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Amitrajeet A. Batabyal
Utah State University

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**HABITAT CONVERSION, INFORMATION ACQUISITION,
AND THE CONSERVATION OF BIODIVERSITY**

by

AMITRAJEET A. BATABYAL

**Department of Economics
Utah State University
3530 Old Main Hill
Logan, UT 84322-3530**

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AND THE CONSERVATION OF BIODIVERSITY**

Amitrajeet A. Batabyal, Associate Professor

**Department of Economics
Utah State University
3530 Old Main Hill
Logan, UT 84322-3530**

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HABITAT CONVERSION, INFORMATION ACQUISITION, AND THE CONSERVATION OF BIODIVERSITY

Amitrajeet A. Batabyal

ABSTRACT

We analyze two questions concerning the conservation of biodiversity in a dynamic and stochastic framework. First, given the link between natural habitats and biodiversity, *when* should a social planner stop the habitat conversion process? Second, what is the nexus between a social planner's optimal conservation policy (OCP) and the *length* of this individual's planning horizon? We obtain the following two results. First, the OCP calls for the social planner to wait a while, i.e., not act upon receipt of the first $(1/e)$ fraction of all utility packets. The social planner should then stop the habitat conversion process upon receipt of the first candidate packet. The probability that the use of this OCP will result in the conversion process being halted at the optimal point is $(1/e) \approx 0.37$. Second, because the proportion of time for which it is optimal to wait before acting is fixed, *longer* planning horizons result in the conservation of relatively *larger* stocks of biodiversity.

JEL Classification: Q28, D81

Key words: Biodiversity, information, natural habitat, optimal stopping

HABITAT CONVERSION, INFORMATION ACQUISITION, AND THE CONSERVATION OF BIODIVERSITY^{1, 2}

1. Introduction

In recent times, a great deal of concern has been expressed about the decline in the world's diverse biological resources. Ecologists and economists now agree that not only are we losing biological diversity (hereafter biodiversity), we are losing it at an unprecedented rate (Swanson 1995a, p. xi). Although popular explanations for the problem of biodiversity loss abound, it is only very recently that ecologists and economists have begun to pool their resources to systematically study issues pertaining to the loss and the conservation of biodiversity.³ An important conclusion emanating from this joint "ecological-economic" approach to the subject is that when viewing the problem of biodiversity loss, it is generally inappropriate to concentrate on the loss of genetic information. Instead, what researchers should be focusing on are the connections between biodiversity loss and the associated loss of ecosystem resilience (Perrings et al. 1995b, pp. 16-17).

Beyond this general finding, ecologists and economists have analyzed three specific issues related to biodiversity. These issues concern the valuation of biodiversity, a determination of the causes for the decline in biodiversity, and the measurement of biodiversity. The valuation of biodiversity has become an important issue not only because of the demonstrated link between biodiversity loss and the loss of ecosystem resilience, but more narrowly, because of its close link

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²Department of Economics and Ecology Center, Utah State University, 3530 Old Main Hill, Logan, UT 84322-3530, USA. Internet batabyal@b202.usu.edu

³For more on this joint research, see the papers in Perrings et al. (1995a) and Swanson (1995a).

to “biodiversity prospecting,” and hence to the potential discovery of new pharmaceutical products. Polasky and Solow (1995), Simpson et al. (1996) and others have investigated this valuation issue. These researchers have shown that by deriving a demand curve for native genetic resources, one can determine the marginal willingness to pay for the marginal species and the marginal hectare of threatened habitat.

Inquiries into the causes for the decline in biodiversity have been conducted by Barbier and Rauscher (1995), by Gadgil (1995), and by Southgate (1995).⁴ By demonstrating a causal link between myopic policy-making and a diminution in biodiversity, these authors have pointed to the need for designing conservation policies which take into account the economics *and* the ecology of the biodiversity loss problem. In particular, Gadgil (1995, p. 107) has pointed out that such policies must acknowledge that the problem of biodiversity loss is closely connected to “the ever-growing resource demands of [citizens of the First World and the Third World elite] . . . and their willingness to permit resource degradation in tracts outside their domain of concern.”

Finally, the measurement issue has been studied by Weitzman (1992, 1993, 1995), by Solow et al. (1993), and by Solow and Polasky (1994). These researchers have shown that the genetic distance between related species can be used to come up with an effective measure of biodiversity. This measure recognizes that the “optimal conservation policy may be defined as the feasible action that yields the highest discounted expected value of diversity (plus whatever other net benefits are attributed to various components)” (Weitzman 1995, p. 22). It is important to understand that this measurement issue has been guided by the realization that conservation resources are scarce. Consequently, in order to determine how these scarce resources should be allocated across

⁴Also see Swanson (1995a) and the papers in Perrings et al. (1995a).

competing needs, it is necessary to measure biodiversity.

While this body of research has undoubtedly shed light on many aspects of the biodiversity conservation question, a number of outstanding questions remain. The purpose of this paper is to pose and answer two such questions. However, before we proceed to the questions themselves, it is important to first say something about the relationship between natural habitats and biodiversity. The basic point is this. The conversion of natural habitats inevitably leads to a loss of biodiversity. For instance, Smith et al. (1995, p. 134) have noted that overexploitation, the introduction of exotic species, and habitat conversion are “the three primary causes of . . . extinctions and endangerments . . .”⁵

The problems associated with habitat conversion are very serious. Consider the case of tropical forests, generally recognized to be a salient source of biodiversity. As noted in Myers (1992, pp. 175-176), commercial logging, fuelwood gathering, cattle raising, and forest farming operations collectively result in the conversion of approximately 200,000 square kilometers of primary forest *every year*. This massive conversion of tropical forests has given rise to a number of startling statistics. Here are two such statistics. First, the tropical forests of West Africa, the Greater Antilles, India, Madagascar, the Philippines, and Atlantic Brazil have already been reduced to *less than* 10 percent of their original areas (Terborgh and van Schaik 1997). Second, as pointed out in Terborgh (1992), outside of protected areas, tropical forests are expected to endure for *only about* 35 to 40 more years. Unfortunately, despite the increased global attention to the loss of tropical forests, it does not appear as though the rate of forest conversion is slowing down. Recent studies—see

⁵For more on the relationship between habitat conversion and biodiversity loss, see Myers (1992), Wilson (1992), Ehrlich (1994), Hartwick (1995), and Krautkraemer (1995). In particular, Myers (1992, pp. 379-383) provides a country by country review of conversion rates in tropical forests.

Whitmore and Sayer (1992) and Aldhous (1993)—suggest that this conversion rate is actually *increasing* in a number of countries.

With these sobering statistics in mind, let us now state the two questions that comprise the subject matter of this paper. First, given the link between natural habitats and biodiversity, *when* should a social planner—who is interested in conserving biodiversity—stop the process of habitat conversion? Second, what is the nexus between this social planner's optimal conservation policy (hereafter OCP) and the *length* of his/her planning horizon? The theory of optimal stopping can be used to shed light on these two questions.⁶ The reader should note that although the *significance* of these optimal stopping questions has been recognized by researchers,⁷ the questions themselves have *not* been analyzed previously in the literature.

Consequently, in the rest of this paper, we provide an optimal stopping perspective on these two questions. This paper's model is adapted from Gilbert and Mosteller (1966). The paper that is most closely related to the present paper is the one by Batabyal (1998). Batabyal (1998) also analyzes the conservation of biodiversity over time and under uncertainty. However, his analysis is conducted within the framework of a Markov decision process. This paper's analysis is more general because we do not make any distributional assumption about the stochastic process that we work with. Moreover, as indicated earlier, an important objective of this paper is to study the link between a social planner's OCP and the *length* of his/her planning horizon; this issue has not been analyzed in Batabyal (1998).

To characterize the social planner's OCP, we shall exploit the previously described

⁶For more on the theory of optimal stopping, see Ross (1983), Harris (1987), Dixit and Pindyck (1994), and Batabyal (1998).

⁷See Polasky and Solow (1995, p. 303), and Swanson (1995b, pp. 226-227) for a more detailed corroboration of this claim.

connections between the preservation of natural habitats and the conservation of biodiversity. As we shall soon see, the social planner's optimal policy is closely related to the length of his/her planning horizon. The rest of this paper is organized as follows. Section 2 formulates and discusses the theoretical framework in detail. Section 3 offers concluding comments and discusses directions for future research.

2. The Theoretical Framework

Consider a country such as India in which the conversion of natural habitat into developed land is taking place over time.⁸ As Wilson (1992) and Krautkraemer (1995) have noted, estimates of the rate of species loss are generally based on the rate of habitat loss. Consequently, we shall interpret the area of natural habitat as a measure of the stock of biodiversity.⁹ The conversion of natural habitat yields information about the consequences of development and the existing stock of biodiversity. This link between habitat conversion and information acquisition has been documented in the literature. For instance, Swanson (1995b, p. 247) has observed that sequential "decision making regarding...conversions implies the passage of time, and one component of time is the accumulation of information."

A social planner—who is interested in conserving the scarce biological resources in his/her country—receives this information sequentially, in packets, one packet per discrete time period. To

⁸We have posed the decision making problem at the level of a country. However, a change of scale—to a region within a country or to a region encompassing more than one country—does not affect the analysis qualitatively.

⁹This kind of interpretation has been used previously in the literature. For more details, see Barrett (1995, p. 285). However, note that for some "hot spot" habitats (see Myers 1992, pp. xxi-xxii), the use of the area of natural habitat as a measure of the stock of biodiversity will need to be augmented to account for the fact that these "hot spot" habitats contain species that are at risk and are found nowhere else. This augmentation can be accomplished by letting the social planner's utility function (see the next paragraph) depend on both the information packets and on a second variable—such as the number of endemic species per unit area—that is an indicator of biodiversity quality.

proceed further, we will need to specify an objective function for this social planner. To this end, we suppose that this social planner has a well defined¹⁰ utility function. In microeconomic theory, the utility function is generally defined over goods. In our case, the relevant goods are the information packets. Consequently, the social planner's utility function is defined over these information packets. Note that because these packets provide information about the consequences of development and the existing stock of biodiversity, the resultant utility to the social planner is also about these two things. In particular, although the levels of utility associated with distinct information packets will typically vary, it is certainly not the case that the only way in which the social planner can generate utility is by halting the habitat conversion process.

On receiving a particular information packet, the social planner must decide whether to act, i.e., to stop the habitat conversion process,¹¹ or to do nothing and permit the conversion process to continue. We shall identify a lower bound on the level of utility that calls for stopping the conversion process. Put differently, we shall pose the social planner's problem as one of maximizing the probability of acting (stopping the conversion process) when the highest possible level of utility has been obtained. The social planner solves his/her problem in a dynamic and stochastic framework. The framework is dynamic because the actual decision making in this paper's setup involves stopping a process—the conversion of natural habitat—that is taking place over time.¹² The

¹⁰This means that the utility function possesses certain standard properties such as continuity. For more on this, see Varian (1992, pp. 94-97).

¹¹The reader should think of this action, i.e., stopping the habitat conversion process as one that results in the creation of a protected area. Examples of such protected areas are Corbett National Park in India, Pico da Neblina National Park in Brazil, and Sierra Nevada National Park in Colombia.

¹²The reader should note the manner in which the problem is dynamic. Although we have not modeled the dynamics of habitat change explicitly, the maintained assumption is that the effects of habitat change are revealed to the social planner by means of the stochastically generated information packets.

framework is stochastic because the conversion process itself is stochastic and because the decision to stop this process depends fundamentally on the uncertain availability of information regarding the desirability of such an action.

We assume that this information is generated in accordance with an independent, and identically distributed (hereafter i.i.d) stochastic process. This means that a particular information packet is received at time t with a certain probability, independent of any previous or subsequent information packets. The specific source of these packets is not critical to the analysis. It could be the result of analysis conducted by governmental research and development departments or it could be the result of government sponsored activities undertaken by private and/or nonprofit agencies.

Let $\bar{u}(\cdot)$ be the social planner's continuous, one-to-one, and strictly monotone utility function. This function maps information about the effects of stopping conversion to utility from stopping conversion. Because $\bar{u}(\cdot)$ is a continuous, one-to-one, and strictly monotone transformation of the stochastic process that generates information, it follows that the social planner's utility, U , retains the properties of the randomly generated information packets.¹³ In other words, we can think of utility as being generated sequentially, in packets, and in accordance with an i.i.d stochastic process. Upon receipt of an information packet and the corresponding utility, the social planner decides whether to stop the conversion of natural habitat, i.e., whether to create a protected area, or to permit conversion and wait for additional information. In what follows, we shall omit further references to information packets; instead, we shall speak of utility packets. However, the reader should bear in mind that it is essentially information that is the driving force behind the social planner's decision as to when to stop the habitat conversion process.

¹³See Wolff (1989, p. 26) for further details.

Let us first focus on the more relevant case of a known, finite number—say n —of utility packets.¹⁴ As indicated earlier, upon receipt of a packet, the social planner must decide whether to stop the conversion process or to do nothing and wait for additional utility packets. The nature of utility is such that if the social planner does not act upon receipt of a specific packet, then the corresponding level of utility associated with that packet becomes useless for future decision making. The social planner has no access to any prior knowledge about the probabilistic nature of the utility packets. We model this by positing that the only knowledge the social planner is privy to is the relative *rank* of a utility packet, as compared to previous packets.¹⁵ The social planner's objective is to maximize the probability of receiving the utility packet of highest rank when all $n!$ orderings of the various packets are equally likely. It is understood that the social planner will stop the habitat conversion process (create a protected area) when (s)he believes that (s)he has received the packet with the highest relative rank. By pursuing this objective, the social planner will in effect be maximizing his/her utility from the creation of a protected area in his/her country.¹⁶

From the standpoint of the social planner, the situation described above involves sequential decision making. In this connection, let us call a utility packet a *candidate* if this packet is of higher utility than any previously received packet. Further, let us say that we are in state a , if the a th packet, $1 \leq a \leq n$, has just been received and this packet is a candidate. Let $Y(a)$ denote the best action

¹⁴Recall that because the number of packets and the number of time periods coincide, n is also the social planner's decision making horizon.

¹⁵Here, rank is a proxy for level. Put differently, if the level of utility associated with packet 1 is higher than the level associated with packet 2, then packet 1 will have a higher relative rank.

¹⁶Note that positive discounting of future packets by the social planner will not alter the analysis in any significant manner. The only change is that instead of focusing on the actual utility of the various packets, the social planner will now focus on the discounted utility. Accordingly, the assignment of ranks will reflect discounted utilities rather than actual utilities.

that the social planner can take in this setting. Then $Y(a)$ can be expressed mathematically by the following equation

$$Y(a) = \max[P(a), R(a)], \quad a = 1, \dots, n. \quad (1)$$

In equation (1), $P(a)$ is the probability that the packet with the highest level of utility will materialize if the *ath* packet is acted upon and $R(a)$ is the best action that the social planner can take if the *ath* packet is not acted upon. Now conditioning¹⁷ on the event that the *ath* packet is a candidate, we get

$$P(a) = P[\text{packet is of highest utility of } n / \text{packet is of highest utility of } a] = a/n. \quad (2)$$

It is now possible to give a concrete interpretation to $R(a)$. $R(a)$ is the *maximal* probability of acting upon the packet of highest utility when the previous a packets have not been acted upon. The reader should note that (i) $P(a)$ is increasing in a and (ii) from the social planner's perspective, the case in which the first a packets have not been acted upon is at least as good as the case in which the first $a+1$ packets have not been acted upon. These two observations tell us that $R(a)$ is decreasing in a . Now because $P(a)$ is increasing in a (see equation (2)) and $R(a)$ is decreasing in a , we know that there must exist a packet b such that

$$a/n = P(a) \leq R(a), \quad a \leq b, \quad (3)$$

and

$$a/n = P(a) > R(a), \quad a > b \quad (4)$$

hold. From equations (3) and (4), the structure of the social planner's optimal conservation policy (OCP) can be determined intuitively. This OCP says the following: For some utility packet $b \leq n-1$,

¹⁷When calculating a particular probability or an expectation, it is often useful to "condition" on an appropriate random variable. This explains why conditioning is a popular procedure in probability theory. For more on this, see Ross (1993, pp. 100-106).

do not act, i.e., do not stop the habitat conversion process; then act (stop the conversion process and create a protected area) upon receipt of the first candidate packet.

Recall that the social planner will act when (s)he believes that (s)he has received the packet with the highest level of utility. Consequently, our next task is to determine the probability— $P_{OCP}(\text{highest})$ —of receiving the highest utility packet when this OCP is followed. From Ross (1993, p. 100), it follows that this probability is given by

$$P_{OCP}(\text{highest}) = \sum_{a=1}^{a=n-b} P_{OCP}[\text{highest of } n/a+b \text{ packet recd}] \cdot P_{OCP}[a+b \text{ packet recd}]. \quad (5)$$

Now following the line of reasoning that led to equation (2), the conditional probability on the right hand side (RHS) of equation (5) can be simplified. This yields

$$P_{OCP}[\text{highest of } n/a+b \text{ packet recd}] = (a+b)/n. \quad (6)$$

The second probability on the RHS of equation (5) can also be simplified by writing this probability as a joint probability. This simplification yields

$$P_{OCP}[a+b \text{ packet recd}] = [b/(a+b-1)][1/(a+b)]. \quad (7)$$

With equations (6) and (7), the expression for $P_{OCP}(\text{highest})$ in equation (5) can be rewritten. This gives

$$P_{OCP}(\text{highest}) = (b/n) \sum_{c=b}^{c=n-1} (1/c), \quad (8)$$

where $c = a + b - 1$. The probability in equation (8) is what the social planner wishes to maximize. Inspection of equation (8) tells us that the function on the RHS of this equation is *not* differentiable. This means that in the finite number of utility packets—and the finite decision making horizon—case, calculus cannot be used to solve this maximization problem. Consequently, in the remainder of this section, we shall focus attention on the asymptotic case in which $n \rightarrow \infty$. The reader

should think of this asymptotic case as an *approximation* to the more relevant finite decision making horizon case.

For large n , the RHS of equation (8) can be approximated well by the natural logarithm function. Using this approximation, we get¹⁸

$$P_{OCP}(\text{highest}) = (b/n) \log_e [(n-1)/b]. \quad (9)$$

Let $f(v) \equiv (v/n) \log_e [(n-1)/v] = P_{OCP}(\text{highest})$. We can now state the social planner's optimization problem. This planner solves

$$\max_v [(v/n) \log_e [(n-1)/v]]. \quad (10)$$

The first order necessary condition to this problem is

$$v^* = (n-1)/e. \quad (11)$$

Substituting v^* from equation (11) into $f(\cdot)$ gives

$$f(v^*) = P_{OCP}(\text{highest}) = 1/e, \quad (12)$$

because $[(n-1)/n] \rightarrow 1$ as $n \rightarrow \infty$. Equation (12) contains the correct expression for the social planner's OCP. In turn, this equation leads to

THEOREM 1: For the infinite decision making horizon case, the social planner should not act upon receipt of the first $(1/e)$ fraction of utility packets; (s)he should then stop the habitat conversion process upon receipt of the first candidate packet.

¹⁸Note that although equation (9) bears some resemblance to the information-theoretic Shannon-Wiener function (see Krebs 1994, pp. 704-705), the probability described by equation (9) and the Shannon-Wiener function are dissimilar concepts. The Shannon-Wiener function seeks to construct an index of species diversity by determining the informational content of a sample. In contrast, the purpose of equation (9) is to provide a differentiable approximation to the probability of receiving the highest utility packet when the OCP of this paper is followed.

2.1. Discussion

Theorem 1 provides us with an answer to the “When to halt the habitat conversion process” question. This theorem tells us that the OCP calls for the social planner to wait a while, i.e., not act upon receipt of the first $(1/e)$ fraction of all utility packets. The social planner should then act and stop the habitat conversion process upon receipt of the first candidate packet. The probability that the use of this OCP will result in the conversion process being stopped at the optimal point can be easily computed. This probability is $(1/e) \approx 0.37$.

To see the connection between the theoretical result stated in Theorem 1 and actual conservation policy, consider the case of protected areas such as Corbett National Park in India, Pico da Neblina National Park in Brazil, and Sierra Nevada National Park in Colombia. As indicated in footnote 11, the reader should interpret the act of stopping the habitat conversion process as one that results in the creation of a protected area. Why is it optimal to wait a while before creating a protected area? This is because waiting a while permits the social planner to “ascertain areas of high biodiversity and conservation priority and to plan effective protected area networks” (MacKinnon, 1997, p. 40). A specific case in point is the Conservation Needs Assessment (CNA) project in Papua New Guinea. By waiting a while, the CNA project was able to “compile and synthesize large quantities of geographical and distributional data relevant to biodiversity conservation” (MacKinnon, 1997, p. 40).

Theorem 1 also demonstrates the dependence of the OCP on the *length* of the social planner’s decision making horizon. To see the relevance of this result for actual conservation policy, consider

the more relevant finite decision making horizon case.¹⁹ If we think of a time period as being 1 year long and the decision making horizon is 10 years, then Theorem 1 says that habitat conversion should be stopped after 3.7 years. Similarly, if the decision making horizon is 20 years, then Theorem 1 says that habitat conversion should be stopped after 7.4 years. Put differently, in the 10 year decision making horizon case, natural habitat is preserved for 6.3 years and in the 20 year decision making horizon case, natural habitat is preserved for 12.6 years. Because the proportion of time for which it is optimal to wait before acting is *fixed*, we see that a longer decision making horizon will result in the conservation of a relatively larger stock of biodiversity.

The reader will note that a particular contribution of Theorem 1 is that it specifies the *exact nature* of the functional relationship between the length of a social planner's decision making horizon and the number of time periods for which biodiversity is conserved. Generally speaking, Theorem 1 calls for the use of *long* decision making horizons in the design of conservation policy. Is this result consistent with current thinking on the subject of biodiversity conservation? The answer to this question is yes. In this regard, Jonathan Haufler (1999, p. 28)—a wildlife manager at the Boise Cascade Corporation in Boise, Idaho—has noted that “time frames need to be long enough to consider the disturbance regimes and successional processes affecting the ecological communities.” Along the same lines, Brian Kernohan—a project manager in the Minnesota Ecosystem Management Project at the Boise Cascade Corporation in International Falls, Minnesota—and Jonathan Haufler (1999, p. 238) have pointed out that maintaining “biological diversity involves time frames that are often far beyond traditional planning horizons.”

¹⁹Strictly speaking, Theorem 1 holds only for the asymptotic ($n \rightarrow \infty$) case. Further, as indicated previously, the asymptotic case is an approximation to the finite decision making horizon case. In particular, as n gets small, the quality of this approximation decreases. In reading the rest of this paragraph, the reader should keep these details in mind.

Theorem 1 has three additional implications. First, when pondering the OCP described in this theorem, it is important to take the following into account. The decision maker in this paper is a social planner who takes all of society's welfare into account. Social welfare depends not only on biodiversity conservation but also on things like housing, industries, and roads, all of which typically involve the conversion of natural habitats. Consequently, in deciding how long to wait before halting the conversion of natural habitats, the social planner optimally trades off these competing benefits and costs. This suggests that intertemporal studies of biodiversity conservation ought to *endogenize* the length of the decision making horizon. Second, it is never optimal to wait for the entire length of the decision making horizon before acting to halt the conversion of natural habitat. Third, the shorter the decision making horizon, the shorter is the length of the waiting period. In particular, when the decision making horizon is one period long, the social planner should stop the conversion of natural habitat immediately. To the best of our knowledge, these linkages between the length of the decision making horizon and optimal biodiversity conservation policy have not been studied previously in the literature.

The theoretical analysis of this paper provides some insights into the temporal dimension of the biodiversity conservation question. As in all theoretical papers, the obtained results of this paper depend on the assumptions made. In particular, we assumed that information is generated in accordance with an i.i.d. stochastic process. Although this is a salient assumption, it is important to remember that this assumption is routinely made in other areas of economics—such as econometrics—that study stochastic processes. This paper's OCP is not independent of either the stock of biodiversity or the benefits of habitat conversion. This is because the OCP *depends* on the sequentially received information packets and the information that these packets contain is about the existing stock of biodiversity and the consequences of development (habitat conversion). Finally,

note that no scaling of any kind is needed to obtain the result stated in Theorem 1.

The act of stopping the habitat conversion process (creating a protected area) can be interpreted as one that “invests” in biodiversity. With this interpretation of the problem, Theorem 1 tells us that it is optimal to wait a while before making this investment. In this way, Theorem 1 nicely complements the “value of waiting to invest” result that is to be found in the investment under uncertainty literature.²⁰

3. Conclusions

In this paper we analyzed two questions about biodiversity conservation by studying the optimal stopping time of the related habitat conversion process. In this setting, in response to the “When to stop the habitat conversion process” question, we provided an OCP for the social planner. With this policy, a social planner makes a probabilistic comparison of the utility from stopping the conversion process upon receipt of a specific information packet with the utility from not stopping and waiting for new information. Because the proportion of time for which it is optimal to wait before acting is fixed, a salient policy implication of this analysis is that, *ceteris paribus*, longer decision making horizons will result in the conservation of a relatively *larger* stock of biodiversity.

The analysis of this paper can be extended in a number of directions. In what follows, we suggest two possible extensions. First, note that the social planner’s OCP is of an “all or nothing” type. This means that the social planner either stops all conversion or permits all conversion to continue. An examination of the social planner’s optimization problem when partial stopping is a

²⁰For more on this literature, see Pindyck (1991), Dixit and Pindyck (1994), and Batabyal (1996, 1997). The present paper differs from Batabyal (1996) in three ways. First, Batabyal (1996) conducts his analysis in a Markov decision theoretic framework; we do not make any similar distributional assumption. Second, the stopping rules used in these two papers are different. Third, Batabyal (1996) does not analyze the link between the optimal stopping rule and the length of the decision making horizon; this paper does.

possibility, will permit a more elaborate analysis of the connections between information production and the optimal point at which the habitat conversion process should be stopped.

Second, if the social planner learns about the statistical properties of the information generation process over time, then it is likely that (s)he will eventually know the distribution from which the utility packets are generated. One could then analyze the impact of this knowledge on the “When to halt the habitat conversion process” question. An analysis of this aspect of the problem will enable one to study the ways in which learning affects the nature of optimal biodiversity conservation policies.

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