The impact of rainforests' biodiversity loss on Vanguard's pharmaceutical portfolio

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1 Introduction

While climate risk is recently widely accepted by financial regulators, central banks and investors (PwC, 2020) to have impact on the financial sector, the financial impacts of biodiversity loss are still not recognized. This paper attempts to quantify the biodiversity-related financial risk to a large financial institution, namely the Vanguard Group, one of the largest asset management companies in the world. Specifically, we estimate how much money of their clients Vanguard would lose if Vanguard's pharmaceutical portfolio devalues due to biodiversity loss as a result of rainforest deforestation. We set out to assess the financial impact of biodiversity loss in rainforests on the pharmaceutical industry which depends, historically speaking, highly on the information provided by nature to develop new medicines (Young, 1999; Rosenthal, 1996; Tan et al., 2006; Hendriks et al., 2006). Many studies agree that we are experiencing the sixth mass extinction (Barnosky et al., 2011; Ceballos et al., 2015; Ceballos et al., 2017; McCallum, 2015), and one of the drivers of this is the steady decline in rainforest area worldwide. With this tremendous loss of biodiversity, planet Earth is not only losing large parts of its beauty and diversity, but also a pool from which potential lifesaving medicines can be discovered (Alho, 2008). The outlook of this study is even more relevant in time of a worldwide pandemic and the associated pressured search for a cure.

The paper starts with a review of existing research on deforestation and how the loss of rainforests leads to biodiversity loss. We then connect the importance of biodiversity to drug discovery of the pharmaceutical industry and attempt to quantify the potential financial loss to the industry as a consequence of deforestation-related biodiversity loss. To do this, we apply the potential contribution to drug discovery of around $3,000 incremental value per hectare of rainforest as calculated by Rausser and Small (2000) to the three scenarios of rainforest loss by 2050 of 232 million, 260.5 million and 289 million hectares, based on the research of Busch and Engelmann (2015) and WWF/IIASA (2011). A sensitivity test is carried out with different variations of the incremental value per hectare of rainforest from Rausser and Small (2000), in which the effects are estimated using the largest and the smallest incremental value from this paper at $14,000 and $355, respectively. Finally, we estimate how much the Vanguard's pharmaceutical portfolio would be devalued in each of our three scenarios of rainforest deforestation. Vanguard has 7.36% of their equity portfolio invested in the (bio)pharmaceutical industry. The pharmaceutical portfolio has a total market value of more than $205 billion as of Q1-2020, of which the exposure of the Vanguard's pharmaceutical portfolio is about 2%. Using three scenarios of rainforests' deforestation and three incremental values for the loss of potential contribution to drug discovery per hectare of rainforests, we calculate the potential

devaluation to the Vanguard's portfolio by carrying out a discounted cash flow analysis. The results show that the potential loss to the portfolio value ranges from $282 million to as high as $14 billion, with $2.7 billion loss being the most likely scenario. These are substantial financial impacts to Vanguard and ultimately to their clients that need to be seriously taken into account. Finally, we recommend how Vanguard and pharmaceutical companies can mitigate the biodiversity-related financial risk.

2 Biodiversity loss: background analysis

2.1 Historical overview of deforestation worldwide

The main drivers of biodiversity loss are climate change, natural disasters and deforestation (Fagúndez, 2013). This paper focuses on deforestation at first, which is shown to substantially lead to the loss of biodiversity (Vié et al., 2009). The relationship of the loss of natural habitat and corresponding number of species is called "Species Area Relationship", which normally assumes a function with a positive first- and a negative second derivative. In other words, with the decreasing living area, the number of species decreases at an accelerating rate (Tjørve, 2003). Therefore, the loss of forest in different regions in the world is the center of attention in the present section. In general, the total forest area worldwide has been decreasing, but the rate has slowed down in the last two decades thanks to efforts of forest restoration. The restoration is most visible in Asia-Pacific, however the forest area in this region is relatively small.

The main drivers for deforestation worldwide are population growth, increase in global consumption of natural resources, global land scarcity and agricultural expansion (Thompson et al., 2012). The last cause has the most severe impact on rainforests. Commercial agriculture has been responsible for approximately 2/3 of deforestation in Latin America. In Africa and Asia, subsistence farming is the major driver of land use change, where tropical forests are converted to agricultural land (Kissinger et al., 2012). According to the World Bank, it is observed that from 1990 to 2016, we lose on average 50 thousand km^2 of forest area worldwide each year, which is more than the size of the Netherlands. Between 1990 and 2016, the net loss of forest amounted to 1.3 million km^2 or 3.21% decline in the total forest area worldwide. In the region of Africa between 1990-2016, a decline in forest area of about 400 thousand km^2 or equivalently 6.14% decrease is estimated (World Bank, 2020). About 73% of the world's forest is rainforest (see Figure 5-1, Appendix). The main causes of deforestation increase in this region are timber production, commercial logging and the high growth of population density.

The so-called "hotspots" are regions with an exceptionally high density of different species. Among them, Latin America is the most worrisome area, because it is the largest forest hotspot worldwide and at the same time also has the highest rate of deforestation. In 1990, Latin America's 10.2 million km^2 of tropical rainforest covered a quarter of the world's forest area. In 2016, the forest area has shrunk to only 9.2 million km^2, which is a decrease of 9.68% for the region or a decrease of 2.40% worldwide. Brazil covers 60% of Amazon rain forests and by itself accounts for a third of the world remaining rainforest. The country is also the world's largest beef exporter. Cattle pasture is the cause of 70% of the deforested area in Brazil (Azevedo-Ramos, 2008). Besides cattle farming, the other drivers of deforestation increase in Latin America are soy and sugarcane production, biofuel production, subsistence farming, and mining exploitation. Fortunately, there are good developments in the Asia-Pacific hotspot. The net loss of forest in Asia-Pacific is not very high compared to the other regions. From 1990 to 2000, the forest area in this region decreased at a rate of 0.04% per year on average. However, from 2000 to 2005, a large increase of 0.32% per year on average is observed thanks to forest restoration. The forest restoration continues in the following decade, although at a lower rate of 0.09% per year on average. The forest area of Asia-Pacific in 2016 is higher than in 1990 by 141,074 km^2, which is equivalent to an increase of 2.25% (World Bank).

Despite forest restoration efforts in some countries, the current high rate of forest loss in tropical and subtropical countries is expected to persist, since the aforementioned drivers of deforestation - population growth, increase in global consumption of natural resources, global land scarcity and agricultural expansion - are expected to remain in the near future (e.g., Rudel et al., 2009; FAO, 2018).

2.2 Scenarios of deforestation

The outlook on the amount of rain forest which is going to vanish in the upcoming decades is difficult to predict and there are different approaches to model the outcomes. In this section, we provide a small insight into different models which illustrate the diversity of predictable future scenarios. One model which is more of economic nature was published by the European Commission (Rademaekers et al., 2010) and considers a set of scenarios for deforestation until 2030. Examples for drivers of deforestation are the increasing demand for biofuels, wood or meat. Other drivers are policies regarding the protection of rainforest or lack thereof, and economic growth in general. The outcomes of the different scenarios can be seen in Figures 5-2 and 5-3 in the Appendix which assume no REDD programs (Reducing Emissions from

Deforestation and Forest Degradation). For instance, the most extreme scenario assumes 15% share of biofuels in total transport energy in 2030 and an overall additional increase of 10% in demand for meat in 2020 and 15% in 2030. This would lead to 102 million of hectares (Mha) of global deforested area. This is about 53% higher than the benchmark scenario of 67 Mha cut. 49 Mha of it is considered to be deforested only in Latin America, the continent with the biggest rainforests worldwide. Even in the most optimistic scenario the 49 Mha loss would only decrease by 4 Mha.

Busch and Engelmann (2015) use spatial projections with data about protected status, topography, potential agricultural revenue, accessibility, as well as an inverted-U-shaped trajectory of deforestation they observe. Using a multivariate regression model, the authors try to explain observed annual grid cell-level deforestation. Following their model, in the absence of new forest conservation policies, worldwide approximately the area of India (289 million hectares) of tropical forest are going to be cut between 2016 and 2050, which amounts to one seventh of the total forest area worldwide. This is considerably more than the calculation of 232 million hectares of a similar model approach (WWF/IIASA 2011).

2.3 Deforestation and loss of biodiversity

In the following section, our focus shifts to the extinction rates projected for rainforest in the academic literature. Because this area of research is quite sparse and partially outdated, deforestation as the main driver for biodiversity loss in rainforest as a well-developed academic field is discussed in more detail. Forests in general contain most of Earth's terrestrial biodiversity. Among them, tropical rainforests experience the highest rate of biodiversity loss (Silver et al., 2000). Hubbell et al. (2008) state that there are over 11,000 tree species just in the Amazon forests, where 1,800 to 2,600 species are predicted to become extinct in the next few decades. According to the report of the European Commission (Rademaekers et al., 2010), tropical forest is home to more than 50% of the world's biodiversity. According to the study, the forest area in Asia-Pacific is similar in size to the one in Africa and accounts for 16% of the global forest coverage. The region can lose up to ¾ of its original forest and up to 42% of its biodiversity by 2100. For 65% of the 10.000 endangered species, tropical forest is their natural habitat (Isese, 2019). Brooks et al. (2002) investigate the biodiversity loss in 25 hotspots around the world. The authors take lists of threatened and already extinct species and use these to estimate the extinction of several types of species for an additional 1000 km^2 forest loss in a 5 year window for each hotspot. Taking Brazil's Cerrado as an example: in the case that 1000

km^2 forest gets cut down, 0.2 species would go extinct. For the Mesoamerica rainforest, it would be 0.179 endemic species in 5 years. The article states that about 57% of the terrestrial vertebrates as a whole are threatened or already extinct. Pimm and Raven (2000) project 18% extinction by 2100 due to deforestation to date in tropical forest "hotspots". The authors project 40% extinction if these regions retained natural habitat only in currently protected areas. The most recent estimates about biodiversity loss in rainforests is presented by Alroy (2017). In the study, the extinction rate for trees and 10 kinds of animals are projected and related to disturbances of rainforests like hunting and again, mainly deforestation. The results are summarized in the following graphs.

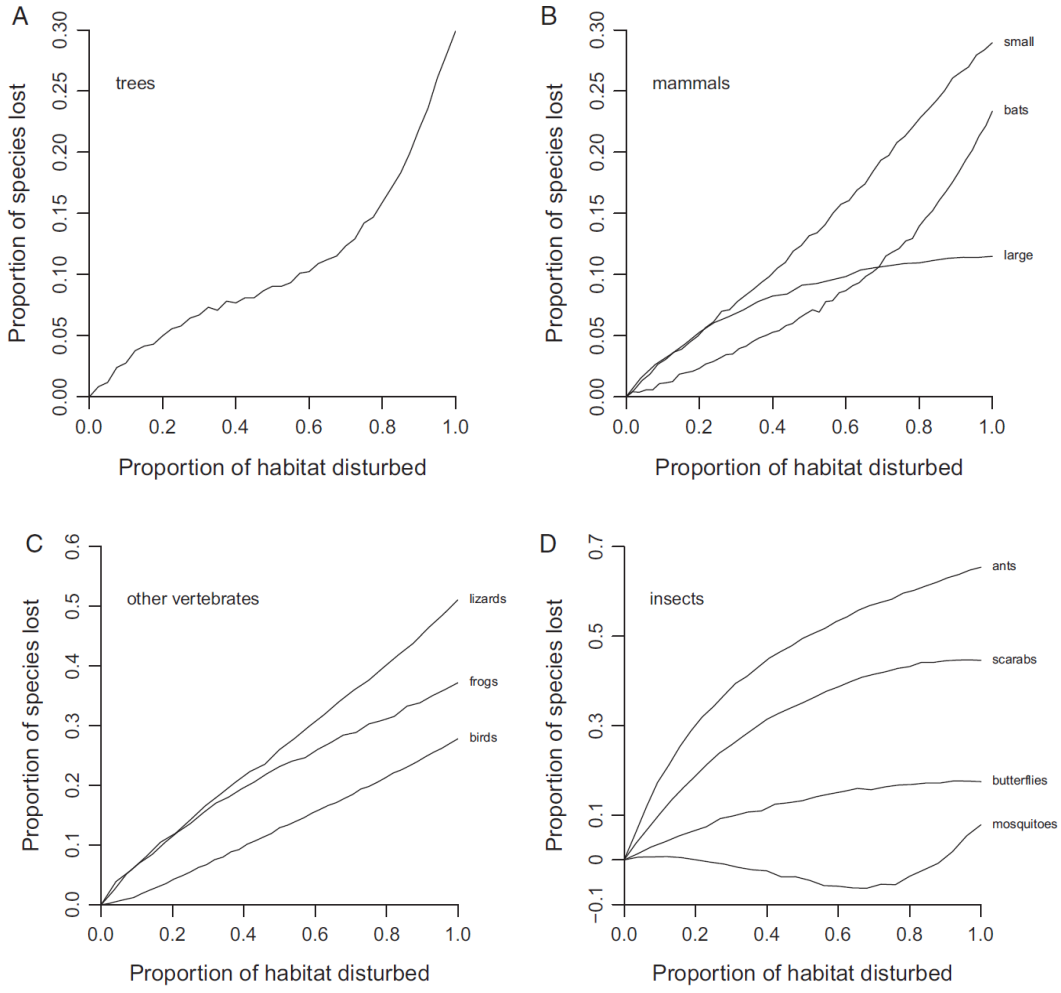

Figure 2-1: Projected species loss at different levels of disturbance

While the relationship between disturbance and species loss expects an exponential function for trees, it is approximately linear for the category "other vertebrates", which makes it difficult to generalize the results. However, these results might be prone to underestimation as they are

based on relatively benign land uses and the density of species in the areas of reference might be too high (Giam 2017).

Taking the literature reviewed so far into consideration, we decide to continue with the following three scenarios of biodiversity resulting from deforestation until 2050. Our worst-case scenario uses the magnitude of deforestation projected by Busch and Engelmann (2015), which is 289 million hectares of tropical forest loss between now and 2050. The best-case scenario uses the estimation of WWF/IIASA (2011), which puts the number at 232 million hectares. An intermediate scenario takes the average of these two numbers and comes to the potential deforestation of rainforests of 260.5 million hectares by 2050. These are the first input for the calculations of this paper's scenarios. We chose to disregard the estimations of Rademaekers et al. (2010), since these scenarios are only until 2030. An average drug research and development process is complicated and usually takes more than 10 years (see Figures 5-4 and 5-5, Appendix), therefore a horizon of more than a decade from now is needed. We are aware of the fact that we have to make several assumptions leading to simplification and generalization in order to come up with these scenarios. However, this particular field of literature is new and therefore demands a certain amount of creativity in forming the models we need.

2.4 Biodiversity of rainforests and the pharmaceutical industry

In this section, we aim to point out the undeniable dependence of drug discovery, development and production on natural resources. More precisely, we review the relevant literature discussing what percentage of pharmaceutical products are directly and/or indirectly derived from the biodiversity of tropical rainforests.

Newman and Cragg (2016) draw attention to the increasing significance of natural product research in relation to the drug industry. In their work, they construct a comprehensive survey on drug origin, covering a period of 34 years (1981-2014). They conclude that the utilization of natural products (or their novel structures), in order to discover and develop new drugs, still plays a crucial role in the modern pharmaceutical industry. According to Steenhuysen (2007), 70% of new drugs introduced in the US since the 1980s were derived from natural products. In fact, despite being able to synthesize compounds, pharmaceutical companies derive nearly 80% of the top 150 prescription drugs sold in the US from natural sources (Daily et al., 1997). An estimated 52,000 flowering plant species out of 422,000 are used for medicinal purposes

globally (Golden et al., 2012; Schippmann et al, 2002). Tropical rainforests are important habitats of medicinal resources, since they are the most biodiverse ecosystems and house about 50% of the total number of species in the world (Myers, 1988; Gurib-Fakim, 2006; Morley, 2009). It has been estimated that less than 5% of these species have been examined for their medicinal value (Newman & Cragg, 2016).

Since we investigate the potential loss to Vanguard and their clients as a result of a decrease in biodiversity due to the adverse deforestation trends, we need to be more precise and investigate the connection of rainforests' biodiversity and the pharmaceutical industry. This narrower definition of drugs' origin is necessary, since the aforementioned numbers on the dependence of this industry on nature also include marine life, terrestrial lands, forests other than tropical rainforests and other crucial ecosystems. It is estimated that 25-50% of medicinal drugs used in modern medicine are either directly or through modifications coming from the biodiversity of tropical rainforests (Zakrzewski, 2002; Nanjunda 2010; Skirycz et al., 2016; Shah & Bhat, 2019). Based on this number, we make a general assumption that 25-50% of revenues and profits of this industry are fully dependent on the existing biodiversity of rainforest. Furthermore, it is crucial to denote that a significant part of rainforests' biodiversity has not been discovered yet, hence there is an immense upward potential for future profits of the pharmaceutical industry from novel drug development. Alho (2008) refers to this as a gap between the current realized values of biodiversity and its potential future value.

Various research has attempted to put a value on the potential contribution of rainforests to novel drug discovery, for example Simpson et al. (1996) and Rausser and Small (2000). This results in different valuations due to different assumptions used and different methods of calculation. The estimated value ranges from $21 per hectare (Simpson et al., 1996) to $9,177 per hectare (Rausser and Small, 2000). The research from Rausser and Small (2000) bases their calculation on 18 biodiversity hotspots, which are all rainforests. Since this paper focuses on the impact of the biodiversity loss from rainforest deforestation, we chose to use the valuation of Rausser and Small (2000) as it comes the closest to our own assumptions. In their model, the authors look at each of the 18 hotspots and determine what the probability is that testing the promising leads in an interested area will yield a drug discovery, given the biodiversity of the area. The degree of endemism among higher plant species is used as a proxy for the quality of the area as a potential source of new drugs. The higher the biodiversity in the area, the higher the chance the testing will produce a useful substance. The cost of testing is taken into account. When a test is successful, a return is realized, which is the expected revenue from the new drug minus the R&D, production and advertising costs. The pharmaceutical company thus either stop the testing project when a test is successful, or when the maximum cost that the company

is willing to pay for the project is reached. The net present value of the *n*th lead in a testing project is then estimated and used as an input for the calculation of the marginal values per hectare for the 18 hotspots. The other important inputs of Rausser and Small (2000) are 26 testing projects per year to yield 10 new natural-source drugs per year, a return of $450,000,000 for each successful discovery, a discount rate on firms' future benefits and costs of 10% per year, and the cost per test of $485 per test (all amounts in 2000 USD). The calculated incremental value per hectare for each of the 18 hotspots are presented in Table 2-1 below.

Table 2-1: Bioprospecting Values in Several Ecosystems, as a Function of Density of Endemic Species

Biodiversity "Hot Spots"	Forest Area (1,000 ha)	Density, Endemic Species/1,000 ha	Hit Probability (/1,000 ha)	Incremental Value ($/Hectare)	Scarcity Rent ($/Hectare)
Western Ecuador	250	8.75	0.000105	**$ 9,177.00**	$ 20.63
Southwestern Sri Lanka	70	7.14	0.0000857	$ 7,463.00	$ 16.84
New Caledonia	150	5.27	0.0000632	$ 5,473.00	$ 12.43
Madagascar	1,000	2.91	0.0000349	$ 2,961.00	$ 6.86
Western Ghats of India	800	2.03	0.0000244	$ 2,026.00	$ 4.77
Philippines	800	1.98	0.0000238	$ 1,973.00	$ 4.66
Atlantic Coast Brazil	2,000	1.88	0.0000226	$ 1,867.00	$ 4.42
Uplands of Western Amazonia	3,500	1.1	0.0000132	$ 1,043.00	$ 2.59
Tanzania	600	0.88	0.0000106	$ 811.00	$ 2.07
Cape Floristic Province of South Africa	8,900	0.71	0.00000852	$ 632.00	$ 1.66
Peninsular Malaysia	2,600	0.62	0.00000744	$ 539.00	$ 1.47
Southwestern Australia	5,470	0.52	0.00000624	$ 435.00	$ 1.22
Ivory Coast	400	0.48	0.00000576	$ 394.00	$ 1.14
Northern Borneo	6,400	0.42	0.00000504	$ 332.00	$ 0.99
Eastern Himalayas	5,300	0.42	0.00000504	$ 332.00	$ 0.98
Colombian Choco	7,200	0.32	0.00000384	**$ 231.00**	$ 0.75
Central Chile	4,600	0.32	0.00000384	**$ 231.00**	$ 0.74
California Floristic Province	24,600	0.09	0.00000108	$ -	$ 0.20
Average incremental value in 2000 USD				**$ 1,995.56**	

Source: Rausser and Small (2000)

The incremental value is thus the contribution of the drug discovery to the return of the pharmaceutical companies. We choose to use the incremental values as calculated by Rausser and Small (2000) as input for the calculations of our scenarios. Specifically, we use the average of the 18 values for our baseline scenario, which is $1,995.56 in 2000 USD incremental value to drug discovery per hectare of rainforests. For the sensitivity test, the largest incremental value of $9,177 and the smallest incremental value of $231 are employed. Since these values are net present value calculated in 2000 US dollars, we adjust the numbers for inflation to arrive at the values of $3,064.27, $14.091.70 and $354,71 in US dollars of 2020. See Table 5-1 in the Appendix for the annual inflation rates used and the inflation adjustments of the values.

3 Potential financial impact of biodiversity loss as a result of rainforest deforestation on Vanguard's pharma portfolio

3.1 The pharmaceutical industry and Vanguard's pharma portfolio

In this paper, we refer to the pharmaceutical industry as including both traditional pharmaceutical companies which create medicines from chemicals and synthetic processes and biopharma companies which use biotechnology to produce medicine from living organisms. Most large cap pharmaceutical companies currently have both traditional pharmaceutical and biopharma operations. Despite its high risk, the pharmaceutical industry has always been attractive to investors due to its growth and sheer volume. The worldwide revenue of the industry increases 45% between 2006 and 2015, $534 billion to $775 billion in real 2015 dollars (GAO, 2017, see Figure 3-1). EvaluatePharma (2019) forecasts that the revenue will reach $1.18 trillion by 2024. At the same time, the risk of the industry lies in the uncertainty of finding a "blockbuster" drug and being able to optimally monetize it to cover the long and costly R&D process. At the moment, pharmaceutical companies rely more on sales of generic drugs than on new drugs. The current challenges of rising R&D costs and fewer drugs in the R&D pipeline lead to lower return on R&D investment (Deloitte, 2016). On average, about 13% of the industry's worldwide sales goes to R&D cost (GAO, 2017, see Figure 3-2).

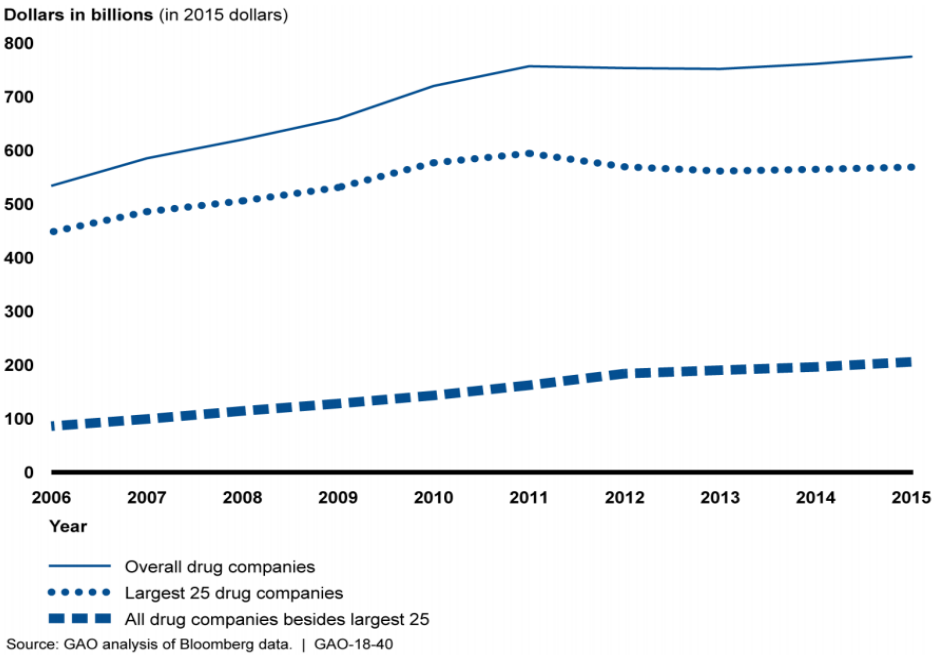

Figure 3-1: Aggregate Worldwide Pharmaceutical and Biotechnology Sales Revenue for Drug Companies, Overall, Largest 25, and All Others, 2006-2015

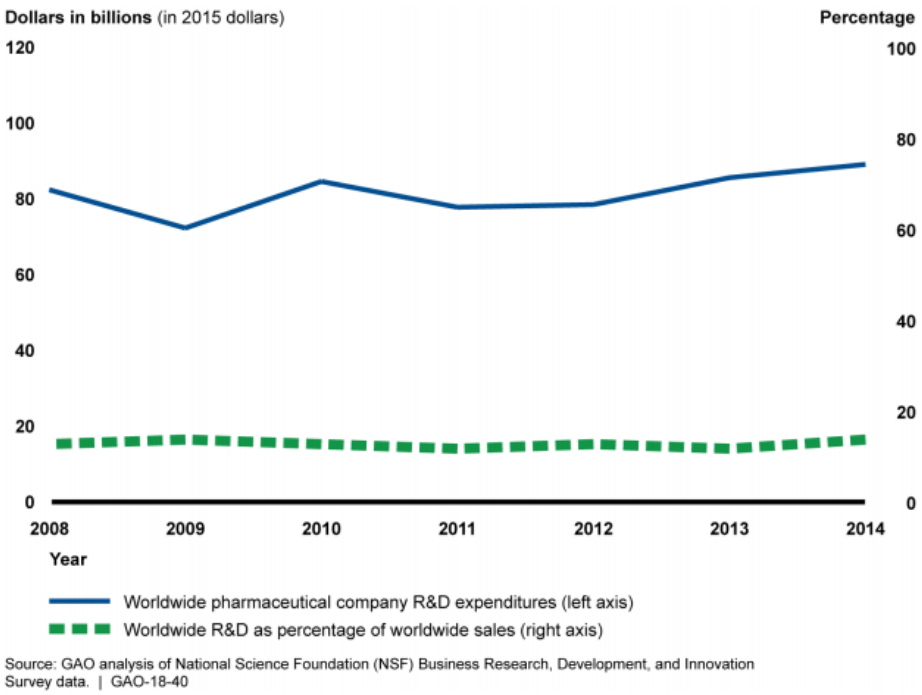

Figure 3-2: Estimated Worldwide Pharmaceutical Company-Reported Research and Development (R&D) Expenditures and Expenditures as Percentage of Worldwide Sales, 2008 – 2014

According to Cragg and Newman (2013), the number of new chemical entities decreases from 60 per year in the 1980s to 23 per year on average in the 2000s, which corresponds to a period of major pharmaceutical companies' low interest in finding novel drugs from natural sources. The pharmaceutical industry eventually realized their mistake, which sparks a recent renewed attention in finding drugs from nature (Newman and Cragg, 2016). However, loss of biodiversity, especially in biodiversity rich areas like rainforests, will have a negative impact on the chance of them discovering novel drugs and in turn on the return on R&D investment for pharmaceutical companies.

While it is widely accepted that the loss of biodiversity has a substantial impact on our society, it is difficult to agree on a method to evaluate the biodiversity-related financial risks. PwC (2020) warns that "it is particularly dangerous for the financial sector not to account for biodiversity loss, as all economic sectors in which they invest, they finance, or they insure depend on biodiversity". BaFin (2019) attempts to classify biodiversity-related financial risk into current risk types, as seen in Figure 3-3 below.

	Credit risk	Market risk	Operational risk
Transition risk	Investee suffers substantial losses due to sanctions, damages or increased taxes stemming from its negative impact on biodiversity	Long-term price increases as a result of biodiversity change	Image loss resulting from failure to switch to biodiversity management
Physical risk	Revaluation of debt-servicing capacity and collateral	Rating downgrades and share price losses after biodiversity loss	Biodiversity loss affects balance sheet
Litigation risk	• Litigation as pertaining to biodiversity loss and breach of the under-lying legal frameworks • New regulatory rules impose limitations on investing in activities with an impact on biodiversity • Damages due to false reporting of biodiversity risks • Damages due to greenwashing		
Systemic risk	Economy can no longer be insured at reasonable cost	Market-threatening effects from biodiversity loss in an entire region	Reputational losses for entire industries/entire markets

Source: adapted from BaFin (2019)

Figure 3-3: Classification of biodiversity-related financial risk into current risk types

According to the "Classification of biodiversity-related financial risk into current risk types" as proposed by BaFin (2019), the risks to the pharmaceutical industry are physical risk of biodiversity loss that leads to on the one hand market risk in share price losses and on the other hand operational risk in value decline of PPE. The risk to investors in the pharmaceutical industry is the market risk of share price losses, which reduces the market value of the investors' pharmaceutical portfolio.

In this paper, we focus on Vanguard as the financial institution that stands to lose as the pharmaceutical industry is negatively affected by biodiversity loss as a result of rainforest deforestation. The Vanguard Group is an American asset management company, one of the largest ones in the world. As of 31 January, 2020, it has $6.2 trillion (Vanguard, 2020) in global assets under management. 7.36% of their equity portfolio is invested in about 895 (bio)pharmaceutical companies worldwide, 53% of them are from the US. As an overview of Vanguard's pharmaceutical portfolio, the Top 5 holdings are presented in Table 3-1 below, together with their market values, revenues and R&D costs for 2019. All five companies have been in the Top 30 pharmaceutical companies worldwide based on revenue for many years, with the US-based Johnson & Johnson dominating the number 1 position in the last decade. The pharmaceutical portfolio has a total market value of more than $205 billion at the end of the first quarter of 2020, which is 2.27% of the total market value of the pharmaceutical industry. In the last decade, the yearly revenue of the constituents of Vanguard's pharmaceutical equity portfolio is more than $1 billion on average, with $148 million spent on

R&D on average annually (FactSet). The portion of the pharmaceutical industry in Vanguard's equity portfolio has grown by more by 12.5% in the last year, with most of the increase occurring in the first quarter of 2020 (FactSet), which is likely related to the corona crisis.

Table 3-1: Top 5 holdings in Vanguard's pharma portfolio

Company	**Country**	**Market value**	**Revenue 2019**	**R&D 2019**	**Market value of holding**	**% of Vanguard's equity portfolio**
JOHNSON & JOHNSON	US	$ 345.7 billion	$ 82.1 billion	$ 11.3 billion	$ 29 billion	1.04%
MERCK & CO	Germany	$ 195.1 billion	$ 46.6 billion	$ 8.8 billion	$ 15.7 billion	0.56%
PFIZER	US	$ 181.1 billion	$ 51.8 billion	$ 8.6 billion	$ 14.2 billion	0.51%
BRISTOL MYERS SQUIBB CO	US	$ 126.1 billion	$ 26.2 billion	$ 6 billion	$ 10.4 billion	0.37%
ELI LILLY & CO	US	$ 132.8 billion	$ 22.3 billion	$ 5.6 billion	$ 9.5 billion	0.34%
Total market value of the companies in Vanguard's pharma portfolio			**$ 4.5 trillion**			
Market value of Vanguard's pharma portfolio			**$ 205.3 billion**			

Vanguard thus has an exposure of 2.27% to the pharmaceutical industry and its potential financial loss due to the loss of biodiversity, which ultimately affects the return on investment of their clients. In our scenarios of loss of biodiversity as a result of deforestation, we estimate how much money of their clients Vanguard would lose should the percentage loss of biodiversity in rainforests be as projected. Another big asset manager, BlackRock, is reported to have lost their clients $90 billion dollars from fossil fuel holdings over the last decade because it failed to manage the carbon bubble (Buckley et al., 2019). This is an example for Vanguard to learn from so as to mitigate their potential loss from the pharma industry.

3.2 The scenarios of impacts on Vanguard's pharma equity portfolio from loss of biodiversity due to deforestation

We attempt to estimate the potential financial impact to Vanguard's pharma portfolio from loss of biodiversity due to rainforests' deforestation by using a discounted cashflow analysis to calculate the net present value of the potential loss between now and 2050. The inputs and the results of the calculations are discussed below.

3.2.1 Model's inputs

We start with describing the most important inputs for the calculations. The first input in our model is the expected loss of rainforests in the coming three decades. We use three scenarios of rainforests' deforestation. Scenario 1 is the best-case scenario with the lowest expected deforestation of 232 million hectares from WWF/IIASA (2011). Scenario 3 shows the worst-case scenario with the highest expected deforestation of 289 million hectares as projected by Busch and Engelmann (2015). The average of these two estimations is used for the intermediate-case Scenario 2.

To calculate the magnitude of the potential loss to the total pharmaceutical industry for these three scenarios, the valuations of potential contribution to drug discovery per hectare of rainforests as calculated by Rausser and Small (2000) are employed. As the baseline value, the average incremental value of 18 hotpots examined in the paper is used. The average incremental value is $3,064.27 in 2020 US dollars after adjusting for inflation. To see what impacts the changes in this input have on our final results, we also use the highest and lowest incremental values from the Rausser and Small (2000) paper as sensitivity test. These values, after adjusted for inflation, are $14.091.70 and $354,71 in US dollars of 2020, respectively. The inflation adjustments of the values are found in Table 5-1 in the Appendix.

The potential loss per year is adjusted for inflation for the coming 30 years using an inflation rate of 2.53%, which is the average annual inflation rate of the preceding three decades from 1989 to 2019 (see Table 5-1 in the Appendix). The other important input of the model is the weighted cost of capital (WACC), which is used as the discount rate of future cash flows, which in our case are the annual losses for the coming three decades. The WACC for the whole pharmaceutical industry for 2020 is calculated as 24.55% using the parameters stated in Table 3-2 below (values of 2019 is used where data for 2020 is not available). Since most of the

holdings in Vanguard's pharmaceutical portfolio are from the US, the values for excess market return, risk free rate, effective tax rate, debt over equity and the market beta are taken from the US market for simplicity.

Table 3-2: Calculation of the weighted average cost of capital for the total pharmaceutical industry

Parameter	**Value**	**Source**
Rm - Rf	24.41%	(1)
Rf	2.14%	(1)
Effective tax rate	3.52%	(2)
Debt over equity ratio of pharma industry	13.25%	(2)
Beta of pharma industry	0.95	(2)
Total market cap of the pharma industry	$ 9,040,751,610,230	(3)
Total debt of the pharma industry	$ 600,000,000,000	(3)
Total capital structure of the pharma industry	$ 9,640,751,610,230	
Cost of equity	25.33%	
Weighted average cost of capital (WACC)	**24.55%**	

(1) *https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html*

(2) *http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/Betas.html*

(3) *FactSet*

3.2.2 Scenario results

Using the aforementioned inputs, the discounted cash flow analysis is carried out as follows. We want to know what the net present value of the potential loss is on Vanguard's pharmaceutical portfolio. For each scenario of total deforestation of the 30 years, the annual loss is calculated. This value of this annual loss to drug discovery for the whole pharmaceutical industry is then calculated by multiplying the annual deforestation with the incremental values from Rausser and Small (2000). Since the market value of the Vanguard's pharmaceutical portfolio is 2.27% of the total market value of the industry, this portion of the potential loss can be attributed to the portfolio. These annual portfolio losses are then adjusted for inflation using the inflation rate of 2.53%. The yearly result is then discounted back to the present using the WACC of 24.55% as the discount rate. The sum of the annual losses is thus the net present value of the potential portfolio loss for the coming 30 years. Tables 5-2 to 5-10 in the Appendix shows the calculations for the three scenarios, using three different incremental values as inputs. The summary of the most important parameters and the results are displayed in Table 3-3 below.

Table 3-3: Scenarios of impacts on Vanguard's pharma equity portfolio from loss of biodiversity due to deforestation

Period 2020 - 2050	**Scenario 1**	**Scenario 2**	**Scenario 3**
Deforestation of rainforests (hectare) 2020-2050	232,000,000	260,500,000	289,000,000
Deforestation of rainforests (hectare) per year	7,733,333	8,683,333	9,633,333
Exposure of Vanguard's pharma portfolio	2.27%	2.27%	2.27%
Annual inflation rate (average of 1989-2019)	2.53%	2.53%	2.53%
Weighted average cost of capital (WACC)	24.55%	24.55%	24.55%
Loss of potential contribution to drug discovery per hectare of rainforests (Rausser and Small, 2000), in 2020 USD, **average** incremental value	$ 3,064.27	$ 3,064.27	$ 3,064.27
NPV of the potential loss on the market value of Vanguard's pharma portfolio	**$ 2,436,477,996**	**$ 2,735,786,715**	**$ 3,035,095,435**
Loss of potential contribution to drug discovery per hectare of rainforests (Rausser and Small, 2000), in 2020 USD, **largest** incremental value	$ 14,091.70	$ 14,091.70	$ 14,091.70
NPV of the potential loss on the market value of Vanguard's pharma portfolio	**$ 11,204,678,570**	**$ 12,581,115,377**	**$ 13,957,552,184**
Loss of potential contribution to drug discovery per hectare of rainforests (Rausser and Small, 2000), in 2020 USD, **smallest** incremental value	$ 354.71	$ 354.71	$ 354.71
NPV of the potential loss on the market value of Vanguard's pharma portfolio	**$ 282,039,964**	**$ 316,687,115**	**$ 351,334,266**

For our best-case scenario, the baseline result is about $2.4 billion devaluation to today's market value of Vanguard's pharmaceutical, which is 1.2% of the portfolio value. However, the loss can amount to $11.2 billion or 5.5% of the portfolio value when the highest incremental value is used. In the worst-case scenario, the devaluation to Vanguard's pharmaceutical portfolio is $3 billion, but it can go up to $14 billion when the highest incremental value is used. That is between 1.5% to 6.8% of the portfolio value. Even in the very best case of Scenario 1 and the lowest incremental value, the portfolio still suffers a loss of $282 million. We believe that the most likely scenario is a portfolio loss of $2.7 billion, which is the result of Scenario 2 deforestation and the baseline incremental value of $3,604.27 loss of potential contribution to drug discovery per hectare of rainforests. The financial risk to Vanguard's pharma portfolio from loss of biodiversity due to rainforests' deforestation is thus substantial and should not be ignored.

3.3 What can pharmaceutical companies and their investors do to mitigate biodiversity-related financial risk?

Vanguard and other investors can reduce their exposure to the pharmaceutical industry, which puts even more strain on the profitability of the industry. Large cap pharmaceutical companies can acquire smaller pharma to reduce the proportion of R&D cost, because smaller pharmaceutical companies have better return on R&D investment and proportionally more new drugs developed (Deloitte, 2017). Pharmaceutical companies can shift to medicinal fields which rely less on natural ingredients, such as gene therapy or hormone therapy. This depends on whether they can transition successfully into new medicinal fields and how fast. Investment in expensive high-tech research and production facilities for the current medicinal fields will become stranded assets. However, it is unlikely that pharmaceutical companies will be entirely independent of natural sources. Nature will continue to be a source for R&D and production of medicine in the future (Cragg and Newman, 2013). Recently, there has been renewed attention to drug research and development from natural sources (Newman and Cragg, 2016). Due to the aging and growing population and the related emergence of new medical conditions, as well as the emergence of new diseases like the pandemic we are experiencing right now, as broad a pool of medicinal resources and knowledge as possible is needed to find effective treatments. We believe that the best solution is for pharmaceutical companies to collaborate with governmental and supranational organizations to finance efforts to reduce deforestation in combination with expanding protected areas to reduce loss of species. Likewise, Vanguard and the financial sector can "hedge" their biodiversity-related financial risks by investing in biodiversity conservation and/or restoration projects. PwC and WWF estimate that for this, more than $500 billion per year is needed (PwC, 2020).

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5 Appendix

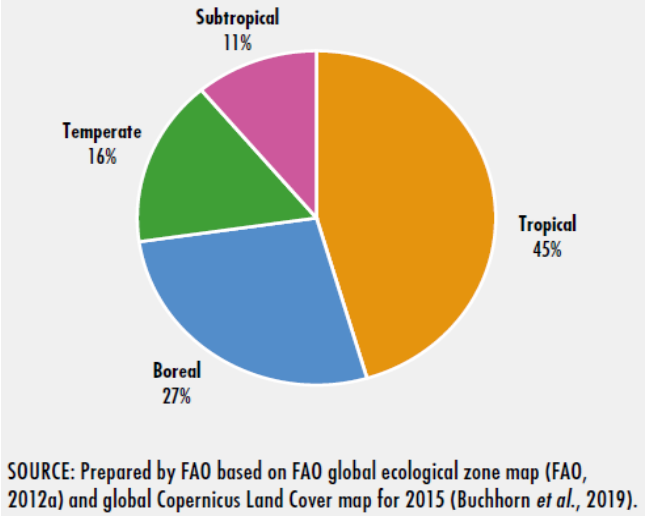
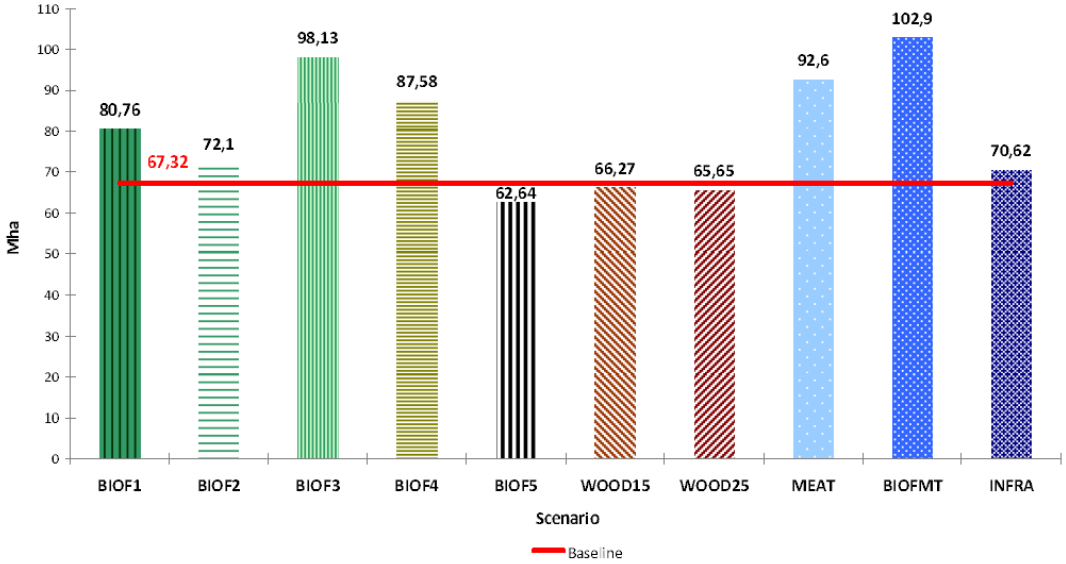
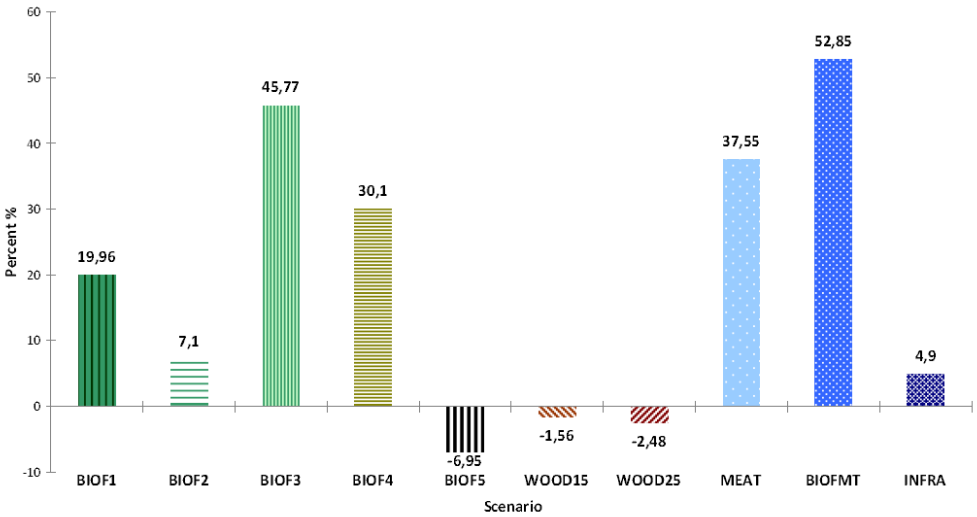


Figure 5-1: Global forest area by climatic domain



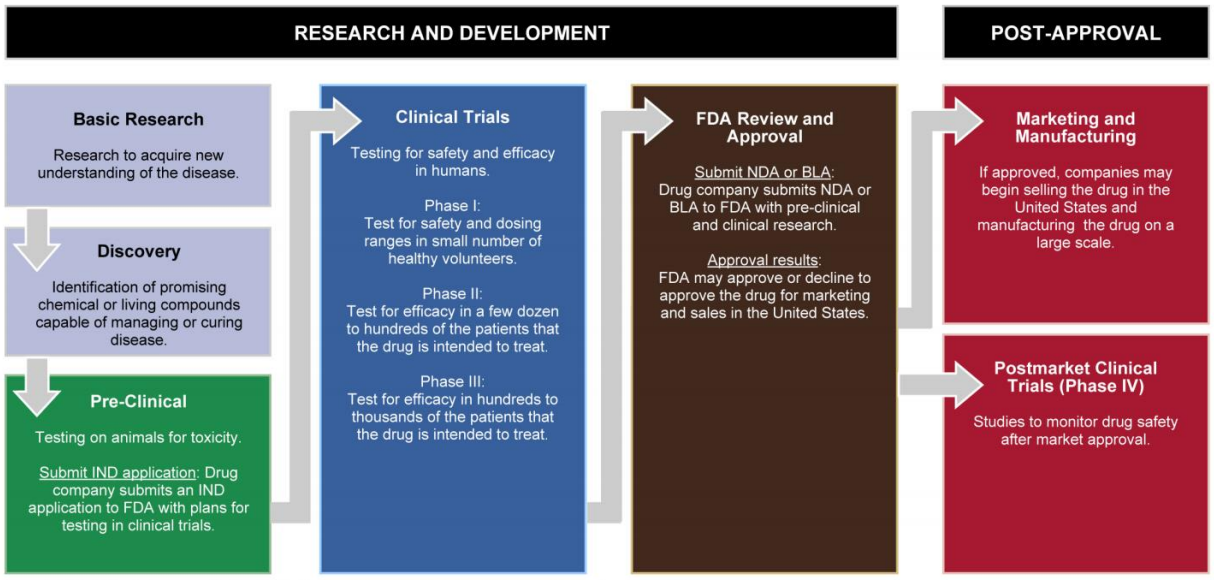
BIOF1 = 15% share of biofuels in total transport energy in the form of a mix of all three types of biofuels (1st generation biodiesel and ethanol and 2nd generation bioethanol).
BIOF2 = 15% share of biofuels in total transport energy in the form of 1st generation ethanol only in 2030.
BIOF3 = 15% share of biofuels in total transport energy in the form of 1st generation biodiesel only in 2030.
BIOF4 = 15% share biofuels in total transport energy in 2030 from 1st generation (mix of biodiesel and bioethanol) only.
BIOF5 = 15% share of biofuels in total transport energy in 2030 from 2nd generation only.
WOOD15 = Overall additional increase of 10% in demand for wood in 2020 and 15% in 2030
WOOD25 = Overall additional increase of 10% in demand for wood in 2020 and 25% in 2030
MEAT = Overall additional increase of 10% in demand for meat in 2020 and 15% in 2030
BIOFMT = Equivalent to a dual shock of BIOF3 and MEAT
INFRA = Transportation costs will decrease by 10% in emerging economies and 5% in developing regions by 2030.
[Source: IIASA]

Figure 5-2: Global deforestation area without REDD under various policy shock scenario between 2020-2030 (Mha)



BIOF1 = 15% share of biofuels in total transport energy in the form of a mix of all three types of biofuels (1st generation biodiesel and ethanol and 2nd generation bioethanol).
BIOF2 = 15% share of biofuels in total transport energy in the form of 1st generation ethanol only in 2030.
BIOF3 = 15% share of biofuels in total transport energy in the form of 1st generation biodiesel only in 2030.
BIOF4 = 15% share biofuels in total transport energy in 2030 from 1st generation (mix of biodiesel and bioethanol) only.
BIOF5 = 15% share of biofuels in total transport energy in 2030 from 2nd generation only.
WOOD15 = Overall additional increase of 10% in demand for wood in 2020 and 15% in 2030
WOOD25 = Overall additional increase of 10% in demand for wood in 2020 and 25% in 2030
MEAT = Overall additional increase of 10% in demand for meat in 2020 and 15% in 2030
BIOFMT = Equivalent to a dual shock of BIOF3 and MEAT
INFRA = Transportation costs will decrease by 10% in emerging economies and 5% in developing regions by 2030.
[Source: IIASA]

Figure 5-3: Percent change, compared to baseline of global deforested area without REDD under various policy shock scenarios between 2020-2030 (Rademaekers et al., 2010)



Legend: BLA = biologic license application; FDA = Food and Drug Administration; IND = investigational new drug; NDA = new drug application

Source: GAO analysis of Food and Drug Administration (FDA) and Pharmaceutical Research and Manufacturers of America information. | GAO-18-40

Figure 5-4: Stages in the Typical Brand-Name Drug Development Process in the United States

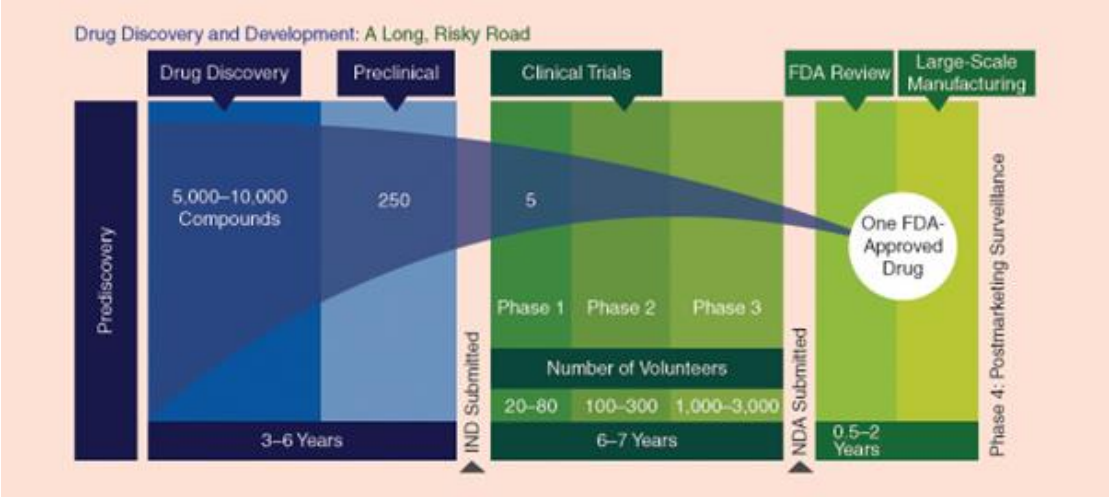


Figure 5-5: Funnel of drug discovery and development **(Keshava, 2017)**

Table 5-1: Annual inflation rates and inflation adjustments of the interested incremental values

Year	Annual inflation rate	Average incremental value adjusted for inflation	Largest incremental value adjusted for inflation	Smallest incremental value adjusted for inflation
2019	1.81%	**$ 3,064.27**	**$ 14,091.70**	**$ 354.71**
2018	2.44%	$ 3,009.79	$ 13,841.18	$ 348.40
2017	2.13%	$ 2,938.10	$ 13,511.50	$ 340.11
2016	1.26%	$ 2,876.82	$ 13,229.70	$ 333.01
2015	0.12%	$ 2,841.03	$ 13,065.08	$ 328.87
2014	1.62%	$ 2,837.62	$ 13,049.42	$ 328.48
2013	1.47%	$ 2,792.38	$ 12,841.39	$ 323.24
2012	2.07%	$ 2,751.93	$ 12,655.36	$ 318.56
2011	3.16%	$ 2,696.12	$ 12,398.71	$ 312.10
2010	1.64%	$ 2,613.53	$ 12,018.91	$ 302.54
2009	-0.34%	$ 2,571.36	$ 11,824.98	$ 297.65
2008	3.85%	$ 2,580.14	$ 11,865.32	$ 298.67
2007	2.85%	$ 2,484.48	$ 11,425.44	$ 287.60
2006	3.24%	$ 2,415.64	$ 11,108.84	$ 279.63
2005	3.39%	$ 2,339.83	$ 10,760.21	$ 270.85
2004	2.68%	$ 2,263.11	$ 10,407.40	$ 261.97
2003	2.27%	$ 2,204.04	$ 10,135.76	$ 255.13
2002	1.59%	$ 2,155.12	$ 9,910.79	$ 249.47
2001	2.83%	$ 2,121.39	$ 9,755.67	$ 245.57
2000	3.38%	$ 2,063.01	$ 9,487.18	$ 238.81
1999	2.19%	**$ 1,995.56**	**$ 9,177.00**	**$ 231.00**
1998	1.55%			
1997	2.34%			
1996	2.93%			
1995	2.81%			
1994	2.61%			
1993	2.96%			
1992	3.03%			
1991	4.25%			
1990	5.39%			
1989	4.83%			
Average previous 30 years	**2.53%**			

Table 5-2: Free cashflow analysis of the potential loss on Vanguard's pharmaceutical industry, using deforestation Scenario 1 and the average incremental value per hectare rainforests

Year	Total value loss Scenario 1	Portfolio loss Scenario 1	Adjust for inflation rate	Discount factor	NPV portfolio loss Scenario 1
1	23,696,994,220	538,113,552	538,113,552	0.80290	432,050,732
2	23,696,994,220	538,113,552	551,713,938	0.64465	355,660,461
3	23,696,994,220	538,113,552	565,658,063	0.51759	292,776,645
4	23,696,994,220	538,113,552	579,954,614	0.41557	241,011,226
5	23,696,994,220	538,113,552	594,612,499	0.33366	198,398,377
6	23,696,994,220	538,113,552	609,640,851	0.26790	163,319,844
7	23,696,994,220	538,113,552	625,049,031	0.21509	134,443,496
8	23,696,994,220	538,113,552	640,846,642	0.17270	110,672,735
9	23,696,994,220	538,113,552	657,043,524	0.13866	91,104,847
10	23,696,994,220	538,113,552	673,649,769	0.11133	74,996,730
11	23,696,994,220	538,113,552	690,675,723	0.08939	61,736,665
12	23,696,994,220	538,113,552	708,131,995	0.07177	50,821,094
13	23,696,994,220	538,113,552	726,029,460	0.05762	41,835,489
14	23,696,994,220	538,113,552	744,379,270	0.04626	34,438,616
15	23,696,994,220	538,113,552	763,192,855	0.03715	28,349,574
16	23,696,994,220	538,113,552	782,481,939	0.02982	23,337,126
17	23,696,994,220	538,113,552	802,258,539	0.02395	19,210,923
18	23,696,994,220	538,113,552	822,534,977	0.01923	15,814,267
19	23,696,994,220	538,113,552	843,323,885	0.01544	13,018,169
20	23,696,994,220	538,113,552	864,638,216	0.01239	10,716,445
21	23,696,994,220	538,113,552	886,491,250	0.00995	8,821,686
22	23,696,994,220	538,113,552	908,896,601	0.00799	7,261,936
23	23,696,994,220	538,113,552	931,868,230	0.00642	5,977,964
24	23,696,994,220	538,113,552	955,420,448	0.00515	4,921,009
25	23,696,994,220	538,113,552	979,567,929	0.00414	4,050,932
26	23,696,994,220	538,113,552	1,004,325,719	0.00332	3,334,693
27	23,696,994,220	538,113,552	1,029,709,241	0.00267	2,745,090
28	23,696,994,220	538,113,552	1,055,734,312	0.00214	2,259,735
29	23,696,994,220	538,113,552	1,082,417,145	0.00172	1,860,194
30	23,696,994,220	538,113,552	1,109,774,366	0.00138	1,531,296
Total NPV portfolio loss Scenario 1					**2,436,477,996**

Table 5-3: Free cashflow analysis of the potential loss on Vanguard's pharmaceutical industry, using deforestation Scenario 2 and the average incremental value per hectare rainforests

Year	Total value loss Scenario 2	Portfolio loss Scenario 2	Adjust for inflation rate	Discount factor	NPV portfolio loss Scenario 2
1	26,608,047,389	604,218,018	604,218,018	0.80290	485,125,930
2	26,608,047,389	604,218,018	619,489,141	0.64465	399,351,509
3	26,608,047,389	604,218,018	635,146,230	0.51759	328,742,741
4	26,608,047,389	604,218,018	651,199,039	0.41557	270,618,209
5	26,608,047,389	604,218,018	667,657,569	0.33366	222,770,591
6	26,608,047,389	604,218,018	684,532,076	0.26790	183,382,842
7	26,608,047,389	604,218,018	701,833,072	0.21509	150,959,185
8	26,608,047,389	604,218,018	719,571,337	0.17270	124,268,308
9	26,608,047,389	604,218,018	737,757,922	0.13866	102,296,606
10	26,608,047,389	604,218,018	756,404,159	0.11133	84,209,690
11	26,608,047,389	604,218,018	775,521,664	0.08939	69,320,695
12	26,608,047,389	604,218,018	795,122,348	0.07177	57,064,203
13	26,608,047,389	604,218,018	815,218,424	0.05762	46,974,763
14	26,608,047,389	604,218,018	835,822,413	0.04626	38,669,222
15	26,608,047,389	604,218,018	856,947,150	0.03715	31,832,172
16	26,608,047,389	604,218,018	878,605,798	0.02982	26,203,972
17	26,608,047,389	604,218,018	900,811,851	0.02395	21,570,885
18	26,608,047,389	604,218,018	923,579,144	0.01923	17,756,968
19	26,608,047,389	604,218,018	946,921,862	0.01544	14,617,384
20	26,608,047,389	604,218,018	970,854,549	0.01239	12,032,905
21	26,608,047,389	604,218,018	995,392,114	0.00995	9,905,384
22	26,608,047,389	604,218,018	1,020,549,847	0.00799	8,154,028
23	26,608,047,389	604,218,018	1,046,343,422	0.00642	6,712,326
24	26,608,047,389	604,218,018	1,072,788,908	0.00515	5,525,529
25	26,608,047,389	604,218,018	1,099,902,782	0.00414	4,548,568
26	26,608,047,389	604,218,018	1,127,701,938	0.00332	3,744,342
27	26,608,047,389	604,218,018	1,156,203,695	0.00267	3,082,310
28	26,608,047,389	604,218,018	1,185,425,811	0.00214	2,537,332
29	26,608,047,389	604,218,018	1,215,386,493	0.00172	2,088,710
30	26,608,047,389	604,218,018	1,246,104,406	0.00138	1,719,408
Total NPV portfolio loss Scenario 2					**2,735,786,715**

Table 5-4: Free cashflow analysis of the potential loss on Vanguard's pharmaceutical industry, using deforestation Scenario 3 and the average incremental value per hectare rainforests

Year	Total value loss Scenario 3	Portfolio loss Scenario 3	Adjust for inflation rate	Discount factor	NPV portfolio loss Scenario 3
1	29,519,100,558	670,322,485	670,322,485	0.80290	538,201,127
2	29,519,100,558	670,322,485	687,264,345	0.64465	443,042,558
3	29,519,100,558	670,322,485	704,634,397	0.51759	364,708,838
4	29,519,100,558	670,322,485	722,443,463	0.41557	300,225,191
5	29,519,100,558	670,322,485	740,702,639	0.33366	247,142,805
6	29,519,100,558	670,322,485	759,423,301	0.26790	203,445,840
7	29,519,100,558	670,322,485	778,617,112	0.21509	167,474,873
8	29,519,100,558	670,322,485	798,296,032	0.17270	137,863,881
9	29,519,100,558	670,322,485	818,472,320	0.13866	113,488,365
10	29,519,100,558	670,322,485	839,158,548	0.11133	93,422,650
11	29,519,100,558	670,322,485	860,367,604	0.08939	76,904,725
12	29,519,100,558	670,322,485	882,112,701	0.07177	63,307,311
13	29,519,100,558	670,322,485	904,407,388	0.05762	52,114,036
14	29,519,100,558	670,322,485	927,265,556	0.04626	42,899,828
15	29,519,100,558	670,322,485	950,701,445	0.03715	35,314,771
16	29,519,100,558	670,322,485	974,729,657	0.02982	29,070,817
17	29,519,100,558	670,322,485	999,365,163	0.02395	23,930,847
18	29,519,100,558	670,322,485	1,024,623,312	0.01923	19,699,669
19	29,519,100,558	670,322,485	1,050,519,840	0.01544	16,216,598
20	29,519,100,558	670,322,485	1,077,070,881	0.01239	13,349,365
21	29,519,100,558	670,322,485	1,104,292,979	0.00995	10,989,083
22	29,519,100,558	670,322,485	1,132,203,094	0.00799	9,046,119
23	29,519,100,558	670,322,485	1,160,818,614	0.00642	7,446,688
24	29,519,100,558	670,322,485	1,190,157,368	0.00515	6,130,049
25	29,519,100,558	670,322,485	1,220,237,636	0.00414	5,046,204
26	29,519,100,558	670,322,485	1,251,078,158	0.00332	4,153,992
27	29,519,100,558	670,322,485	1,282,698,150	0.00267	3,419,531
28	29,519,100,558	670,322,485	1,315,117,311	0.00214	2,814,928
29	29,519,100,558	670,322,485	1,348,355,840	0.00172	2,317,225
30	29,519,100,558	670,322,485	1,382,434,447	0.00138	1,907,520
Total NPV portfolio loss Scenario 3					**3,035,095,435**

Table 5-5: Free cashflow analysis of the potential loss on Vanguard's pharmaceutical industry, using deforestation Scenario 1 and the largest incremental value per hectare rainforests

Year	Total value loss Scenario 1	Portfolio loss Scenario 1	Adjust for inflation rate	Discount factor	NPV portfolio loss Scenario 1
1	108,975,826,480	2,474,633,217	2,474,633,217	0.80290	1,986,880,073
2	108,975,826,480	2,474,633,217	2,537,177,576	0.64465	1,635,582,655
3	108,975,826,480	2,474,633,217	2,601,302,693	0.51759	1,346,397,630
4	108,975,826,480	2,474,633,217	2,667,048,521	0.41557	1,108,342,995
5	108,975,826,480	2,474,633,217	2,734,456,021	0.33366	912,378,459
6	108,975,826,480	2,474,633,217	2,803,567,192	0.26790	751,062,131
7	108,975,826,480	2,474,633,217	2,874,425,092	0.21509	618,267,912
8	108,975,826,480	2,474,633,217	2,947,073,868	0.17270	508,952,849
9	108,975,826,480	2,474,633,217	3,021,558,783	0.13866	418,965,625
10	108,975,826,480	2,474,633,217	3,097,926,245	0.11133	344,888,913
11	108,975,826,480	2,474,633,217	3,176,223,832	0.08939	283,909,599
12	108,975,826,480	2,474,633,217	3,256,500,328	0.07177	233,711,950
13	108,975,826,480	2,474,633,217	3,338,805,748	0.05762	192,389,675
14	108,975,826,480	2,474,633,217	3,423,191,370	0.04626	158,373,532
15	108,975,826,480	2,474,633,217	3,509,709,772	0.03715	130,371,735
16	108,975,826,480	2,474,633,217	3,598,414,856	0.02982	107,320,895
17	108,975,826,480	2,474,633,217	3,689,361,889	0.02395	88,345,642
18	108,975,826,480	2,474,633,217	3,782,607,536	0.01923	72,725,375
19	108,975,826,480	2,474,633,217	3,878,209,891	0.01544	59,866,906
20	108,975,826,480	2,474,633,217	3,976,228,518	0.01239	49,281,924
21	108,975,826,480	2,474,633,217	4,076,724,487	0.00995	40,568,458
22	108,975,826,480	2,474,633,217	4,179,760,411	0.00799	33,395,607
23	108,975,826,480	2,474,633,217	4,285,400,485	0.00642	27,490,978
24	108,975,826,480	2,474,633,217	4,393,710,526	0.00515	22,630,337
25	108,975,826,480	2,474,633,217	4,504,758,016	0.00414	18,629,100
26	108,975,826,480	2,474,633,217	4,618,612,142	0.00332	15,335,315
27	108,975,826,480	2,474,633,217	4,735,343,839	0.00267	12,623,900
28	108,975,826,480	2,474,633,217	4,855,025,836	0.00214	10,391,886
29	108,975,826,480	2,474,633,217	4,977,732,699	0.00172	8,554,512
30	108,975,826,480	2,474,633,217	5,103,540,878	0.00138	7,042,001
Total NPV portfolio loss Scenario 1					**11,204,678,570**

Table 5-6: Free cashflow analysis of the potential loss on Vanguard's pharmaceutical industry, using deforestation Scenario 2 and the largest incremental value per hectare rainforests

Year	Total value loss Scenario 2	Portfolio loss Scenario 2	Adjust for inflation rate	Discount factor	NPV portfolio loss Scenario 2
1	122,362,943,095	2,778,629,108	2,778,629,108	0.80290	2,230,958,013
2	122,362,943,095	2,778,629,108	2,848,856,718	0.64465	1,836,505,525
3	122,362,943,095	2,778,629,108	2,920,859,274	0.51759	1,511,795,615
4	122,362,943,095	2,778,629,108	2,994,681,636	0.41557	1,244,497,199
5	122,362,943,095	2,778,629,108	3,070,369,800	0.33366	1,024,459,433
6	122,362,943,095	2,778,629,108	3,147,970,920	0.26790	843,326,229
7	122,362,943,095	2,778,629,108	3,227,533,347	0.21509	694,218,927
8	122,362,943,095	2,778,629,108	3,309,106,649	0.17270	571,475,074
9	122,362,943,095	2,778,629,108	3,392,741,651	0.13866	470,433,385
10	122,362,943,095	2,778,629,108	3,478,490,460	0.11133	387,256,733
11	122,362,943,095	2,778,629,108	3,566,406,501	0.08939	318,786,425
12	122,362,943,095	2,778,629,108	3,656,544,549	0.07177	262,422,254
13	122,362,943,095	2,778,629,108	3,748,960,764	0.05762	216,023,751
14	122,362,943,095	2,778,629,108	3,843,712,724	0.04626	177,828,901
15	122,362,943,095	2,778,629,108	3,940,859,463	0.03715	146,387,228
16	122,362,943,095	2,778,629,108	4,040,461,508	0.02982	120,504,712
17	122,362,943,095	2,778,629,108	4,142,580,914	0.02395	99,198,447
18	122,362,943,095	2,778,629,108	4,247,281,306	0.01923	81,659,312
19	122,362,943,095	2,778,629,108	4,354,627,916	0.01544	67,221,246
20	122,362,943,095	2,778,629,108	4,464,687,625	0.01239	55,335,954
21	122,362,943,095	2,778,629,108	4,577,529,004	0.00995	45,552,083
22	122,362,943,095	2,778,629,108	4,693,222,358	0.00799	37,498,084
23	122,362,943,095	2,778,629,108	4,811,839,768	0.00642	30,868,102
24	122,362,943,095	2,778,629,108	4,933,455,138	0.00515	25,410,357
25	122,362,943,095	2,778,629,108	5,058,144,238	0.00414	20,917,588
26	122,362,943,095	2,778,629,108	5,185,984,754	0.00332	17,219,179
27	122,362,943,095	2,778,629,108	5,317,056,337	0.00267	14,174,681
28	122,362,943,095	2,778,629,108	5,451,440,648	0.00214	11,668,476
29	122,362,943,095	2,778,629,108	5,589,221,414	0.00172	9,605,389
30	122,362,943,095	2,778,629,108	5,730,484,478	0.00138	7,907,074
Total NPV portfolio loss Scenario 2					**12,581,115,377**

Table 5-7: Free cashflow analysis of the potential loss on Vanguard's pharmaceutical industry, using deforestation Scenario 3 and the largest incremental value per hectare rainforests

Year	Total value loss Scenario 3	Portfolio loss Scenario 3	Adjust for inflation rate	Discount factor	NPV portfolio loss Scenario 3
1	135,750,059,710	3,082,624,999	3,082,624,999	0.80290	2,475,035,953
2	135,750,059,710	3,082,624,999	3,160,535,860	0.64465	2,037,428,394
3	135,750,059,710	3,082,624,999	3,240,415,855	0.51759	1,677,193,600
4	135,750,059,710	3,082,624,999	3,322,314,752	0.41557	1,380,651,403
5	135,750,059,710	3,082,624,999	3,406,283,578	0.33366	1,136,540,408
6	135,750,059,710	3,082,624,999	3,492,374,649	0.26790	935,590,327
7	135,750,059,710	3,082,624,999	3,580,641,601	0.21509	770,169,942
8	135,750,059,710	3,082,624,999	3,671,139,430	0.17270	633,997,299
9	135,750,059,710	3,082,624,999	3,763,924,519	0.13866	521,901,145
10	135,750,059,710	3,082,624,999	3,859,054,676	0.11133	429,624,552
11	135,750,059,710	3,082,624,999	3,956,589,170	0.08939	353,663,250
12	135,750,059,710	3,082,624,999	4,056,588,771	0.07177	291,132,558
13	135,750,059,710	3,082,624,999	4,159,115,781	0.05762	239,657,828
14	135,750,059,710	3,082,624,999	4,264,234,078	0.04626	197,284,271
15	135,750,059,710	3,082,624,999	4,372,009,155	0.03715	162,402,722
16	135,750,059,710	3,082,624,999	4,482,508,161	0.02982	133,688,529
17	135,750,059,710	3,082,624,999	4,595,799,940	0.02395	110,051,252
18	135,750,059,710	3,082,624,999	4,711,955,077	0.01923	90,593,248
19	135,750,059,710	3,082,624,999	4,831,045,941	0.01544	74,575,586
20	135,750,059,710	3,082,624,999	4,953,146,732	0.01239	61,389,983
21	135,750,059,710	3,082,624,999	5,078,333,521	0.00995	50,535,708
22	135,750,059,710	3,082,624,999	5,206,684,305	0.00799	41,600,562
23	135,750,059,710	3,082,624,999	5,338,279,052	0.00642	34,245,226
24	135,750,059,710	3,082,624,999	5,473,199,750	0.00515	28,190,377
25	135,750,059,710	3,082,624,999	5,611,530,460	0.00414	23,206,077
26	135,750,059,710	3,082,624,999	5,753,357,367	0.00332	19,103,044
27	135,750,059,710	3,082,624,999	5,898,768,834	0.00267	15,725,462
28	135,750,059,710	3,082,624,999	6,047,855,460	0.00214	12,945,065
29	135,750,059,710	3,082,624,999	6,200,710,129	0.00172	10,656,267
30	135,750,059,710	3,082,624,999	6,357,428,077	0.00138	8,772,148
Total NPV portfolio loss Scenario 3					**13,957,552,184**

Table 5-8: Free cashflow analysis of the potential loss on Vanguard's pharmaceutical industry, using deforestation Scenario 1 and the smallest incremental value per hectare rainforests

Year	Total value loss Scenario 1	Portfolio loss Scenario 1	Adjust for inflation rate	Discount factor	NPV portfolio loss Scenario 1
1	2,743,098,607	62,290,539	62,290,539	0.80290	50,013,000
2	2,743,098,607	62,290,539	63,864,882	0.64465	41,170,273
3	2,743,098,607	62,290,539	65,479,015	0.51759	33,891,016
4	2,743,098,607	62,290,539	67,133,944	0.41557	27,898,794
5	2,743,098,607	62,290,539	68,830,701	0.33366	22,966,048
6	2,743,098,607	62,290,539	70,570,341	0.26790	18,905,454
7	2,743,098,607	62,290,539	72,353,950	0.21509	15,562,808
8	2,743,098,607	62,290,539	74,182,637	0.17270	12,811,170
9	2,743,098,607	62,290,539	76,057,544	0.13866	10,546,045
10	2,743,098,607	62,290,539	77,979,837	0.11133	8,681,414
11	2,743,098,607	62,290,539	79,950,714	0.08939	7,146,466
12	2,743,098,607	62,290,539	81,971,404	0.07177	5,882,909
13	2,743,098,607	62,290,539	84,043,165	0.05762	4,842,761
14	2,743,098,607	62,290,539	86,167,289	0.04626	3,986,519
15	2,743,098,607	62,290,539	88,345,097	0.03715	3,281,668
16	2,743,098,607	62,290,539	90,577,948	0.02982	2,701,441
17	2,743,098,607	62,290,539	92,867,233	0.02395	2,223,803
18	2,743,098,607	62,290,539	95,214,377	0.01923	1,830,616
19	2,743,098,607	62,290,539	97,620,844	0.01544	1,506,947
20	2,743,098,607	62,290,539	100,088,132	0.01239	1,240,506
21	2,743,098,607	62,290,539	102,617,779	0.00995	1,021,174
22	2,743,098,607	62,290,539	105,211,360	0.00799	840,622
23	2,743,098,607	62,290,539	107,870,493	0.00642	691,993
24	2,743,098,607	62,290,539	110,596,832	0.00515	569,642
25	2,743,098,607	62,290,539	113,392,078	0.00414	468,925
26	2,743,098,607	62,290,539	116,257,972	0.00332	386,015
27	2,743,098,607	62,290,539	119,196,298	0.00267	317,764
28	2,743,098,607	62,290,539	122,208,888	0.00214	261,581
29	2,743,098,607	62,290,539	125,297,619	0.00172	215,331
30	2,743,098,607	62,290,539	128,464,416	0.00138	177,259
Total NPV portfolio loss Scenario 1					**282,039,964**

Table 5-9: Free cashflow analysis of the potential loss on Vanguard's pharmaceutical industry, using deforestation Scenario 2 and the smallest incremental value per hectare rainforests

Year	Total value loss Scenario 2	Portfolio loss Scenario 2	Adjust for inflation rate	Discount factor	NPV portfolio loss Scenario 2
1	3,080,074,082	69,942,609	69,942,609	0.80290	56,156,838
2	3,080,074,082	69,942,609	71,710,352	0.64465	46,227,828
3	3,080,074,082	69,942,609	73,522,773	0.51759	38,054,352
4	3,080,074,082	69,942,609	75,381,002	0.41557	31,326,016
5	3,080,074,082	69,942,609	77,286,196	0.33366	25,787,308
6	3,080,074,082	69,942,609	79,239,543	0.26790	21,227,891
7	3,080,074,082	69,942,609	81,242,258	0.21509	17,474,618
8	3,080,074,082	69,942,609	83,295,591	0.17270	14,384,956
9	3,080,074,082	69,942,609	85,400,820	0.13866	11,841,573
10	3,080,074,082	69,942,609	87,559,256	0.11133	9,747,881
11	3,080,074,082	69,942,609	89,772,246	0.08939	8,024,372
12	3,080,074,082	69,942,609	92,041,167	0.07177	6,605,594
13	3,080,074,082	69,942,609	94,367,433	0.05762	5,437,669
14	3,080,074,082	69,942,609	96,752,494	0.04626	4,476,242
15	3,080,074,082	69,942,609	99,197,835	0.03715	3,684,804
16	3,080,074,082	69,942,609	101,704,981	0.02982	3,033,299
17	3,080,074,082	69,942,609	104,275,492	0.02395	2,496,986
18	3,080,074,082	69,942,609	106,910,971	0.01923	2,055,498
19	3,080,074,082	69,942,609	109,613,060	0.01544	1,692,068
20	3,080,074,082	69,942,609	112,383,441	0.01239	1,392,896
21	3,080,074,082	69,942,609	115,223,842	0.00995	1,146,620
22	3,080,074,082	69,942,609	118,136,032	0.00799	943,888
23	3,080,074,082	69,942,609	121,121,825	0.00642	777,000
24	3,080,074,082	69,942,609	124,183,081	0.00515	639,620
25	3,080,074,082	69,942,609	127,321,709	0.00414	526,530
26	3,080,074,082	69,942,609	130,539,662	0.00332	433,435
27	3,080,074,082	69,942,609	133,838,947	0.00267	356,800
28	3,080,074,082	69,942,609	137,221,618	0.00214	293,714
29	3,080,074,082	69,942,609	140,689,784	0.00172	241,783
30	3,080,074,082	69,942,609	144,245,605	0.00138	199,034
Total NPV portfolio loss Scenario 2					**316,687,115**

Table 5-10: Free cashflow analysis of the potential loss on Vanguard's pharmaceutical industry, using deforestation Scenario 3 and the smallest incremental value per hectare rainforests

Year	Total value loss Scenario 3	Portfolio loss Scenario 3	Adjust for inflation rate	Discount factor	NPV portfolio loss Scenario 3
1	3,417,049,558	77,594,680	77,594,680	0.80290	62,300,676
2	3,417,049,558	77,594,680	79,555,823	0.64465	51,285,383
3	3,417,049,558	77,594,680	81,566,532	0.51759	42,217,688
4	3,417,049,558	77,594,680	83,628,060	0.41557	34,753,239
5	3,417,049,558	77,594,680	85,741,692	0.33366	28,608,569
6	3,417,049,558	77,594,680	87,908,744	0.26790	23,550,329
7	3,417,049,558	77,594,680	90,130,567	0.21509	19,386,429
8	3,417,049,558	77,594,680	92,408,544	0.17270	15,958,742
9	3,417,049,558	77,594,680	94,744,095	0.13866	13,137,100
10	3,417,049,558	77,594,680	97,138,676	0.11133	10,814,348
11	3,417,049,558	77,594,680	99,593,778	0.08939	8,902,279
12	3,417,049,558	77,594,680	102,110,930	0.07177	7,328,279
13	3,417,049,558	77,594,680	104,691,702	0.05762	6,032,577
14	3,417,049,558	77,594,680	107,337,700	0.04626	4,965,966
15	3,417,049,558	77,594,680	110,050,574	0.03715	4,087,940
16	3,417,049,558	77,594,680	112,832,013	0.02982	3,365,157
17	3,417,049,558	77,594,680	115,683,751	0.02395	2,770,169
18	3,417,049,558	77,594,680	118,607,565	0.01923	2,280,379
19	3,417,049,558	77,594,680	121,605,275	0.01544	1,877,189
20	3,417,049,558	77,594,680	124,678,751	0.01239	1,545,286
21	3,417,049,558	77,594,680	127,829,906	0.00995	1,272,066
22	3,417,049,558	77,594,680	131,060,703	0.00799	1,047,154
23	3,417,049,558	77,594,680	134,373,157	0.00642	862,008
24	3,417,049,558	77,594,680	137,769,330	0.00515	709,598
25	3,417,049,558	77,594,680	141,251,339	0.00414	584,135
26	3,417,049,558	77,594,680	144,821,352	0.00332	480,855
27	3,417,049,558	77,594,680	148,481,595	0.00267	395,835
28	3,417,049,558	77,594,680	152,234,348	0.00214	325,848
29	3,417,049,558	77,594,680	156,081,948	0.00172	268,236
30	3,417,049,558	77,594,680	160,026,794	0.00138	220,809
Total NPV portfolio loss Scenario 3					**351,334,266**