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“Nature as Model: Spontaneous Industrial Recycling Networks in Early Industrialization and the Origins of the Industrial Ecology Metaphor.”

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Abstract :

Despite widespread current beliefs to the contrary, much evidence indicates that past entrepreneurs, managers and technicians were often able to create recycling networks between firms, in the process generating both economic and environmental benefits. This paper documents early cases of such win-win situations and further demonstrates that the basic insight of the industrial ecology metaphor, i.e. using nature as a model or inspiration for loop-closing, was well understood in the second half of the 19th century. The last section offers some speculations as to why this perspective was apparently forgotten in the middle of the 20th century and had to be independently rediscovered and popularized in recent years.

Keywords : Industrial ecology metaphor, recycling networks, spontaneous order, sustainable development, Lyon Playfair, Peter Lund Simmonds, Victor Shelford.

The odds that any 21st century intellectual research program would be entirely without precedents are small. Not surprisingly, the idea that modern industrial economies should mimic the cycling of waste materials in what we now call ecosystems has roots that stretch much further back in time than the 1960s system analysis tradition to which it is usually traced back [1].¹ The aim of this paper is to present some evidence on the propensity of past managers, technicians and entrepreneurs to spontaneously create recycling networks between firms and how this widespread behavior led some writers to draw parallels between the way nature and market economies recycle waste products. I then speculate as to why this perspective was seemingly forgotten and had to be independently rediscovered and popularized in recent decades, most prominently by Frosch and Gallopoulos [2].

1. Industrial waste recovery in historical perspective

Numerous books and articles published between the first decades of what would later be called the Industrial Revolution and the first Earth Day in 1970 document the

spontaneous creation of recycling networks between firms and the profitable uses of what had formerly been industrial waste products, in the process creating both environmental and economic benefits [3]. In this writer's judgment, the best English language surveys on this topic are listed in Table 1.²

Table 1: Main English Language Surveys on Industrial Waste Recovery, 1876-1963

Author, profession, nationality	Title	Year, edition, number of pages	Publisher
Simmonds, Peter Lund, specialized journalist, Danish-born British citizen	Waste Products and Undeveloped Substances: A Synopsis of Progress Made in Their Economic Utilisation During the Last Quarter of a Century at Home and Abroad.	1876, 3 rd edition, 491 pages (1 st edition 1862)	Hardwicke and Bogue (London)
Koller, Theodor (chemist), German	The Utilization of Waste Products: A Treatise on the Rational Utilization, Recovery, and Treatment of Waste Products of all Kinds	1918, 3 rd revised edition, 338 pages (First German edition 1880)	D. Van Nostrand Company (New York)
Kershaw, John Baker Cannington (chemical engineer), British	The Recovery and Use of Industrial and Other Waste.	1928, 1 st edition, 212 pages	Ernest Benn Limited (London)
Lipsett, Charles S. (specialized journalist), American	Industrial Wastes and Salvage: Conservation and Utilization.	1963, 2 nd revised edition, 407 pages (First edition 1951)	Atlas Publishing Co. (New York)

While it is impossible to cover in any detail the content of these books, the breath of past recycling networks they describe can be guessed from a summary of “The Utilization of Waste Products” published in an 1881 issue of the American periodical *Manufacturer and Builder*:

The glycerin industry, which has attained to large proportions, is a remarkable illustration of a great industry based entirely upon what was, until lately, a waste product of the soap boiler. As even more important in this category, we may name the industries connected with the manufacture of aniline dyes and artificial madder³ from the refuse of coal tar, that was once the abomination and nuisance of the gas works. Old boots and shoes, and leather waste generally, are now turned to good account by the chemical manufacturer in producing the cyanides, ferro and ferrid-cyanides, that have

become indispensable in color printing and in photography. Of the carcasses of slaughtered animals not a scrap or morsel is allowed to go to waste; and even the waste blood of the abattoir is utilized by the sugar refiners and the manufacturers of albumen.

Sawdust, mixed with blood or other agglutinative substances, and compressed by powerful pressure in heated dies, is formed into door knobs, hardware and furniture trimmings, buttons, and many other useful and decorative articles. The spent tan-bark of the tanneries is utilized as fuel under steam boilers. Oyster shells are burned to lime; the waste of linseed oil factories is largely sought after as food for cattle; the waste ashes of wood fires are leached for alkali; river mud, mixed with chalk, is ground and burned to make the famous Portland cement; the waste gases of the blast furnace are utilized to heat the blast, and to generate the steam that drives the engine that furnishes the blast; and the slag⁴ of the iron furnaces that from time immemorial only served to decorate the hillsides, is now cast into building blocks, granulated to make building sand, made into cement, mixed with suitable chemicals and made into the commoner grades of glass, or blown by steam jets into the finest filaments to make the curious mineral wool for covering boilers, steam pipes, etc. The waste heat of the lime kiln, in England, is made to generate steam and to heat large buildings... And so the record might be indefinitely extended, showing how modern science with the most beneficent results is steadily teaching the world to utilize the waste substances of nature and the arts, enabling us to reap advantages where none were supposed to exist, or where, if they were suspected, they were undervalued or neglected [4].

Perhaps the best summaries of the extent and benefits of these past practices are to be found in two figures drawn by the American zoologist Victor E. Shelford (1877-1968) [5]. The first illustrates the “various wastes and the useful substances into which they may be manufactured or which may be obtained from them” (Figure 1) while the second illustrates “the various wastes and the damage they do when not properly recovered” (Figure 2).

FIG. 2. Diagram showing the various wastes and the damage they do when not properly recovered.

Most past authors credited both competitive pressures and human creativity for these positive outcomes. For example, in the preface of his *The Utilisation of Wood-Waste*, whose 2nd revised and enlarged edition was first published in English in 1902, the German chemist Ernst Hubbard observed:

The rational utilization of waste products is at all times important, but as our industries become more and more developed the working up of the waste or bye-products which may be produced in any process becomes absolutely essential from an economic standpoint. Many instances could be cited in which a waste product has become one of the chief products, sometimes

nearly, if not quite, as important as the material which was first made. This has proved to be the case in many industries [6].

Similar comments were also made a few years later by the American agricultural economist Rudolf Clemen:

Modern conditions make it almost impossible materially to cut production and distribution of expense for the majority of commodities; hence one of the most important opportunities for gaining competitive advantage, or even for enabling an industry or individual business to maintain its position in this new competition, is to reduce its manufacturing expense by creating new credits for products previously unmarketable... Indeed, the materials from which the by-products in nearly all industries are manufactured today were formerly partially or wholly wasted, and the change to intensive utilization of these materials for by-product manufacture has been brought about by the ever-increasing force of competition in American business, both between individual concerns within a single industry and among different ones [7].

This assessment was not limited to supporters of market economies. Indeed, Karl Marx (1818-1883) himself wrote that industrial by-product recovery “reduces the cost of the raw material to the extent to which it is again saleable, for this cost always includes the normal waste, namely the quantity ordinarily lost in processing. The reduction of the cost of this portion of constant capital increases *pro tanto* the rate of profit.” As a result, he observed, “the capitalist mode of production extends the utilisation of the excretions of production and consumption” and “the so-called waste plays an important role in almost every industry” [8].

These practices led some past writers to draw a parallel between the fate of waste products in both nature and industrialized economies. The extent to which this “nature as model” metaphor (or analogy) proved influential or merely described typical business practices is difficult to assess retrospectively, but it certainly captured the spirit of past individuals involved in industrial production. This topic will now be discussed in more detail.

2. The early origins of the industrial ecology metaphor

The *Oxford English Dictionary*, defining *ecology*, under its initial spelling, *oecology*, as “the science of the economy of animals and plants,” dates the word’s first written appearance in English to 1873 and notes that the coinage follows *economy*. Initially, *oecology* referred to both the animal and plant communities, but under its modern spelling, dated as 1896, the word denoted only plant communities until 1930, when animals were again included. The fact that there is very little waste in nature, however, was understood for some time before the appearance of the word ecology. It is therefore not entirely surprising that the core insight of the industrial ecology metaphor is actually older than the term *ecology*.

Perhaps the first English-speaking author to draw a parallel between nature and industry in terms of waste recovery was the Scottish chemist and parliamentarian Lyon Playfair (1818-1898)⁵ in a lengthy essay on the chemical principles of the manufactures displayed during the Great Exhibition of 1851.⁶ He discussed the metaphor in the following passage:

[Modern people] observe and investigate the phenomena and properties of each body, so as to ascertain how far it may be made subservient to their desires. In these investigations Chemistry offers vital aid: she, like a prudent housewife, economizes every scrap. The horseshoe nails, dropped in the streets during the daily traffic, are carefully collected by her, and reappear in the form of swords and guns. The clippings of the traveling tinker are mixed with the parings of horses’ hoofs from the smithy, or the cast-off woolen garments of the poorest inhabitants of a sister isle, and soon afterwards, in the form of dyes of brightest blue, grace the dress of courtly dames. The main ingredient of the ink with which I now write was possibly once part of a broken hoop of an old beer-barrel. The bones of dead animals yield the chief constituent of lucifer-matches. The dregs of port-wine, carefully rejected by the port-wine drinker in decanting his favourite beverage, are taken by him in the morning, in the form of Seidlitz powders, to remove the effects of his debauch. The offal of the streets and the washings of coal-gas⁷ reappear carefully preserved in the lady’s smelling-bottle, or are used by her to flavour blancmanges for her friends. This economy of the chemistry of art is only in imitation of what we observe in the chemistry of nature. Animals live and die; their dead bodies, passing into putridity, escape into the atmosphere, whence plants again mould them into forms of organic life; and these plants, actually consisting of a past generation of ancestors, form our present food [9].

To my knowledge, Playfair only revisited the topic in some detail in the November 1892 issue of the *North American Review* where he restated the metaphor in the following terms:

As knowledge progresses, man discovers new uses for the most common objects, and learns that, though bodies may undergo many transformations, each one has its destined utility. Nature is most economical of material, and does not admit the idea that any substance can become useless. The waste matter of animals during their lives and their own bodies after death become transformed into the food of plants and constitute the basis for new generations of living beings... As nature does not admit the idea of waste matter, man, when under the guidance of knowledge, should not be inclined to deem anything as a waste product. It may be unused, because he has not learned how to apply it to a useful purpose, but the time arrives when it will be converted into a practical utility. The whole history of manufactures is a commentary on this text. The refuse of the produce of to-day may possibly become the chief source of profit to-morrow. Scarcely a single article of use or ornament, after it has served its first purpose, is not used over again for another service, perhaps in a new and distinct form, or in composition with other materials [10].

Playfair's role in promoting by-product recovery in the interval was nonetheless significant. As one of the leading organizers of the Great Exhibition of 1851, he proved instrumental in suggesting that a portion of its profits be used to set up a "waste exhibit." The man who would eventually be most closely associated with this endeavor was the journalist Peter Lund Simmonds (1814-1897)⁸ who synthesized the information he had gathered on the topic in his massive (420 pages) 1862 *Waste Products and Undeveloped Substances: or, Hints for Enterprise in Neglected Fields* and in a thoroughly revised, updated and expanded edition in 1873.

Simmonds not only documented the profitable reuse of everything from cotton seeds to the refuse of fisheries and "waste mineral substances," but also borrowed Playfair's metaphor and used it in different forms in virtually all of his writings on the topic. For instance, he writes in the opening page of his *Waste Products and Undeveloped Substances*: "When we perceive in nature how nothing is wasted, but that every substance is reconverted, and again made to do duty in a changed and beautified form, we have at least an example to stimulate us in economically applying the waste materials we make,

or that lie around us in abundance, ready to be utilized” [11]. He reiterated this point in later years: “There is no waste in Nature. Matter is indestructible, but passes through an endless cycle of change. In this wise economy there is a hint which has been eagerly seized by the man of practical science” [12]. He adopted a more lyrical tone on another occasion:

Our aim is now to utilise all things to the utmost possible extent. The uses to which they are turned are not always stale, flat, or unprofitable. We now produce valuable articles from what a few years ago was thrown away as nuisance. Once the raw material gets into the clutches of the manufacturer, it is tortured by a score of processes to yield up all its virtues. This system extends throughout all our modern actions in domestic and rural economy, and in our commercial undertakings...

Nothing comes amiss to our ingenuity. We consume our smoke, write and print on the remnants of our ragged shirts, and triumph over decomposition and stenches. Utilisation is the great law of Nature, and we are only following her teaching. The air we inspire gives us life, the poison we expire gives life to plants. She, true to herself, is never at a loss what to do with any of her elements. Man, in an artificial state of society, and in an enlightened age, also provides for converting all the material he uses into useful purposes. There must be no loss of anything once within his grasp [13].

An acquaintance of Simmonds who drew a similar parallel was the Austrian Archduke Rainer Ferdinand von Habsburg (1827-1913)⁹ under whose tutelage the authorities of the 1873 Vienna International Exhibition created a special section to afford each exhibiting country the opportunity to demonstrate what it had accomplished in this field since the London exhibition. The Archduke thus invited the display of waste materials and their products in an 1870 circular that contained a short description of numerous recent advances along with the following paragraph:

The consumption of soap and paper, the quantity of letters exchanged, the extension of public libraries, and the use made of them, &c., are often taken as a measure of the actual degree of civilization of a nation. An extensive and refined use made of the waste materials of industry and housekeeping might be considered with equal right as the measure of the degree of industrial development and capability. It would also scarcely be possible to find in the processes of Manufacture and in Agriculture an instance which shows to the same extent the really creative force of Science, and the characteristic

tendency of a nation to economise, as well as its endeavour to keep, like nature, all within the circle of reproduction [13].

Another reference to this metaphor can be found in the first paragraph of an article published in a 1902 issue of the American *Gunton's Magazine* by the popular writer George Ethelbert Walsh (1865-1941): “The utilization of by-products is a source of wealth today that has made many a millionaire and revolutionized many an industry. Going upon the generally accepted theory that there is no loss in nature, the chemist and scientist proceed to experiment with all sorts of products to discover some new useful article that will either make his fortune or benefit mankind” [14]. He added that in this endeavor the experimental chemist had become a “mighty factor” and that, for instance, in the iron and steel industry, expert chemists were paid not only to perfect the manufacture of steel and reduce the cost of production, but also “to find some more profitable way of using by-products” [14].

Another American writer who formulated similar comments is George Powell Perry in his 1908 book *Wealth from Waste*. Perry, who must have been a preacher or a deeply religious man, describes several cases of profitable by-product reuse, along with potentially new uses, in a few topical chapters. As he put it, “the greatest source of wealth, in these days of great riches, has been acquired largely through the wise use of that which men term *waste*. In all departments of life men have studied how to utilize to the utmost the refuse and remnants that follow in the wake of legitimate enterprise” [15]. He added that this process had led to many useful inventions, made many individuals wealthy, added greatly to the comforts people enjoy, and was the mark of an advancing civilization. Part of it, Perry believed, derived from Christian ethics because the “great Teacher” taught his disciples after the miraculous multiplication of breads and fishes to “Gather up the fragments that nothing be lost” [15].

Although he did not refer to him directly, Perry was undoubtedly influenced by Playfair's 1892 essay,¹⁰ although he gave a religious connotation to the chemist's insight: “It is through obedience to this law that nature continues so productive. God allows nothing to go to waste... When anything is left over it is turned to advantage through some

ingenious way. That which we consider the most disagreeable refuse becomes through the laws of nature the basis of a future growth that yields for our tables the best product of the fields” [15]. He added a few pages later: “Never was there so much thought given [to save that which is going to waste]. Men are more and more patterning after the Maker and turning everything into a source of wealth. It is a law of nature and the closer that we keep to this law the wiser and wealthier we grow” [15].

While other writers might have used or alluded to this metaphor in later years, preliminary research suggests that it was in time forgotten until independently rediscovered by various individuals from the 1960s onward [1], most prominently by Frosch and Gallopoulos in 1989 [2]. Why did this happen? One might speculate that this eclipse mirrors decreasing levels of industrial waste recovery from the 1930s onward, but this hypothesis seems unlikely in light of the work of the American journalist Charles Lipsett [16] and his collaborators.¹¹ At any rate, this does not tell us why is it now widely believed among sustainable development theorists that our ancestors were unable to “close the loop” on industrial waste.¹² I will now suggest a few possible explanations.

3. Why did the “nature as model” metaphor need to be rediscovered?

Perhaps the main reason why the “nature as model” metaphor needed to be rediscovered independently in recent years is that, despite much evidence to the contrary, doomsday visions of the environment have become the dominant discourse over the last four decades and have helped promote, among other things, the perception of a garbage crisis that can only be cured by mandatory recycling programs [17]. In this context, the idea that our ancestors might have been able to solve a large number of pollution problems profitably through normal business operations was simply too remote from mainstream environmental thought to be seriously entertained.

Another problematic issue is the now dominant belief that the profit motive leads to shortsighted and harmful outcomes instead of giving firms an incentive to pass as much of their inputs as possible through the economy. While the latter perspective might have been well understood during the 19th century, by the turn of the 20th century a majority of

intellectuals, bureaucrats and policy makers had become convinced that central planning by a technocratic elite would lead to more satisfactory social outcomes. Numerous books, articles and political tracts thus indicted market economies for their inherent anarchy and wastefulness, although few authors actually addressed the issue of byproduct recovery in any detail [18]. One of the few exceptions is the British professor of engineering Henry John Spooner (born in 1856) who argued the following in his 1918 book *Wealth from Waste*:

The marked success attending the spasmodic and sporadic attempts that have been and are being made to collect waste articles is a sure indication of the enormous amount of wealth awaiting organised collection and treatment. The municipalities have it in their power to render great services to the State by organising a complete system, including house-to-house calls by voluntary women helpers. But nothing of real importance is likely to be done on an extensive scale until such schemes are organised throughout the country from some State department, such as the Local Government Board [19].

Similar ideas are promoted today by a number of sustainable development theorists, although it is probably fair to say that most are unaware of their intellectual roots. Somewhat ironically, however, the central planning of industrial by-product recovery was attempted on a large scale in Eastern Europe in the post War period, but the results proved disastrous [18,20].

Perhaps another problem is that industrial waste recycling has always taken place outside the public view. As a prominent Philadelphia engineer, John Birkinbine (1844-1915), wrote in an 1899 monograph on the topic: “The facts that old rags and paper enter into the production of other paper, that scrap-iron and other metals are transformed by the cupola or furnace into new forms, that leather-scrap are useful in chemical manufacture, apparently cover the extent of popular knowledge, unless the legend is accepted that old paper, tin cans, and bottles are the most nutritious food for goats” [21]. Similarly, the journalist Frederick A. Talbot (born in 1880) wrote his 1920 book *Millions from Waste* (308 pages) in order to introduce the “uninitiated reader” to “a subject of which very little is known outside privileged circles, and the possibilities of which are but scantily appreciated by the average individual” [22].

Despite its somewhat hidden nature, industrial waste recovery has nonetheless always been of sufficient interest to warrant periodical monographs and articles aimed at an audience of managers and technicians. Unfortunately, many authors who praised the advances of their days displayed an uncanny tendency to denigrate past behavior. A case in point is the journalist Frederick Talbot, a man who acknowledged in the introduction of his 1920 popular book on waste that he was not a specialist of the issue:

In the spirit fostered by our traditional improvidence we have sought to adapt another existing term to meet the situation. We glibly dismiss waste as rubbish. It is not, but because we have been too indolent to occupy our minds in the elaboration of further possible applications for what we do not actually require for conduct of the operations with which our individual exertions are identified, we seek to satisfy our consciences in the easiest manner. In so doing we essay to flout a fundamental law of Nature – the indestructibility of matter. We have failed to appreciate that what may be of no immediate value to ourselves may, indeed can, with judicious and scientific handling be persuaded to serve in the capacity of indispensable raw material to other ranges of endeavour. It may even go so far as to supply the wherewithal for the creation of new industries, widening the possible fields of employment, and contribute pronouncedly towards the wealth of the nation [22].

On the other hand, Talbot thought he was witnessing the birth of a new commercial ethos where “the reclamation and exploitation of waste products for a variety of industrial uses constitute one of the most fascinating and increasingly important developments in modern industry” [22]. As a result, “to relate all the fortunes which have been amassed from the commercialisation of what was once rejected and valueless would require a volume. Yet it is a story of fascinating romance and one difficult to parallel in the whole realm of human activity” [22]. Similar variations on this theme can now be found in countless books aimed at business people and policy makers.¹³

Perhaps a last problem is the evolution of the nature of academia in the last century. On the one hand, the increasing specialization and focus on abstract theorizing in most disciplines might not have been conducive to broad synthesis on a topic as applied and diverse as inter-firm recycling linkages. On the other, the internal paradigms of a number

of disciplines probably hindered the study of the topic. For example, one of the dominant beliefs among economists, management theorists and business historians for much of the 20th century was that production on a large scale and vertical integration were the essence of the modern industrial age. As a result, the study of inter-firm linkages was, for the most part, relegated to backwater sub-disciplines such as economic geography whose practitioners neglected the issue of resource recovery and generally failed to attract much attention to their work.¹⁴

Conclusion

As long as humans have been manufacturing things and have been free to indulge in creative experiments, some individuals have seen the opportunity, and in many cases probably felt a moral imperative, to create something valuable out of what was previously waste and often pollution. While there is no point in arguing that past industrial activities did not generate important pollution problems, perhaps our ancestors should be given more credit than they generally are for being able to profitably solve environmental problems, to create recycling networks and to learn from nature that, with some creative thinking and much effort, there might be a productive use for most things in most circumstances. Perhaps another useful lesson from our ancestors' achievements is that the rational interest of business has never been as far apart from the environmental interest of society at large as many academics, activists and regulators currently believe. As such, spontaneous market coordination should probably be given more consideration in recycling networks than it currently is.

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¹ The meaning given in this text to the "industrial ecology" metaphor is the minimalist one that industrial systems should maximize the economical use of waste. Of course, different writers have interpreted it somewhat differently and have looked for deeper meanings and parallels in this metaphor. For example, some authors go beyond the notion of recycling and discuss issues or notions such as diversity, species, locality, aggregations, relationships and connections, climax, energy use, productivity, and evolutionary processes. For recent survey of the various perspectives on the metaphor, see Isenmann [23], Levine [24] and Baldwin et al. [25].

² This judgment is based on several years of “detective” work spent trying to track down the most significant literature in this area using various databases, reference catalogs and examination of references cited in various works. Two outstanding work on the topic published in French, but to my knowledge never translated are Charles de Freycinet’s 1870 *Traité d’assainissement industriel* [26] and Paul Razous’ 1937 (first edition 1905) *Les déchets industriels. Récupération – Utilisation* [27].

³ Madder is a plant from which various colors were derived and used as pigments in inks and paints.

⁴ Slag is the more or less completely fused and vitrified matter separated during the reduction of a metal from its ore.

⁵ For more detailed biographies of Playfair, see *The 1911 Encyclopedia* (available at http://80.1911encyclopedia.org/P/PL/PLAYFAIR_LYON_PLAYFAIR_1st_BARON.htm) and an Edinburgh university webpage (available at http://www.chem.ed.ac.uk/welcome/history_playfair.html)

⁶ For a short history and description of the Great Exhibition of London, see <http://www.victorianstation.com/palace.html>

⁷ Coal gas, or town gas, was the result of a process that converted coal partially or completely to combustible gases. It was produced by adding hydrogen and heating coal in the absence of air, yielding a gas whose heating value was about 50% that of natural gas. It was mostly used as a fuel and illuminant from the early 19th century to the 1940s when the growing availability of low-cost natural gas led to its demise.

⁸ To my knowledge, Simmond’s only recent biographical treatment is Greysmith [28].

⁹ Rainer Ferdinand Maria Johann Evangelist Franz Ignaz von Habsburg-Lothringen was the Son of the Viceroy of Lombardy-Venetia Rainer Josef and Princess Maria Elisabeth of Savoy. Between 1861 and 1913 he was, among other things, “Kurator” of the Austrian Academy of Sciences and, from 1863 onward, “Protektor” of the Austrian Museum of Art and Industry.

¹⁰ Perry refers to a writer in a popular magazine who, a few years earlier, had told of the peculiar practice in Paris of feeding rats on dead carcasses, in the process cleaning bones and providing raw materials for glove makers – a story told in gruesome detail by the Scottish chemist (and in more detail by Simmonds (1876: 122-125)). Perry’s description of gas tar by-products (p. 72), along with a few other examples, also bear an uncanny resemblance to various portions of Playfair’s article.

¹¹ During his seven decade career that began at the turn of the 20th century, Lipsett was one of the main voices of American waste traders and brokers, and was often simultaneously a lobbyist and reformist of this trade. Lipsett’s prominence in the field can be traced back to his early years, when he had decided on a career in publishing and journalism. Early in the 20th century, he observed that the waste material trade, by then already a flourishing industry, lacked a specific publication. He therefore launched the *Atlas Publishing Company* and its flagships *Waste Trade Directory* and *Waste Trade Journal* in 1905. To these publications, Lipsett and his staff would later add periodicals such as *The Daily Metal Reporter*, *The Daily Mill Stock Reporter* and *Rebuilt Tire Journal*, along with compendiums such as *Who’s Who in Steel and Metals* and various other books on trade-related topics. Although Lipsett mainly focussed on periodicals, he eventually published a compendium on industrial by-product recovery, first in 1951 and in a thoroughly revised edition in 1963. With 66 topical chapters and over 400 pages, the 1963 edition of *Industrial Wastes and Salvage: Conservation and Utilization* aimed to respond “to the long unfilled need for a semi-technical book dealing with the conservation and utilization of industrial wastes, popularly known as ‘scrap’ or waste materials, but perhaps better described today as ‘secondary raw materials’ since they constitute an important source of supply for basic industries, having similar or identical properties, available at lower cost” (Lipsett, 1963: iv).

¹² Desrochers [3] lists several examples of sustainable development theorists who believe that past industrial development was not characterized by widespread loop-closing.

¹³ One can think of several reasons for this, ranging from a lack of historical knowledge to a desire to highlight the originality of one’s contribution to a belief that “new ideas” might prove a better sell to business people. A recent best-seller that reproduces this old pattern is *Natural Capitalism* by Paul Hawken and Amory and L. Hunter Lovins [29].

¹⁴ This writer is an economic geographer by training.