Rising carbon prices and delayed forest planting: countervailing factors

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Abstract

Rising prices for carbon dioxide fluxes suggest that it would be advantageous to delay forestry programmes designed to fix carbon from the atmosphere, when the available land resources are limited. Immediate rather than delayed programmes may however be justified if, during the delay period, a forest cycle can be accommodated whose other benefits exceed the carbon costs of a sequestration–volatilisation cycle. Immediate programmes may also support positive feedbacks for climate change mitigation; or they may be deemed critically urgent to resolving the climate crisis; or other means of resolving the crisis or justifications for discounting may render delayed forest solutions superfluous. Surprisingly, prices based on the *summed* social cost of carbon may rise little with increasing *annual* cost, and this may give only small advantage to delayed plant–fell–replant programmes.

Keywords: Forest carbon sequestration; rising carbon prices; social cost of carbon; oceanic CO_2 uptake; sustainable forestry; planting delay

Highlights

Several arguments may favour immediate forest programmes to sequester carbon, even under rising carbon prices.

These include the various benefits of infill forest cycles during periods of delay before the ultimate programme.

Calculating summed annual costs of carbon with a fixed time horizon may lead, surprisingly, to only a small long-term price rise, and so a limited case for delay.

Forest sequestration should supplement programmes for reducing emissions, not displace them.

Introduction

It has been shown (Price and Willis, main text) that without discounting but under rising prices for CO_2 fluxes, conventional forestry economics assigns either negative or meaninglessly positive net value to the carbon account of conventional plantation forestry. This is because post-harvesting volatilisation of CO_2 back *into* the atmosphere (a cost) occurs at a higher CO_2 price than that prevailing during earlier sequestration of CO_2 *from* the atmosphere. This is so with a series of one-hit prices which are applied to individual fluxes at the times of their occurrence. The outcome is the same, using a summed cost of the protracted ongoing effects from a CO_2 flux into or out of the atmosphere. However, using ad hoc forms of analysis, sustainable forestry programmes – such as creation of a normal forest, a fell-and-replant protocol, or a no-harvest regime – can achieve a positive carbon account.

Sohngen and Sedjo (2006) note that “Rising carbon prices provide an incentive for delaying forest abatement actions to later decades, when it is more profitable.” Price and Willis (main text) demonstrate that enhanced economic value does indeed result when such delay is applied to real-world forest growth models. This goes against the intuition, that the urgency of the climate crisis demands prompt action. There have been repeated calls in the popular press to undertake immediate forest planting to balance present fossil fuel burning. Particularly, air travellers have been urged to mitigate their emissions, and quieten their consciences, by purchasing carbon offsets that entail immediate planting. Yet, with a limited area available for afforestation, immediate conversion to forest cover forgoes the opportunity for conversion at a later date, when net carbon fixing might gain a higher price. Delay seems appropriate.

This paper assembles countervailing arguments, under which the delayed planting option need not be significantly more valuable than immediate planting. It considers whether other benefits arising from immediate planting might outweigh the rising value consequent on delayed carbon fixing. Crucially, it investigates whether the rising *annual* values ascribed to fluxes of CO_2 into or out of the atmosphere translate into a commensurate rise in long-term *summed* value.

The value of infill cycles

Consider a baseline under which planting is delayed for 125 years. One plausible follow-up to this might then be for a no-harvest regime to be instituted: however, the exact nature of the delayed planting is immaterial to the argument, as, whatever its value, that will be held constant across all the options considered for the first 125 years.

The question now is whether one or more infill forest cycles could occupy the land during the provisionally unutilised period of 125 years, so as to generate net benefit. The first examined infill is a Sitka spruce crop, productivity 12 m^3/ha/year, unthinned, with a rotation of 124 years (allowing a year's interval before the subsequent no-harvest regime is launched). A 0.5% annual rise of CO_2 price is projected, from the initial one-hit price of £100/tonne of flux.

Under this regime and these prices, Price and Willis (main text) calculate the net carbon account (= sequestration benefit minus later and higher volatilisation cost) as –£80,467: apparently it would be better not to plant this immediate infill. However, some of the following might compensate for the loss.

1. Permanent product storage

Suppose timber could be harvested and stored permanently, rather than volatilising in use. This would be "nature-based" carbon capture and storage. Its success depends on storage's being permanent, as had seemed to be the case with coal formation during the Carboniferous Period. Merely *lengthening* the period of storage, in more enduring products, or by routing redundant products into second uses, is insufficient: thereby, the volatilisation can is merely kicked further down the road, to a time when the economic effect under rising prices would be even more severe. (The same permanence proviso is of course needed for engineered carbon capture and storage.) With *permanent* storage, on the other hand, the land from which timber has been harvested would become subsequently available for *additional* carbon capture and storage, without the occurrence of offsetting volatilisation.

Permanent storage, of approximately 80% of saw timber output from the infill cycle, would be required to offset the net CO_2 cost of the cycle's other elements, which include a 6% per year volatilisation of the non-timber biomass. It is assumed that some of the product is used as biofuel, displacing fossil fuels that have approximately equal carbon content per unit of energy generated.

Some really long-term storage has indeed been enacted by humans in past times: probably millions of tonnes of carbon have remained in place for hundreds of years in the timbers of the UK's medieval cathedrals and churches. But such storage must be a pervasive outcome, not just a small-scale curio like this. And, as the fate of *Notre Dame de Paris* in 2019 showed, even what is stored long-term is not guaranteed to be immune from eventual volatilisation. St Paul's and York Cathedrals in the UK are among many that have also experienced catastrophic fires in the past.

Biochar is a human-made form of carbon in the soil, stored stably in the ground for centuries (Wikipedia: https://en.wikipedia.org/wiki/Biochar), though the residence time is long rather than indefinite. Problematically too, biochar production entails up to 50% volatilisation of the carbon contained in the feedstock biomass.

2. High-embodied-carbon displacement

Displacement, by wood products, of the CO_2 cost attributable to high-embodied-carbon materials like steel and concrete, might equal or exceed the CO_2 volatilisation cost of the wood products themselves. Again, experimental calculation, using reasonable assumptions and a 0.5% per year carbon price rise, showed that about 40% of all saw-timber and board products would have to displace high-embodied-carbon materials, together with full displacement by biofuel. With CO_2 price rising at 1% per year, the required saw and board displacement increases to 90%. These results would be modified by differentials between lifespans-in-use of wood products, and those of displaced materials.

Alternatively, the whole harvestable biomass could be allocated to biofuel. With 0.5% CO_2 price rise, the single 124-year rotation gives a carbon account gain of £38,595. With 1% price rise, however, there is a carbon account loss of £67,544, largely attributable to the 6% annual decay of unharvested biomass. This result is very sensitive to the decay rate: without this decay, the dominant carbon account value would be the positive element resulting from sequestration during the growth phase.

3. Rising timber price

Were the costs of volatilisation to lead to harvesting's being prohibited, postponed or severely reduced globally, timber prices would rise, countering the dominance of rising CO_2 price. Unlike the one-off stock of carbon-sequestration potential on a given area of land, timber yield is a flow resource, that can be exploited there repeatedly and cumulatively. Thus timber revenue from an infill rotation would not compromise the value of a subsequent no-harvest regime.

With 0.5% rise of both CO_2 and timber price, a 124-year infill cycle yields overall NPV of –£3919. With an only slightly lower rate of price rise, NPV becomes positive. But with 1% price rise for both CO_2 and timber, a 124-year infill yields NPV = –£188,382.

With a 0.5% price rise, a 62-year infill cycle yields NPV = +£19,127. This improvement compared with the 124-year infill is due to the reduced separation between sequestration and volatilisation prices for CO_2 fluxes. (Even without timber price rise, the NPV = +£10,389.) A second cycle of 61 years, with the usual 1-year gap between cycles, yields additional NPV of £25,953. Thus, for comparison, we can construct infill options that terminate in time for a no-harvest crop to be initiated at 125 years: both infill cycles add positive elements to overall NPV.

By multiplying the value of the first cycle by successively greater compound interest factors to allow for price rise, one can show the value of an extensive succession of infill rotations. If the base value is positive, positive infill cycle values can accumulate successively, along with indefinite delay of the no-harvest regime. The major insight is that positive forestry activity could after all be justified, during an indefinite interim, as could a wait-and-see strategy, pursuing this activity until we know better what price changes are likely to eventuate.

4. Other non-carbon effects

Moreover, there are other effects from doing forestry, that yield possible benefits (but also possible disbenefits (Price, 2014)), and do so cumulatively over repeating cycles: e.g. effects on water, on wildlife, on landscape. These too might make infill rotations worthwhile, perhaps perpetually so if implied price is rising. Paradoxically, immediate and short-term planting for supposed CO_2 *benefits* might depend for its justification on the configuration of other benefits, which have potential to offset the CO_2 *costs* of infill rotations.

Any of these arguments for infills could conceivably justify creating a new normal forest resource, giving perpetual net carbon and other benefits, while not precluding a progression into the no-harvest option, should new circumstances indicate it.

Inherent advantage of earliness

Some arguments against delay rely not on the offsetting benefits of infill cycles, but on those arising from the immediate planting itself.

5. An immediate threshold

If climate change has reached a threshold where increasing CO_2 concentration threatens to tip it irreversibly and catastrophically, immediate sequestration must have priority. If any future action will be too late, then CO_2 cost (if determined at all) is already at its peak, and maybe should hereafter decline. Thus none of the problems of rising CO_2 price is germane. The 2021 "code red" warning for humanity from the Intergovernmental Panel on Climate Change supports such an argument.

6. Positive feedbacks promoted by immediate fixing

The effect of *early* CO_2 sequestration by forests may initiate and strengthen positive feedbacks in climate change, thereby enhancing long-term mitigation. Among the mechanisms are: ameliorating the adverse effect of ocean warming on oceans' ability to take up CO_2; diminishing release of soil-bound methane, through earlier moderation of temperature change; and reducing ice sheet melting with favourable effects on albedo. (However, the effect of dark-canopied forests on albedo should also be considered (Jarvis et al., 2009; Favero et al., 2018). Evaluating such all-system effects requires a wide multidisciplinary approach. We offer it for the attention of a qualified collaborative team.

7. Early resolution of the climate crisis

If the climate crisis is solved soon, not all the potentially afforestable land would be needed for carbon offsetting: its immediate use would hence have no long-term carbon-fixing opportunity cost. The argument could be that alternative means of sequestering (or avoiding emissions) will become more cost-effective than forest planting, but are not so at the moment (otherwise they should already be preferred): forestry is an intended stop-gap.

8. Discounting

In addition to the many general arguments that cast doubt on routinely discounting values which accrue to future generations (Price, 1993), application to climate change effects has been particularly criticised (Broome, 1992; Spash, 2002). The calculations above, and in an earlier paper (Price and Willis, main text) have thus, as a base position, eschewed discounting. A substantial discount on carbon-induced climate costs would both lower the expected discounted cost presently attributed to long-term CO_2 fluxes, and counter the effect of price rise. The arguments for such discounting include:

(a) "humankind destruction" discounting – no-one will be here to benefit from climate mitigation – which contains an element of self-fulfilling prophecy (Price, 1993, chapter 12);
(b) "the-future-doesn't-much-matter-to-us" discounting, a manifestation of pure (selfish) time preference (criticised in Price (1993, chapter 7; 2006)). An element of this standpoint might be defensive discounting, designed to shield us from facing the unpalatable problems that climate change will cause;
(c) discounting on grounds that those who will mostly bear the costs of climate change will have become rich enough in future, that they can sustain even the rising costs more readily than present generations could (Schelling, 1999). The validity of this argument for climate change was queried in Price and Willis (main text);
(d) technological advance discounting. For example, if other means of emissions avoidance or carbon capture and storage became effective in the not-very-distant future, the general cost of CO_2 mitigation might fall. This is a retelling of the "early resolution" argument above.

Any of these would improve the case for *immediate* rather than *delayed* use of forests' finite capacity to capture carbon. But such discounting perspectives also seem hostile to *any kind of active engagement with climate change mitigation*. This is especially so, since the effects of mitigating actions take several decades to mature, owing to the lags in oceanic uptake and temperature adjustment: these are discussed in detail below.

The social cost of carbon

Much used into the 21st century (Cline, 1992; Fankhauser, 1995; Clarkson and Deyes, 2002), the social cost of carbon approach to pricing is based on the effect upon temperature – and hence upon climatic damage – of surplus-over-historical CO_2 levels. The effect of a single CO_2 flux into or out of the atmosphere is mitigated by long-term exchange of CO_2 with oceans (and sometimes with terrestrial ecosystems). The physical model used for the calculations below entails the following steps.

- ❖ Uptake of CO_2 emissions, from atmosphere into the ocean, follows the so-called "five-box model" of Siegenthaler and Oeschger (1978). Table 1 shows the relevant coefficients. The total flux is the sum of partial fluxes from out of each atmospheric "box".

Table 1: Coefficients of the five-box model of uptake

Proportion of excess CO_2 in each atmospheric box	0.1	0.25	0.32	0.2	0.13
Annual rate of oceanic uptake	0.5263	0.0578	0.0136	0.0028	0.0000

Maier-Reimer and Hasselmann (1987) confirm that this model accords well with observations.

Were it not for this uptake, there would always be advantage in early sequestration, as the period of never-diminishing annual benefit from reducing atmospheric CO_2 would start earlier, and the total of benefit become larger.

- ❖ The thermal inertia of the upper ocean means that its temperature rises by about 5% per year towards what the equilibrium would be, if the new atmospheric CO_2 concentration were to remain the same. With changing concentration, however, the equilibrium is ever-shifting. This is shown in figure 1.

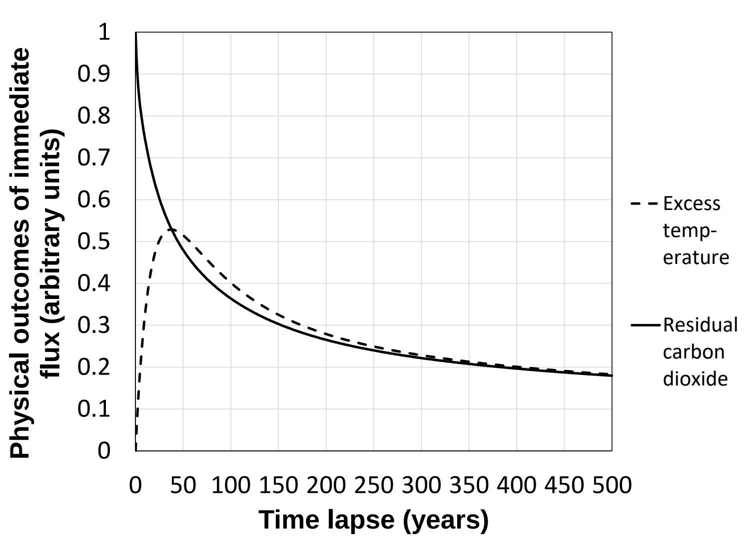


Figure 1: Physical consequences of a single unit of CO_2 flux into the atmosphere

- ❖ Each quantum of increase in temperature causes on-going year-wise damage and opportunity costs
- ❖ Damage/opportunity cost per unit temperature rise is conventionally taken as a positive function of rising GWP (Cline, 1992; Fankhauser, 1995). Hence for *given* temperature change, there would be a rising parameter of year-wise cost (which we will term "the year-wise cost factor").

- Aggregating the damage/opportunity cost over the future yields the summed social cost of carbon.
- Surplus-to-historical atmospheric CO_2, and hence summed social cost, are mitigated initially by forest sequestration, but aggravated subsequently if forest volatilisation occurs.

Further commentary on the use of this model is given in Price and Willis (main text).

9. Social cost of carbon and the time horizon

The path through time of this ongoing summed social cost of carbon depends crucially on what convention is adopted for the time horizon up to which year-wise costs are summed. *Some* time horizon is essential in numerical approaches, because, with the year-wise cost factor rising indefinitely, there is otherwise no finite limit on the summed year-wise cost of emitted CO_2, nor on the benefit of mitigating CO_2 levels.

Suppose that year-wise costs are to be summed over some fixed time period *following the time of any flux*, whenever that flux were to occur. So, for example, the time horizon for an immediate flux might be taken as 500 years from present, whereas for a flux in 60 years' time it would be 560 years from present. If the year-wise cost factor rises by x% per year, delay of the flux by one year would also raise all consequent annual costs by x%, and so also the sum of these costs. This is so, whether the time horizon is set at 500, 1000 or 3000 years *after the time of the flux*, and for any values of x, and of the period of delay until the flux occurs.

This algebraic conclusion is supported by year-on-year numerical calculations, as illustrated in figure 2. This depicts two profiles of year-wise effects for the years following a flux into the atmosphere: firstly one occurring at the present; and secondly one occurring in 60 years' time.

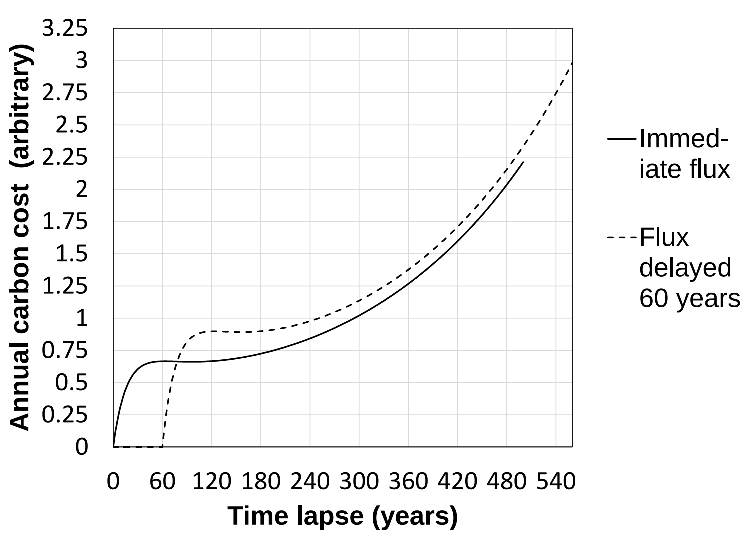


Figure 2: Profile of year-wise costs arising from immediate and delayed single fluxes into the atmosphere; 0.5% annual increase of year-wise cost factor, set in arbitrary units.

Four relevant effects of a unit of CO_2 emission are apparent.

i. An immediate flux brings immediate increase of CO_2 in the atmosphere (see figure 1). As the temperature adjusts upwards towards equilibrium, year-wise cost increases year on year. Lagged oceanic uptake of CO_2 from the atmosphere eventually commutes this effect progressively, although the rising year-wise cost factor acts oppositely.

ii. A delayed flux brings later impact. However, eventually the physical effects on CO_2 concentration in the atmosphere and on temperature combine to exceed those applying to immediate planting. This physical effect comes during a later period than that following immediate flux, a time when the year-wise cost factor would be higher. The monetary effect thus exceeds the cost resulting from the same physical profile that arises from immediate emission.

iii. The year-wise costs resulting from immediate emission exceed those resulting from delayed emission until about year 70, whereafter those resulting from delayed emission are higher. Rough visual appraisal suggests that the summed overall effect of delayed flux is never much greater than that of immediate flux, up to 500 years.

iv. The effects of an immediate flux reach their time horizon at 500 years. The sum of annual effects is 520.4 in the arbitrary units adopted. Thereafter, up to 560 years, included effects occur only for the delayed flux. The sum of all annual effects for the delayed flux is 702.0 arbitrary units.

The annual compound rate of increase of summed social cost over the period of delay is $(702.0/520.4)^{(1/60)} - 1 = 0.500\%$, exactly as had been projected previously.

Obversely, the same effects apply to the cost *saving* generated by immediate and by delayed forest sequestration.

However, the result differs fundamentally if the time horizon is set at a fixed number of years *after the time of decision making* (time 0), rather than *after the time of flux*. If the effects resulting from a delayed single flux, as shown in figure 2, are truncated at the same 500-year time horizon as those from an immediate flux, the summed social cost is only 543.1 arbitrary units, compared with the 520.4 arbitrary units recorded previously for the immediate flux. The rate of increase of summed social cost over the period of delay is now only $(543.1/520.4)^{(1/60)} - 1 = 0.071\%$, compared with the 0.5% growth rate of the year-wise cost factor. In the period beyond 500 years, should the time horizon be extended, delayed emission always has a slightly greater effect; however, the *proportional* gap between delayed and immediate year-wise effects narrows at any point in time, since in both cases the resultant atmospheric CO_2 concentration is becoming asymptotic to the same 13% of the initial change.

To test the robustness of this result and conclusion, table 2 compiles rates of increase of summed year-wise costs (or mitigation of costs), attributable to a single flux delayed for 100 years, by comparison with those attributable to a flux occurring immediately. The rate of increase in each case is represented by the geometric mean rate of increase during a 100-year period. That is:

$$\{ \text{[summed costs from flux at time 100]} \div \text{[summed costs from flux at time 0]} \}^{(1/100)}$$

Various rates of increase in year-wise cost factor are used, and various fixed time horizons. The “normal” suite of parameters for oceanic uptake of CO_2 are those given by Siegenthaler and Oeschger (1978); some parameters are also applied individually, to reveal sensitivity further.

Table 2: Rate of change of summed year-wise costs of CO_2, due to a 100-year delay of flux, various parameters

Parameters of annual oceanic CO_2 uptake	% rate of annual increase of year-wise cost factor	Time horizon of costs (years from now)	Geometric mean annual rate of increase of summed year-wise cost of CO_2, between a flux at time 0 and one at time 100
“Normal” set	0.5%	500	0.069%
	0.5%	1000	0.048%
	0.5%	2000	0.004%
	0.5%	3000	0.000%
	2%	500	0.115%
	2%	1000	0.033%
	2%	2000	0.002%
	2%	3000	0.000%
	10%	3000	0.000%
	0%	3000	–0.031%
	–2% (≡2% discount)	500	–2%
	–2%	3000	–2%
	–10%	3000	–10%
All oceanic uptake @			
0.52630	0.5%	3000	0.5%
0.52630	10%	3000	5.26%
0.05780	0.5%	3000	0.5%
0.01360	0.5%	3000	0.5%
0.00280	0.5%	3000	0.28%
0	0.5%	3000	0%
0	0.5%	500	–0.07%

For the “normal” uptake parameter set, rate of rise in the year-wise cost factor always translates into a *much* lower rate of rise in summed year-wise costs.

(However, negative annual price rise is equivalent to discounting, and the summed year-wise cost declines exactly in line with that discount.)

If all the oceanic uptake were very rapid (e.g. rate parameter = 0.52630), the summed year-wise costs would rise at the same rate as the year-wise cost factor, since nearly all the damage or mitigation would occur very quickly, and the time horizon would play no significant role. If no uptake at all took place, no rise of summed year-wise costs would occur, irrespective of the rate of increase of the year-wise cost factor. Indeed, with a 500-year time horizon the dominant influence of extra physical effects in the earlier years causes summed year-wise costs to *decline* with increasing delay.

Evidently, uptake parameters are theoretically important: but these calculations are presented merely for illustration: the “normal” uptake parameters, or something close to them, are the realistic ones.

Further calculations show that the rate of summed year-wise cost increase is similar for all shorter delays of flux, compared with immediate flux. For example, with a 10-year delay, a 0.5% growth rate of year-wise cost factor and a 500-year time horizon, the mean rate of increase of summed year-wise cost over the 10 years is 0.0729%; with a 25-year delay it is 0.0725%. (For comparison, the figure given in table 2 for the 100-year delay was 0.0688% (≈0.069).)

The relationship of rate of change of summed year-wise costs to the adopted time horizon is illustrated in figures 3a and 3b. The illustrative delay of flux is again 100 years. Rate of increase of summed year-wise costs over time is again represented as its geometric mean rate between times 0 and 100.

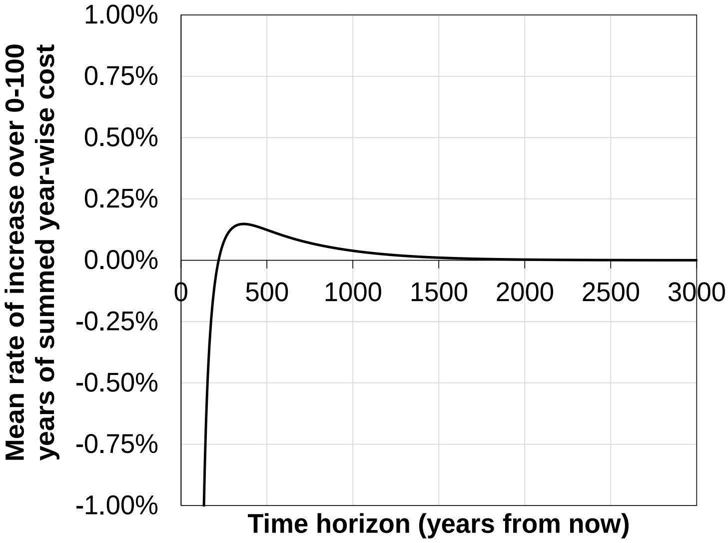


Figure 3a: Variation of summed year-wise costs with extension of time horizon; 1% per year increase in year-wise cost factor

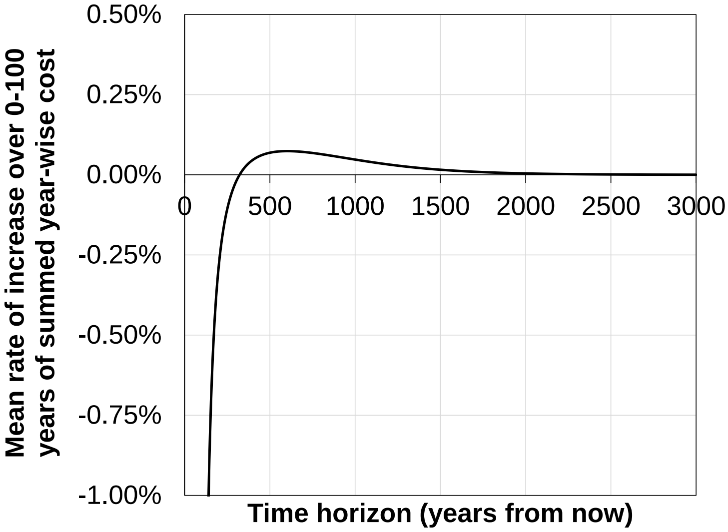


Figure 3b: Variation of summed year-wise costs with extension of time horizon; 0.5% per year increase in year-wise cost factor

With a short time horizon, the rate of rise is undefined, because only the costs of immediate flux are included. As costs begin for the 100-year delayed flux, the ratio remains negative for many years. It becomes positive eventually, as the current year-wise cost differential achieves dominance. It never rises above a small fraction of the rate of increase in year-wise cost factor. As time horizons become very distant, the amounts of atmospheric CO_2 remaining from immediate and delayed flux become almost identical (asymptotic to 13% of the initial flux). The very large year-wise cost factors, which by then prevail, mean that the resultant near-identity of year-wise costs dominates the whole ratio of summed year-wise costs, bringing the ratio close to unity.

Delay of a plant–replant programme

The convention for time horizon also – and expectedly – affects the outcome from delaying an entire plant-fell-replant programme. The results displayed in figure 4a are based on Sitka spruce, productivity 12 m^3 per hectare per year, thinned, with rotation 60 years. Replanting occurs immediately after felling of the previous cycle. The year-wise cost factor rises at 0.5% per year. The summed social value of the immediate programme is 141.01 in arbitrary units with a time horizon of 500 years. If the time horizon for a 60-year delayed programme is extended to 560 years (figure 4b) the summed social value is 192.16 arbitrary units. This amounts to a value increase per year of delay of $(192.16/141.01)^{(1/60)} - 1$ or 0.517%. Note that this is *not* precisely 0.5%: the difference is attributable to the irregular pattern of fluxes and the curtailing effect of the time horizon.

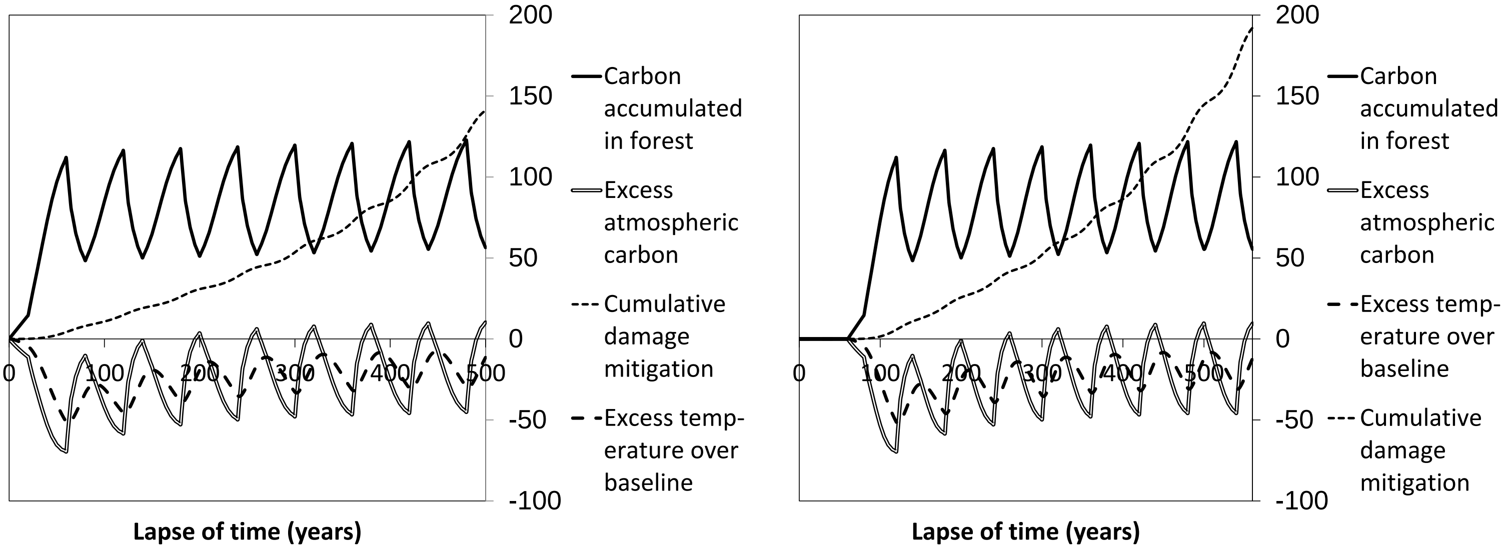
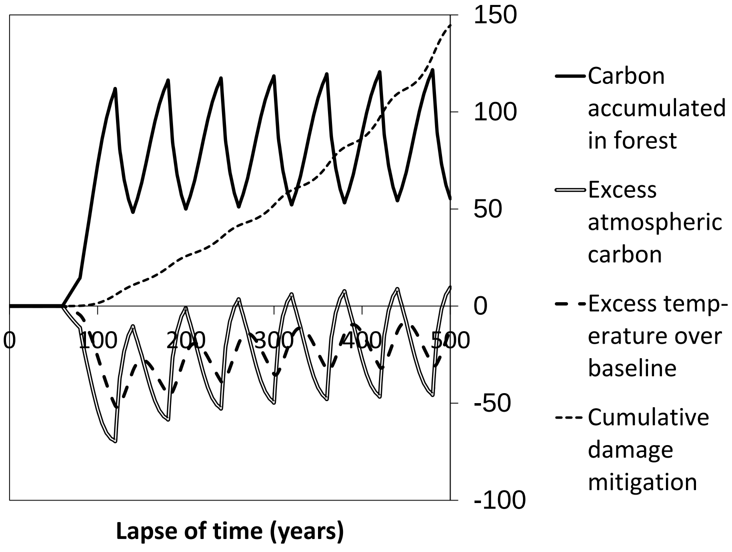


Figure 4: Consequences of repeated cycles of plantation forestry. (a) immediate with 500-year horizon (b) delayed with 560-year horizon (c) [below] delayed with 500-year horizon



However, if the time horizon is truncated at 500 years for the delayed programme as well as the immediate one, its value is only 144.58 arbitrary units (figure 4c). The increase from 141.01 for the immediate flux = $(144.58/141.01)^{(1/60)} - 1$ or only 0.042% per year.

Figure 5 shows the effect of setting different time horizons, again using a 60-year programme delay and a 0.5% annual rise in year-wise cost factor: these values are chosen because they show the difference of profiles as clearly as possible.

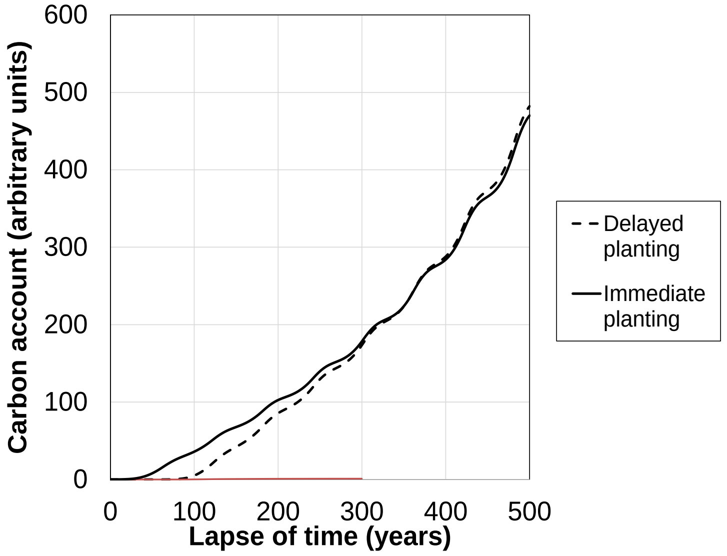


Figure 5: Difference in cumulative carbon value between immediate and delayed planting programmes

Table 3 shows a set of effects of different rates of rise of year-wise cost factors.

Table 3: Effects of delaying a repeating planting programme; "crossover" is the first year in which the summed year-wise carbon value of the delayed programme exceeds that of the immediate programme

Rate of rise in year-wise cost factor	Year of cross-over	Ratio between immediate and delayed, time horizon = 500 years	Geometric mean rate of rise over 60 years' delay	Maximum ratio achieved …	… at year
0.5%	354	1:1.025	0.041%	1:1.025	500
1%	227	1:1.055	0.089%	1:1.075	401
2%	170	1:1.047	0.077%	1:1.155	281
5%	134	1:1.037	0.061%	1:1.167	218

Once again these valuations according to the summed year-wise costs of CO_2 do not indicate that any major advantage accrues from delay, and not any advantage at all until after a long period has elapsed.

The ratio between values of delayed and immediate programmes oscillates as the time horizon is extended, as shown in figure 6. A 2% yearly rise in the year-wise cost factor is used, in order to show the oscillations clearly. They occur on the 60-year cycle of the rotation period, varying according to the relative dominance of sequestration and volatilisation during the cycle. The peaks show a slow downward trend towards unity.

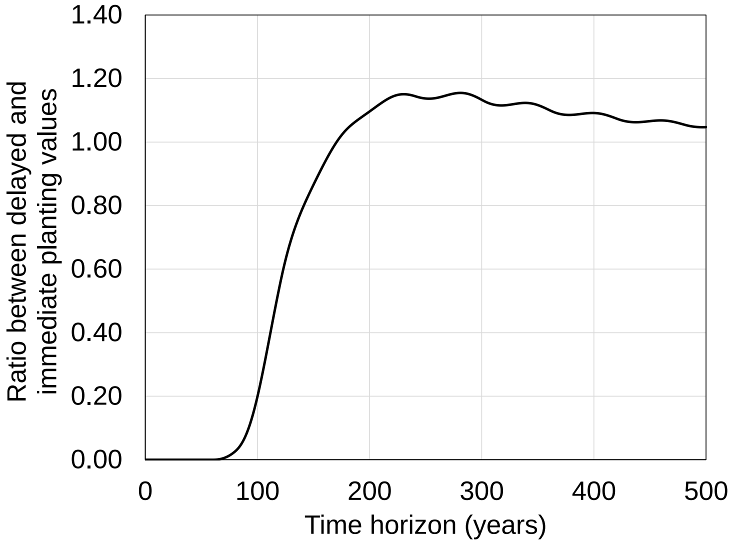


Figure 6: Variation in the relationship between immediate and delayed planting values

The potential difficulty with any kind of rising carbon cost is that it focuses on “the last things”, so that what we potentially need to know about is actually what is most difficult to predict. Fortunately, however, in judging the effect of delay it seems to matter little when the time horizon is set.

The fundamental question now is: how *ought* the time horizon to be defined? Generally in economics, time horizons, if any, are set at a given number of years from *now*, the present, the time of decision. If this convention is adopted, then summed year-wise costs for CO_2 need not be considered to rise much through time, almost regardless of any reasonable rate of increase in year-wise cost factor. On this understanding, there is a substantial case neither for delay nor for advance of planting.

Nonetheless, a potential opportunity cost through immediate planting does remain, in that planting *now* still precludes the possibility of new net carbon fixing by later initiation of planting on the site.

A predictable by-product of this investigation of summed year-wise costs through time has been that, without discounting, this cost rises without limit *as the time horizon is extended*. Planting, at whatever time but probably immediately, should hence have priority over all *finite* forestry effects.

Conclusions

This paper has explored the circumstances in which rising carbon price may not, after all, favour delay of investment in forest-based carbon sequestration programmes. Some arguments are based on benefits other than carbon sequestration; some on the effects of early sequestration in itself; some on the profile of effects to be included, when the price is based on the social cost of carbon. Each of these merits fuller examination, to verify and quantify their practical efficacy.

It remains an issue, that using forest land for carbon sequestration will generally commute the possibilities for so using it in later times: there is an opportunity cost. Hence forest sequestration as a means to offset current emissions is at best a short-term strategy. At worst, it may be presented as justifying emissions, on the mistaken grounds that there are no later costs in doing so.

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