

# ETHICS AND ECONOMICS: LEWIS GRAY AND THE CONSERVATION QUESTION\*

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**Abstract:** In “The Economic Possibilities of Conservation” [1913], Lewis Gray reinterpreted from an economic point of view the idea of conservation which had popularized the American Conservation Movement. He linked intergenerational equity and non-renewable resource extraction rate. Gray’s article can be considered as an antecedent of two significant debates in modern natural resource economics. On the one hand, it is a direct precedent of the environmental discussion about the meaning of discounting. On the other, it is an important element in the historical conformation of the sustainability debate.

**Keywords:** Gray, conservation, natural resource economics, discounting, intergenerational equity

## 1. Introduction

At a macroeconomic level, the utilization of natural wealth –and especially of non-renewable resources– is linked to the ethical problem of intergenerational equity. In his book *The Coal Question*, published in 1865, Jevons was already fully conscious of this connection between ethics and economics, although he did not pause in order to consider it in detail: “The only suggestion I can make towards compensating posterity for our present lavish use of cheap coal is [...] the reduction or paying off of the National Debt” (Jevons, 1965[1865]: 448). Like the classical economists, he thought that any increase in the National Debt involved transferring a burden to future generations.

Later, the American Conservation Movement (1890-1920) would insist again on the responsibility towards future generations in nature utilization. The practical expression of this responsibility was the idea of conservation: since scarcity of natural resources was objective and inescapable, conservation was necessarily related to concepts like “wise use” and “scientific management”. The ultimate purpose was to get the maximum physical yield from the use of natural resources, which Samuel Hays (1959) summarized as “the gospel of efficiency”. Consequently, science and technology should be the key towards the conservationist goal.

But it was not until 1913 when Lewis Cecil Gray (1881-1952) –an economist who had studied at the University of Wisconsin during the golden age of the American Conservation Movement– brought really into contact ethics and economic theory in “The Economic Possibilities of Conservation”. The aim of this article was to study in a new way –with the analytical instruments of economists– one of the most burning issues of North America at the beginning of the twentieth century: the conservation of natural wealth. Actually, until then nobody had analyzed this matter from the perspective of economic science.

According to Gray, the conservation problem was macroeconomic and necessarily linked to the ethical question of intergenerational equity. In essence, it could be reduced to a discussion about the discount rate of the future in relation to the aggregate utilization of non-renewable resources. Therefore, the question of efficiency referred to the intertemporal allocation of exhaustible resources

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and could not be separated from ethical considerations. Apart from this conclusion, it was probably the first time in economic literature that somebody considered the importance of the discount rate for extraction rates of natural resources, a question which Gray would develop later putting forward a very complete microeconomic theory of mining (Gray, 1914) –although today it is usual to quote Hotelling (1931) as the only historical reference on this matter.

Gray (1913) can be considered as an antecedent of two important debates in natural resource economics. On the one hand, Gray anticipated partially the modern discussion about the meaning of discounting from an environmental perspective. Today, this discussion does not only refer to the extraction rate of non-renewable resources, but also to the discount rate of costs and benefits associated with public investment projects with evident impacts –sometimes irreversible– on unique environments. On the other hand, Gray can also be seen as an indirect predecessor of the present debate on the requirements of a sustainable economy, because he put onto the agenda of economic theory the problem of intergenerational equity linked to the utilization of natural wealth. In fact, the moral obligation of present generations towards the future is the basic element of the actual definition of a sustainable economy: an economy that is on a time path –not necessarily efficient– “where future generations have economic opportunities that are at least as large as earlier generations” (Pearce and Barbier, 2000: 18-9). In this way, after the wide gap denounced by Amartya Sen (1987), ethics and economics have become connected again in an important matter.

In conclusion, in spite of the scarce interest aroused by “The Economic Possibilities of Conservation” [1913], this article belongs to the origins of natural resources economics. In fact, its relevancy has increased lately due to the recent thematic evolution of this discipline, where the intergenerational resource allocation and the sustainability debate have become of central importance. Perhaps, this reason explains why, until now, the majority of the studies on Gray’s writings have been specially concentrated in analysing his work of 1914 on the microeconomic theory of mining –such as Crabbé (1983) or more clearly Robinson (1980, 1989) and Cairns (1994).

To understand adequately the significance of Gray’s contribution, it must be situated in the context of the American Conservation Movement. Therefore, in the first place the idea of conservation presented by the conservationists will be examined. Next, Gray’s (1913) work will be analyzed, where the question of conservation was tackled for the first time from an economic point of view. The fourth section will be dedicated to revise briefly the evolution of the economic idea of conservation after Gray. Finally, we shall highlight the new lines of research that he opened up in the field of natural resource economics.

## **2. The American Conservation Movement: Wise use and future generations**

The American Conservation Movement (1890-1920) is a fundamental historical reference point for the understanding of how the actual social concern about the environment came about. It meant, for the first time, large scale awareness about environmental problems, and led to public and private initiatives without precedents whose aim was the preservation of wild life and unique natural sites<sup>1</sup>. In practical terms, conservation doctrine became part of an important program of political reform during the presidencies of Theodore Roosevelt (1901-9) and William Howard Taft (1909-13).

Initially, the concept of conservation had referred to reservoir storage of flood waters and controlled grazing on the Western range but later came to connote efficiency in the development and use of all [natural] resources (Hays, 1959: 123). Around 1908, conservation was defined as the use of foresight and restraint in the exploitation of the physical sources of wealth as necessary for the perpetuity of civilization, and the welfare of future and present generations<sup>2</sup>. However, in the final phase of the Conservation Movement, the conservationist doctrine abandoned its exclusive emphasis on natural resources and reached the point of including diverse ideas on social welfare, attempting to gain political support.

In any case, the idea of conservation was inspired by a fundamental principle: the ethical obligation towards future generations in the utilization of natural wealth. Gifford

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<sup>1</sup> The American Conservation Movement created a model of preservation of the environmental values of a territory –administered by public agencies– which would be imitated all over the world: the National Parks. It supported an advanced federal legislation for the protection of specific types of wild life –establishing natural reserves– and promoted the carrying out of quantitative studies on the American natural patrimony. The American Conservation Movement is linked as well to the first systematic attempts to control pollution impacts on health and human welfare, and to the promotion of environmental education initiatives (like informative guides, exposures, youth hiking, and so on). All these achievements reflect an important change of attitude towards nature (Huth 1972[1957]; Ekirch, 1963). It is also remarkable the fact that thanks to the Conservation Movement the principles of optimal forest management became the basis of a large scale governmental policy. The systematic and multifunctional development of the fluvial basins –with the construction of dams for irrigating the arid west lands– was another aim of the conservationists (Worster, 1985).

<sup>2</sup> Philip P. Wells, “Conservation of Natural Resources”, quoted in Hays (1959: 123). In 1932 Franklin D. Roosevelt would promote a second conservation movement as part of *New Deal* policy. Again, it would pay

Pinchot (1865-1946) who between 1898 and 1910 was the leader of the Conservation Movement as Chief of the Forest Service and right-hand man of Roosevelt pointed out with a marked utilitarian bias:

Conservation means the greatest good to the greatest number for the longest time [...] It demands the complete and orderly development of all our resources for the benefit of all the people, instead of the partial exploitation of them for the benefit of a few. It recognizes fully the right of the present generation to use what it needs and all it needs of the natural resources now available, but it recognizes equally our obligation so to use what we need that our descendants shall not be deprived of what they need (Pinchot, 1914: 48 y 80) <sup>3</sup>.

This obligation towards future generations resulted in the imperative of making wise use of natural resources: not to damage the capacity of regeneration of renewable resources, to use them instead of non-renewable ones always when possible, and to exploit first the more abundant minerals. In fact, wise use was the only way to face the fundamental problem which man had to confront the problem of scarcity without mortgaging drastically the future.

Scarcity was a feature of nature, a fact intrinsically part of life. It derived from the finite character of natural resources, which imposed inescapable physical limits. For example, the supply of coal, petroleum or gas whose use was a necessity for the industrial society was fixed in aggregate terms, but when these elements were burned they would disappear forever. Minerals, though recyclable, were also liable to exhaustion, because of factors such

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special attention to the development of fluvial basins and the construction of dams for generating hydroelectric energy. The “Tennessee Valley Authority”, for example, would be created to assist these kind of projects.

<sup>3</sup> Pinchot represented the dominant viewpoint within the Conservation Movement: the cult of physical efficiency, stressing the economic value of forest stands as sustained producers of wood under an adequate use. But there was also a preservationist wing, leaded by John Muir, which defended the cult of wildlife and virgin nature (Hays, 1959: 189-198). A good example of the contrast between both positions was the controversy over the project of a reservoir in the Hetch Hetchy Valley –part of Yosemite National Park– in order to improve the water supply of San Francisco. Finally, in spite of the firm opposition of John Muir and his Sierra Club, the dam was built. But it made clear the existence of conflicts within the Conservation Movement that anticipated future debates. On John Muir and other American conservationist pioneers –such as Thoreau, Marsh or Powell– see Dorman (1998).

as corrosion, loss or damage. But the concept of scarcity and, as a result, of limits was also multidimensional, since natural resources [were] specific in type, location, qualities, and relationships to one another. And economic scarcity in the sense of limited physical availability [characterized] all the dimensions (Barnett y Morse, 1963: 77). Therefore, scarcity could only be satisfactorily characterized by a vector description. In addition, there was interdependency among nature and biological organisms and its geological and atmospheric features. For example, the destruction of the forests altered the quality and distribution of water, increased the soil erosion and reduced the level of humidity. That is, quantities and qualities of individual natural resources depend one upon another. Consequently, physical interdependencies in nature which were related to the idea of ecological equilibrium were another basic factor to consider in analyzing scarcity<sup>4</sup>.

Inevitably, human activities aggravated scarcity the natural limits to the availability of resources due to the distortion of ecological equilibrium and the utilization of minerals. However, the degree of aggravation depended on human behaviour, which could be or not in accordance with wise use. In particular, conservationists paid special attention to waste since this was an active element in the generation of scarcity, contributing to reduce labour productivity and to increase the real cost of all products<sup>5</sup>.

Waste was physical inefficiency in the use of resources, and it adopted different forms (Barnett and Morse, 1963: 81-2). Firstly, the overexploitation or damage of the renewable

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<sup>4</sup> The influence of G.P. Marsh (1965[1865]) on conservationist conceptualization of scarcity as a multidimensional phenomenon is evident. He rejected the emphasis of classical economists on agricultural land and insisted on the importance of ecological equilibrium. Conservationists also rejected the consideration of land as a mere factor of production, without reference to its 'vital' values. However, their vision of the scarcity of natural resources as an absolute limit was similar to the classical one, in spite of having a clearer perspective of the significant technical progress of the century.

<sup>5</sup> Conservationists thought that the aggravation of natural resources scarcity (in combination with the high levels of efficiency of the trust as a form of industrial organization) would reinforce the power of monopolies in society. In addition, as a consequence of scarcity increasing segments of the population were separated from their livelihood on the land and a close association with nature. This fact altered negatively the traditional values of American society (Barnett and Morse, 1963: 83-6; Hays, 1959: 142-5).

resources owing to an inadequate use, or alternatively the incapacity to obtain the maximum sustained physical yield from these resources. Secondly, the bad management of mineral deposits that resulted from a failure to get the maximum yield of extractive product from the physical resources which were destroyed. And finally, the misuse of final products and services derived from natural resources (for example, because of a low thermal efficiency in the use of fuels, the waste of the potential of recycling and reutilization, or the unnecessary shortening of product life cycles). The only way to guarantee a satisfactory development of the natural wealth of a country was the scientific management of its resources (fluvial basins, forests, mineral deposits and so on), based on the physical efficiency criterion and directed by engineers and scientists from public administration (Bowler, 1998: 231). Indeed, according to the conservationists, economic concepts such as consumer sovereignty and laissez-faire often [undermined] the wise use of natural resources (Kula, 1998: 48) <sup>6</sup>.

Anyway, the conservationist conception of scarcity was essentially descriptive and referred specifically to the North American case. Moreover, in the heterogeneous conservationist writings whose main purpose was to serve as instruments of socio-political reform there was little or no recourse to precise economic formulation and statement <sup>7</sup>. Therefore, the obligation towards future generations, apart from the wise use precept, was reduced to a simple ethic ideal, unrelated to concrete economic considerations. In this context, Gray's work has a special relevancy, since transcending the generalized social opinion of that period it reinterpreted the concept of conservation and explored for the first

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<sup>6</sup> According to conservationists, "conscious purpose, science and human reason could create out of the chaos of a laissez-faire economy where short-run individual interest provided no thought for the morrow" (Hays, 1959: 124). The exaltation of "scientific management" denoted a remarkable confidence in scientific authority as a guide for human action and also a very ingenuous conception of the political process and the workings of public administration.

<sup>7</sup> Barnett and Morse (1963: 96). The more important works of the main authors of the American Conservation Movement can be consulted at <<http://memory.loc.gov/ammem/amrvhtml/conshome.html>>.

time from an economic viewpoint the implications of the idea of intergenerational equity for the utilization of natural wealth.

### **3. Lewis Gray and the conservation question: discounting and intergenerational equity**

As it has already been pointed out, Lewis C. Gray (1881-1952) studied at the University of Wisconsin during the golden age of the Conservation Movement. There, Richard T. Ely (1854-1943) taught him the rudiments of natural resources economics. Ely had learned them in Germany from Historical School, and he was the first American economist who showed a systematic interest in this matter. But Gray was not to adopt the inductive and descriptive viewpoint of his master to investigate the conservation question: his method of analysis was neoclassical (Crabbé: 195-6 and 199).

For Gray, conservation implied an ethical problem entirely novel in its scope, since it concerned unborn generations. It referred basically to non-renewable resources, whose supply was absolutely limited and whose utilization obliged to make a definitive choice between present and future. In other words, the real heart of the conservation problem [presented] an issue which [taxed] the resources of economic theory to the utmost [...]: the problem of adjusting the conflict between the interest of present and future (Gray, 1913: 501 y 499). Resources, hence, were considered essential (irreplaceable), and conservation was equivalent to non-utilization or at least to the achievement of lower extraction rates (p. 515).

In Gray's opinion, to design a conservation policy understood as the slowdown of the extraction rate of non-renewable resources required to define a macroeconomic framework in which later on it would act the microeconomic forces of self-interest and economic efficiency. The aim was to create social conditions that provided motives for conservation. So the first task was to inquire what [were] the conditions which, in the case of the individual, [determined] the profitableness of a conservation policy (p. 504). Since economic agents

sought to maximize the present value of the future net returns derived from their assets, the most important of these conditions was the discount rate<sup>8</sup>. Consequently, after discussing extensively the relevance of the discount rate for the rate of extraction of non-renewable resources<sup>9</sup> –which is probably the first approach to this question in economic literature–, Gray concluded that the rate of extraction could be slowed down if the interest rate was rendered as low as possible. This should be the main instrument of the conservation policy, although an increase of the non-renewable resource market value could also contribute –in certain cases– to the conservationist objective of slowdown<sup>10</sup> (pp. 517-8).

A strict interpretation of conservation –“as a single principle of action”– involved the equal importance of future wants and present wants, which in economic language meant a zero discount rate. But this was absurd, because then the amount of present use would become infinitesimal and the period of utilization would be increased to infinity (p. 515). In any case, on the basis of economic theory the optimal level of conservation could not be established –characterized by a specific discount rate– or its counterpart, the most convenient degree of social resource utilization. Before being able to say something relevant on this matter, economists must be capable of solving several problems. For example, they should be able to establish a criterion of social value in order to compare the relative desirability of two social alternatives, or they should determine if the future should be discounted from a social viewpoint to the same extent as from an individual perspective (p. 518-9). Therefore, Gray concluded that, 菟hilosophically considered, the question [of the proper balance between utilization and conservation] cannot be answered with finality without definite comprehension of the purpose of human existence [...]. In the absence of more infallible foundations we shall doubtless lean on the 祖rutch of common sense樯<sup>11</sup> (Gray, 1913: 515).

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<sup>8</sup> Later, in his microeconomic theory of mining, Gray (1914) stated that the optimal intertemporal utilization of exhaustible resources should be guided by the equalization of the present value of the marginal profit obtained in each period as a result of extraction. That is, the marginal profit (the price minus the marginal cost of extraction) should increase at a constant rate: the market interest rate.

<sup>9</sup> “The owner of the mine is confronted by a dilemma. If he postpones the appropriation of the coal, he loses the interest on the invested returns from his product. If on the other hand he attempts to appropriate the entire quantity of mineral, the expense of appropriation becomes so great that the surplus per ton is greatly diminished [...] If the interest rate is high, the postponement of removal until a future period becomes less profitable than would be the case under a lower rate of interest [...] Thus the general effect of a high interest rate, other things being equal, is rapid exploitation; whereas a lower interest rate makes a policy of conservation more profitable to the owner” (Gray, 1913: 505-6).

<sup>10</sup> “The effect of the rise in the value of natural resources is twofold: first, to increase the quantity of resources that are brought under utilization; and second, to create motives for economizing those already in use” (Gray, 1913: 508).

<sup>11</sup> Many years later, at the end of an article published in 1940, Gray pointed out that the discount rate it was not so relevant to define a conservation policy as he had thought previously: “Considerations as continuity and security of the state, aesthetic qualities of landscape, the costliness of periodically liquidating and recreating communities, probability of developing substitutes or of changing requirements are of significance. Such considerations may have



After appealing to common sense, Gray (1913: 516) even advocated a wider vision of economics in order to evaluate human wants –whose satisfaction implied eventually the utilization of resources<sup>12</sup>. There was no direct connection between social progress and utilization of natural resources. Maximum production did not necessarily mean progress, because a bad system of distribution could “demand more rapid production, and therefore a more rapid utilization of the resources of society”. Moreover, “a vast amount of consumption [was] neither based on welfare nor on enjoyment; it [was] solely dictated by convention”<sup>13</sup>. The electrical advertising in the great cities, which implied an enormous waste of coal, was a good example of this exploitative consumption.

In Gray’s brief article that has just been analyzed, some future lines of research were sketched out. Basically, it stated the problem of compatibility between efficient intertemporal allocation of exhaustible resources and intergenerational equity. At the same time, this work marked the beginning of environmental discussion about the meaning of discounting and, since it put on the agenda of economic theory the problem of intergenerational equity linked to the utilization of natural wealth, it also meant an advance towards the modern idea of sustainability. And it even pointed to a line of research that today is defended by the most radical economists in the field of natural resource economics: the development of a theory of necessities, distinguishing between vital ones and superfluous ones.

#### **4. The conservation question forgotten: a long oblivion**

Apart from some rare references, Gray’s article was completely forgotten<sup>14</sup>. And the lines of research that his work had suggested in connection with conservation and intergenerational equity remained practically unexplored till the 1970s, when natural resource economics became an independent discipline.

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more to do than market valuations and competitive discount rates with answering such difficult questions as whether we owe future generations as opulent a supply as we may enjoy in the present or whether we should conserve the cream of our resources in quality and location by consuming the skim milk in the present” (Gray and Regan, 1940: 45-6). On the other hand, Gray also recognized the inevitability of a positive discount rate, even from a social viewpoint: “even though the form of social organization and social policy were divorced from individual time preference, some social premium on present utilization [of limited and irreplaceable resources] would probably result from consideration of increasing productivity and increasing utility” (p. 45).

<sup>12</sup> “The necessities of conservation may compel the economist to enlarge his field so as to apply the test of economy as one of the criteria for the justification of wants” (Gray, 1913: 516).

<sup>13</sup> These opinions recall some of J.S. Mill’s ideas. In the chapter sixth (book IV) of his *Principles*, he questioned the desirability of “the mere increase of production and accumulation”, and the implicit identification between welfare and consumption capacity (Mill, 1965[1848]: 755). Later, during the thirties, the relationship between human necessities and natural resources would be stated again by Lancelot Hogben, in dispute with Hayek (Martínez Alier, 1987: 149-55). More recently, as Smith (1982: 488n) has pointed out, this matter has continued arousing interest, Tibor Scitovsky’s article, for example, “Can changing consumer’s tastes save resources?”, *Journal of Cultural Economics*, 1977, I: 1-12.

<sup>14</sup> According to Crabbé (1983: 213), before 1970 there are only six quotations of the Gray’s article in the economic literature (two of them by Ely and one by Ciriacy-Wantrup). Till 1980 there are only two additional quotations.

The American Conservation Movement began to lose importance at the beginning of the First World War, and then both Gray and his master Ely redirected their studies towards the field of agrarian economics. Between the economists trained during the conservationist period, only John Ise (1885-1969) continued paying attention to the conservation of natural resources, writing applied studies of the forest, oil and national park policies in the United States<sup>15</sup>. In the theoretical field, Ise (1925) analyzed the most convenient price policy for non-renewable natural resources. For those without clear renewable substitutes, some discount rate of the future under conditions of uncertainty should be used, although it was not possible to say which in advance (p. 285). Not only there was a problem in connection with the valuation in the present of the future generation's needs, but also in relation to the assumptions adopted: the choice of a discount rate in order to optimize the use path it would take, would always be based on particular assumptions about technical change and the resource substitutability degree. In the case of non-renewable resources with clear renewable substitutes, prices should be established according to the approximate cost of producing satisfactory substitutes (Ise, 1925: 286). In this way, there would be incentives to conservation and to the development of effective substitutes.

Afterwards, among the most prominent economists, only Pigou appeared to be interested in conservation and intergenerational equity. In *The Economics of Welfare*, he made a brief allusion to the “wasteful” effect of discounting for the utilization of natural resources. The influence of the conservationist conceptions is to be seen in his words:

甜The] slackness of desire towards the future is [...] responsible for a tendency to wasteful exploitation of Nature gifts. Sometimes people will win what they require by methods that destroy, as against the future, much more than they themselves obtain [...] There is also waste in the sense of injury to the sum total of economic satisfaction, when one generation, though not destroying more actual stuff than it itself obtains, uses up for trivial purposes a natural product which is abundant now but which is likely to become scarce and not readily available, even for very important purposes, to future generations (Pigou, 1950[1920]: 28)

The human tendency to discount the future –which had such negative effects on natural resources utilization– was inevitable. As a result, for Pigou only the State could preserve the interests of unborn generations:

典he State should protect the interest of the future in some degree against the effects of our preference for ourselves over our descendants. The whole movement for

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<sup>15</sup> John Ise, *The United States Forest Policy*, New Haven, Yale University Press, 1920; *The United States Oil Policy*, New Haven, Yale University Press, 1926; *Our National Park Policy: A Critical History*, Baltimore, Johns Hopkins Press, 1961.

Conservation in the United States is based on this conviction. It is the clear duty of Government, which is the trustee for unborn generations as well as for its present citizens, to watch over, and if need be, by legislative enactment, to defend, the exhaustible natural resources of the country from rash and reckless spoliation. How far it should itself, either out of taxes, or out of State loans, or by the device of guaranteed interest, press resources into undertakings from which the business community, if left to itself, would hold aloof, is a difficult problem (Pigou, 1950[1920]: 29 -30).

In his *Economics in Practice*, Pigou insisted again on the need for State intervention to avoid waste. For him, a zero discount rate was the only one that was strictly in accordance with the ethical criterion of intergenerational equity. By then, the Cambridge philosopher Frank Ramsey had already qualified the discount of future utility as “ethically indefensible”<sup>16</sup>. Indeed, there is “a strong Cambridge tradition (Mill–Sidgwick–Marshall–Pigou–Ramsey) against discounting future utilities” (Collard, 1996: 585).

Hotelling (1931), to a certain degree, also wrote his famous article on optimal extraction of exhaustible resources in response to the social atmosphere created by the Conservation Movement<sup>17</sup>. However, he did not deal with the conservation problem specifically. He concentrated his analysis on the microeconomic aspects of mining and, hence, did not take into consideration the ethical problem of intergenerational equity in connection with the aggregate exploitation of non-renewable resources. In fact, only the German economist S.V. Ciriacy-Wantrup (1906-80) –attached to the Department of Agrarian Economics at Berkeley– paid any attention to the conservation question before 1970. During this period, rapid technical progress seemed to have removed from the agenda of economic research any source of worry about the exhaustibility of natural resources<sup>18</sup>. Actually, Ciriacy-Wantrup (1969:

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<sup>16</sup> F. Ramsey, “A mathematical theory of saving”, *Economic Journal*, vol. XXXVIII, 152, 1928, p. 543.

<sup>17</sup> At the beginning of his work, Hotelling (1931: 137-8) wrote: “The feeling that these products [minerals, forests and other exhaustible assets] are now too cheap for the good of future generations, that they are being selfishly exploited at too rapid a rate, and that in consequence of their excessive cheapness they are being produced and consumed wastefully has given rise to the conservation movement. [...] In contrast to the conservationist belief that a too rapid exploitation of natural resources is taking place, we have the retarding influence of monopolies and combinations [...] The conservation movement, in so far as it aims at absolute prohibitions rather than taxation or regulation in the interest of efficiency, may be accused of playing into the hands of those who are interested in maintaining high prices for the sake of their own pockets rather than of posterity”.

<sup>18</sup> In 1963, Barnett and Morse published a famous work on natural resource scarcity that constitutes a good example of the technological optimism of this period. The economic scarcity indicators utilized were the extraction costs per unit (measured in terms of capital and labour per unit of output) and the tendency of the prices in the analyzed sectors (agriculture, mining, forestry and fishery). The main conclusion was that there had been a general decrease of these indicators between 1870 and 1957 –except in the case of forest resources. Therefore, the study denied the existence of a general and absolute scarcity that was inescapable. This idea was associated with the *malthusian* scarcity –characterized by an ultimate limit to the disposability of lands for cultivation– and also with the *ricardian* scarcity –where to the quantitative limits it had to add the diminishing qualities of land. After emphasizing the technological capacity (to reduce the monetary costs of extraction, to achieve a greater substitution between factors and resources, and to increase the number of mineral deposits

1314) himself lamented that natural resources and institutions had been removed from modern economic growth models, the academic attention being focused on technological change.

To face the conservation problem, Ciriacy-Wantrup (1952) was conscious of the need of a good understanding of the economic forces (interest rates, regimes of property, prices and so on) that acted at the microeconomic level within a specific institutional frame. Otherwise, if one adopted a purely technological or educational viewpoint –such as that of the American Conservation Movement–, results would be very poor:

The economics of conservation attempts to understand the distribution of resource use over time in terms of the relations between technological knowledge, individual motivation, and social institutions; to analyze the economic forces affecting changes in this distribution; and to scrutinize criteria for that distribution that is alleged to be privately or socially best (Ciriacy-Wantrup, 1952: 18).

However, Ciriacy-Wantrup, who defined conservation aseptically in terms of changes in the intertemporal distribution of use<sup>19</sup>, wanted to remove from his analysis the ethical considerations on intergenerational equity. In this way, his work took a direction completely different from the Gray's original proposal. Firstly, in tune with the common tendency of this period to follow a technical approach in accordance with positive economics, he considered that it had to separate the economic and technological aspects of conservation from ethical, metaphysical and other connotations. [...] The concept of conservation can become neutral in terms of value judgments (wertfrei) (Ciriacy-Wantrup, 1952: 20). Secondly, Ciriacy-Wantrup paid special attention to renewable resources<sup>20</sup>. In reference to them he made his major

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economically accessible), Barnett y Morse (1963) concluded that flexibility was what characterized the relationship between man and his physical environment: the natural restrictions would have always a relative character.

<sup>19</sup> “In conservation, the redistribution of use is in the direction of the future; in depletion, in the direction of the present [...]. Conservation always implies comparison of two or more time distributions of use [...] The terms ‘in the direction of the future’ and ‘in the direction of the present’ could be defined simply on the basis of the time sequence of increases and decreases of use rates [...] We may then quantitatively define ‘conservation’ as changes in the time distribution of use rates of individual resources in which the aggregate weighted change in use rates is greater than zero” (Ciriacy-Wantrup, 1952: 51 y 53).

<sup>20</sup> After exposing a classification of natural resources, Ciriacy-Wantrup (1952: 47) pointed out: “the confidence that technological progress will make social action in the interest of the distant future unnecessary appears justified for some important stock resources –for example those used in the production of energy”. *Resource Conservation* went through two later editions, in 1963 and 1968, but the original viewpoint –with a special stress on renewable resources– was not modified. This book contained a more comprehensive exposition of the ideas

contribution to conservation policy: the proposal of defining safe minimum standards, in physical terms, to avoid irreversible damages under uncertainty<sup>21</sup>. Finally, the conservation question was not stated in fully convincing terms, since it was analyzed from two different perspectives that were not clearly related to each other. In the first place, he examined the private economics of conservation, inquiring into the economic forces that influenced the optimizing of individual decisions (based on the present value maximization of the net returns derived from natural assets). Next, he analyzed the social economics of conservation, focused essentially on guaranteeing a safe minimum standard for renewable resources, together with certain recommendations about environmental education, administrative regulation and the coordination of international public actions. In fact, Ciriacy-Wantrup thought that the idea of optimization was an useful theoretical tool to examine the factors that conditioned conservation at a microeconomic level, but he rejected the idea of a social conservation optimum (expressed as the present value maximization of the social net income-flow). In view of problems like extra-market values, externalities, uncertainty and so on, at a social level it was only possible to design conservation policy measures through trial and error, attempting to increase the present social net revenues of such measures<sup>22</sup>. Anyway, the discussion of social discounting linked to natural wealth utilization hardly has relevance in Ciriacy-Wantrup's analysis.

## 5. From the idea of conservation to the sustainability debate

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that Ciriacy-Wantrup had developed in a previous work: *Conservation of Natural Resources: An Inquiry into Economic Theory and Public Policy*, Berkeley, University of California, 1945.

<sup>21</sup> Later this idea would be developed by Bishop (1978).

<sup>22</sup> "The practical goal in conservation policy is not the optimum time distribution of use rates, but a step-by-step improvement of the existing one through trial and error. The improving is made by comparing the present value of total additional social costs of whole measures of conservation policy (changing use rates in a number of intervals) with the present value of total additional social revenues of such measures. In other words, the practical criterion is an increase of present total social net revenues" (Ciriacy-Wantrup, 1952: 249).

At the end of the 1960s environmental problems in industrialized societies had become important enough to be seriously taken into account, and at the beginning of the 1970s took place the petroleum crisis. In this context, economists after decades of indifference returned to pay considerable attention to issues related to natural resources and environment. And it would be also then when the questions that Gray had studied in 1913 would be reconsidered from new viewpoints. On the one hand, the relationship between intergenerational equity and efficient use of the natural exhaustible stock became a central topic, culminating finally in the sustainability debate a wider debate but on the same basic idea of moral obligation towards future generations. On the other hand, the question of the social discount rate which by then had already been broadly discussed in connection with public investment projects began to be discussed specifically in connection with the environment, with special reference to ethical considerations. These two aspects can be analyzed separately.

After a long period of sustained economic growth with a high rate of technical change, social concern about the exhaustion of natural resources seemed something belonging to a remote past. For instance, in 1967 John Krutilla analyzed again the old conservation question, but redefining it completely: from now on the main goal of conservation economics should be the preservation of unique natural sites, on which certain human actions like the construction of a dam could cause irreversible impacts:

From the time of Pigou [...] until quite recently, the central concerns [of conservation economics] have been associated with the question of the optimal intertemporal utilization of the fixed natural stocks. [...] [But these] traditional concerns [...] the husbanding of natural resource stocks for the use of future generations may now be outmoded by advances in technology. [...] The central issue seems to be the problem of providing for the present and future the amenities associated with unspoiled natural environment, for which the market fails to make adequate provision [...] On what basis, then, can we make

decisions when we confront a choice entailing action which will have an irreversible adverse consequence for rare phenomena of nature? (Krutilla, 1967: 777 -8).

Krutilla's article meant an important contribution to the economic literature on natural resources (for example, it anticipated the idea of existence value and underlined the problem of decision making when the results can be irreversible environmental impacts<sup>23</sup>). However, his prediction about the new directions of conservation economics was incorrect. As a result of the petroleum crisis, the question of intergenerational equity associated with the utilization of exhaustible natural resources which had been stated by Gray sixty years before became again meaningful. In this way, for example, Talbot Page's important book *Conservation and Economic Efficiency* [1977] recovered to a certain extent the same scheme of discussion proposed by Gray, that is, the idea of complementarity between the macroeconomic criterion of intergenerational equity and the microeconomic one of efficiency. In other words: to design a conservation policy would mean to define a general frame for delimiting the subsequent action of the microeconomic forces linked to efficiency<sup>24</sup>.

Confronted with the pessimistic perspectives of the Meadows Report of 1972<sup>25</sup>, economists extended the conventional economic growth model in order to include exhaustible resources as a new input of the aggregate production function<sup>26</sup>. The aim was to define optimal use paths of non-renewable resources in which the intertemporal social

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<sup>23</sup> In a later work, Krutilla –with Fisher– developed a famous model to determine the range of discount rates that would be admissible when the cost-benefit analysis was applied to evaluate projects with clear irreversible impacts on unique natural sites (Fisher and Krutilla, 1975).

<sup>24</sup> The connection between Gray (1913) and Page (1977) has been pointed out by Gerald Alonzo Smith (1982: 488n) and by Philippe Crabbé (1983: 208) as well. Page (1977: 205) says: “The conservation criterion [intergenerational equity] functions at the macroeconomic level establishing a context for markets; the present value criterion functions at the microeconomic level of market efficiency”. Whereas for Gray (1913: 517) “the interest rate must be rendered as low as possible” –in order to slow down the extraction rates of exhaustible resources–, Page’s prescription is to establish “a severance tax [...] to promote a fairer distribution of resource use and control across generations”.

<sup>25</sup> D.H. Meadows, *et al.*, *The limits to growth*, London, Pan Books, 1972.

<sup>26</sup> Toman, Pezzey and Krautkraemer (1995) is a good summary of this question.

welfare was maximized. Among the numerous works on this matter, which differed basically in the way of defining the social welfare function, perhaps the most influential was Solow (1974a)<sup>27</sup>. This author attempted to apply Rawls' maximin criterion to an intergenerational context (that is, the maximization of the welfare level of the least well-off generation<sup>28</sup>). His conclusion was that the optimal solution consisted in achieving the maximum sustained consumption over time. This possibility depended on the assumption of perfect substitutability between human-made capital and non-renewable resources; moreover, the elasticity of production with respect to man-made capital should be greater than with respect to natural resources. Shortly afterwards Hartwick (1977) showed that in a Cobb-Douglas economy similar to Solow's with constant population sustained consumption over time would be possible if the Hotelling scarcity rents from non-renewable resources were invested in human-made capital. This idea, known as Hartwick's rule, would be finally advocated by Solow (1986) himself as a prescription for a sustainable economy: that is, sustainability would mean to maintain a constant value of the aggregate capital stock, which would require sufficient investment in physical capital to replace the natural capital that is being depleted. Nowadays, this view is generally referred to as weak sustainability<sup>29</sup>.

As a response to this position came into being the other perspective of the contemporary debate, the strong sustainability view which to a large extent is based on

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<sup>27</sup> This work was written for an important symposium on the economics of exhaustible resources. The most noteworthy papers (by Solow, Dasgupta and Heal, Stiglitz, etc.) was collected in the *Review of Economic Studies*, 1974, vol. 41.

<sup>28</sup> The Rawlsian "veil of ignorance" is the basis of this criterion: "The persons in the original position have no information as to which generation they belong" (Rawls, 1971: 137). For a discussion on alternative criteria for intergenerational equity see Dasgupta (1974).

<sup>29</sup> *The Brundtland Report* (WCED, 1988) popularized the expression "sustainable development", defined as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. This definition is ambiguous and –in practice– it can be interpreted in different ways. One of them is the *weak* sustainability view, which to a certain extent was anticipated by Jevons (1965[1865]) when he proposed the utilization of the prosperity derived from coal to reduce the National Debt. That is, the paying off of the Debt would be a way of transferring physical capital to future generations, compensating them for the progressive exhaustion of such an essential resource for the nineteenth century



Georgescu-Roegen's work. The proponents of strong sustainability deny the idea of no difference between natural capital and man-made capital. One cannot be substituted by the other because they are complementary. More sawmills and more fishing boats cannot substitute the reduction of forests or the shrinkage of the quantity of fish, and human-made capital is increased when we want to raise the capacity of production, for which purpose more natural capital is needed. Certainly technology allows us to make better use of raw materials and to use energy more efficiently, but there are limits to both processes (Daly, 1990). Moreover, apart from the mere provision of energy and raw materials, natural capital is essential both for survival and well-being in general. Added to that, there is a problem of uncertainty because we know very little about the working mechanism of many ecological processes, and there is also a danger of irreversible loss of some essential ecological resources and services as a result of problems like cumulative impacts of pollution, habitat modification and over-exploitation of some biological resources. Therefore, strong sustainability would require keeping at least a proportion of natural capital designated as critical capital as constant.

In any case, setting aside the details of the current sustainability debate, what is relevant for this work is that Gray's (1913) article can be considered as an important precedent of this debate, because he stated explicitly the problem of intergenerational equity in connection with the depletion rate of non-renewable resources. And as has already been shown, this problem gave rise to the theoretical developments that since the 1970s and starting from the analytical basis of economic growth models ended in the current broad controversy on sustainability.

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industrial civilization. Pigou (1950[1920]) can also be considered as a forerunner of the weak sustainability view.

But where Gray appears to have anticipated more clearly current concerns is with reference to the contemporary discussion about the meaning of discounting in the field of environmental economics. During the 1960s special attention had been paid to the social discount rate applicable to public investment evaluation<sup>30</sup>. But when the energy crisis of the 1970s came, together with the question of the intertemporal utilization of exhaustible resources, the discussion about the meaning of discounting from an environmental point of view reappeared (discussion that Gray had already set out in its ethical aspects).

Discounting which implies an undervaluing of the future is present in any intertemporal decision through the net present value criterion. In principle, a high discount rate means a faster degradation of the natural resource basis. Moreover, since it involves attaching less importance to long-term profits and costs associated with investment projects, it will be easier to implement certain projects with substantial short-term profits, but with disastrous consequences in the long term from an environmental viewpoint (for instance, those linked to the emission of accumulative pollutants).

Economic justification of discounting is based primarily on the ideas of future temporal preference, capital productivity (capital use opportunity cost), uncertainty about the future, and growing wealth as a result of present investment (assuming the diminishing marginal utility of consumption). As opposed to these reasons, and leaving aside the several technical arguments that raise doubts about such ideas <sup>31</sup>, the essential objection to

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<sup>30</sup> It exists a long list of remarkable articles on this matter. For example: S.A. Marglin (1963), "The Social Rate of Discount and the Optimal Rate of Investment", *Quarterly Journal of Economics*, 77: 95-111; M.S. Feldstein (1964), "The Social Time Preference Discount Rate in Cost Benefit Analysis", *Economic Journal*, 74: 360-79; A.K. Sen (1967), "The Social Time Preference Rate in Relation to the Market Rate of Interest", *Quarterly Journal of Economics*, 81: 112-24; W.F. Baumol (1968), "On the Social Rate of Discount", *American Economic Review*, 57: 347-59; o K.J. Arrow and R.C. Lind (1970), "Uncertainty and the Evaluation of Public Investment Decisions", *American Economic Review*, 60: 364-78.

<sup>31</sup> For example, it is asserted that "impatience" or pure temporal preference could be irrational, because it does not contribute necessarily to maximize the individual welfare over the life cycle. Likewise, uncertainty about future benefits and costs would not be always related to time. On the other hand, it is alleged that to justify positive discount rates on the basis of decreasing marginal utility of consumption has no sense, because positive discount rates could lead to environmental degradation, which might prevent the growth of per capita

discounting from an environmental viewpoint is still ethical, as Gray (1913) pointed out in his day and has later been corroborated in many studies – such as Pearce (1983), Arrow et al. (1995) or Portney and Weyant (1999) –. Discounting involves a discrimination against the future, and therefore the selected discount rate summarizes the way of valuing unborn generations. But, as Georgescu-Roegen (1977: 95-6) argued, if a multigenerational perspective were adopted – for immortal bodies like nations or humanity – discounting would be absurd.

In any case, the upshot of all this is not that the discount rate should be reduced by a certain amount. Nor that it should be zero. The conclusion is that there is not any answer from the conventional economic analysis to the problem of choosing the most appropriate discount rate. Economic analysis simply allows us to assert that there is not a single relationship between high discount rates and environmental damage<sup>32</sup> (Lozada, 1993). But the discussion about discounting necessarily transcends purely economic aspects to end up in the field of ethics, as Gray showed almost a century ago. For this reason, the environmental criticism of discounting is ultimately associated with works of a philosophical nature<sup>33</sup>.

## 6. Conclusion

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consumption over time. Finally, positive discount rates could be incompatible with sustainability. Anyway, it should be also taken into account that technical change makes difficult to choose a rate at which to discount long-term costs and benefits associated with public investment projects (Pearce y Turner, 1990: chapter 14).

<sup>32</sup> At a macroeconomic level, high discount rates can involve the transfer of costs to future generations, but they can also have a depressive effect on investment and on the general rate of development, reducing in this way the demand for natural resources and the creation of waste products. At a microeconomic level, high discount rates can act as a disincentive to development projects with negative environmental impacts –like large dams– whose benefits are concentrated in the long term and whose short-term investment costs are significant (Martínez Alirol y Roca, 2000: 215-6).

<sup>33</sup> For example, Barry (1977), Norton (1982), Parfit (1983) or Weiss (1989).

The aim of this article has been to emphasize the relevance of Gray (1913) as a basic antecedent of two important current controversies in the field of natural resource economics: the discussion about the meaning of discounting from an environmental viewpoint and the sustainability debate. With regard to the first aspect, *The Economic Possibilities of Conservation* is a direct precedent, whereas with regard to the second is only an additional element though important in the historical configuration of this broad contemporary debate.

What gave rise to Gray's (1913) article was the purpose of reinterpreting from an economic perspective the idea of conservation that predominated in North American society at the beginning of the twentieth century. In fact, during those years conservation had turned into the leitmotiv of a great sociopolitical movement: the American Conservation Movement. However, the economic content of these ideas was minimum. Starting from an objective conception of natural resource scarcity understood as an absolute limit of multidimensional character, the need for conservation arose from the moral obligation of human beings towards future generations in the use of nature. Although human activities inevitably increased scarcity the natural limits to the availability of resources, the degree of this increase depended to a great extent on the way natural wealth was used more or less wastefully. For that very reason, conservation was connected with wise use and scientific management the achievement of maximum physical efficiency in natural resource utilization.

Going beyond this intuitive conservationist conception, Gray (1913) was the first author who dealt with the subject from an economic point of view. Conservation was for him a macroeconomic problem linked to an ethical commitment with future generations. In short, conservation referred to the discussion about discounting in connection with the intertemporal use of non-renewable resources. As a matter of fact, it was with reference to

these resources where conservation equivalent to non-utilization, or failing that, to the achievement of lower use rates was really problematic, since it involved a drastic intertemporal choice associated with a difficult ethical dilemma: adjustments between present and future interests.

For Gray, in mineral resource exploitation the main determinant of individual decisions prompted by the net present value maximization of the future returns derived from natural assets was the discount rate (a question into which Gray went more deeply in his important article of 1914). Therefore, with the object of slowing down the extraction rate of exhaustible resources, the guiding principle behind a conservation policy understood as the definition of an adequate macroeconomic scenario for the action of microeconomic forces should be the reduction of market interest rates as far as possible. However, economic theory does not give us a solution to the problem of optimal conservation level summed up in the choice of a certain discount rate, because it involves valuing in the present future necessities, which unavoidably leads to broader philosophical considerations. It could only be asserted that a strict conservation position, associated with a zero discount rate, implied attaching the same importance to present and as to future necessities, which would be absurd because in this way the amount of present use would become infinitesimal and the period of utilization would be increased to infinity. In conclusion, in the absence of more solid foundations, all that was left to do was to lean on the *virtue* of common sense and to appeal to possible future developments in economic analysis in order to evaluate human wants the satisfaction of which will determine natural resource allocation.

After the end of the American Conservation Movement, Gray's (1913) work fell into oblivion, as did the conservation question. Till the seventies –setting aside isolated references– only the German economist S.V. Ciriacy-Wantrup dealt seriously with the problem of resource conservation. But his approach differed from Gray's, being specially focused on renewable resources and –above all– Ciriacy-Wantrup tried to deal with the question with no reference at all to ethical aspects.

When the first clear symptoms of serious environmental damage appeared and the energy crisis came, natural resources became again a relevant matter for research by professional economists. And it was then that the issues that Gray had raised for discussion were taken up again.

On the one hand, the relationship between intergenerational equity and use of the non-renewable resource stock. The analysis of this connection ended finally in the sustainability debate much more extensive but focusing on the same basic idea of moral obligation towards future generations. In fact, some of the first important works on such a difficult question such as Solow (1974) or Hartwick (1977) should be placed in the early stages of the modern sustainability debate.

On the other hand, there is the environmental discussion about the meaning of discounting. During the 1960s the subject of the social rate of discount had already begun an important controversy in connection with the evaluation of public investment decisions. But it was after the 1970s when discounting became specifically discussed with regard to the environment, paying special attention to ethical considerations. Actually, leaving purely economic aspects aside, environmental criticism of discounting leads us inevitably to works of philosophical nature. As Gray stated, this controversial theme since it concerns unborn generations is beyond the field of standard economics.

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