and with a much clearer-headed understanding of the true relationship between agriculture and biodiversity than has hitherto been the case.

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