A Generic Look at

Payments for Environmental Services

Plan or Scam?

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Abstract

Sustainable use of a natural resource ensures that the ecosystem associated with that use will also provide long term environmental services to society. Such services might include the provision of clean water, removal of excess CO_2 from the atmosphere, flood protection, pleasant vistas, or enhanced biodiversity. These benefits are becoming less abundant as inappropriate resource uses hasten environmental degradation.

In theory, if beneficiaries pay for the environmental services received, and these payments are given to the resource users/owners to reward, or encourage, sustainable resource use, then such sustainable use will be assured. Schemes to implement such arrangements might be able to support conservation programs, and also supplement income of poor farmers and forest dwellers. Such payments are also seen as a means of encouraging better management of carbon dioxide in our atmosphere, by paying for forest practices which can store CO_2.

How do such systems actually work? Can payments for environmental services encourage better resource management? Might they also create disincentives for management based on ethics, altruism, and stewardship? A generic system dynamics model was used to examine these questions.

Introduction

During the past several years the concept of payments for environmental services has become popular both among those interested in environmental conservation and those interested in international development. Simply put the concept promotes the idea that people should pay for services, normally viewed as free, which are provided by our ecosystem. Some examples of such free services are the provision of clean water from good watersheds; the availability of natural scenic areas; the protection of "biodiversity" for future generations; as well as the expectation of a stable future climate.

In each of these cases human abuse of our natural environment has made the long-term realization of these benefits less likely. The concept of payment for environmental services recognizes the fact that people who are abusing our environment, and thus decreasing the benefits others receive, are sometimes merely trying to make a living. Often they have difficulty changing their resource use patterns without some help. If environmentally degrading activities are to be lessened, this argument goes, some

compensation should be offered to assist these resource users make their activities more sustainable. The logic of these schemes assumes that financial costs should be obtained from those who receive environmental benefits. Such recipients might be individuals, communities or even society as a whole.[1]

Can such schemes work? Some investigators feel that the cash-in value of tropical forests (for example) is too high to be off-set by any reasonable level of payments for benefits (Rice *et al* 1997). Nevertheless, Janzen (1998) makes a good case for the many biodiversity values which tropical forests hold, and provides specific examples as to how these benefits might be incorporated into contracts which can benefit landowners who own and use such forests.

Landell-Mills and Porras (2002) provide a number of examples of such payment schemes. These programs are popular with conservation groups who see them as a means of providing funding for protection of critical biodiversity areas, and among international development specialists who see such payments as providing an income supplement for poor farmers and forest dwellers (Pagiola *et al* 2005). Such payments are also seen as a means of encouraging better management of carbon dioxide in our atmosphere -- a major cause of global warming.[2]

The purpose of this paper is to look at the question of payment for environmental services from a big picture, generic, perspective.[3] By doing that I would like to examine some of the following questions: conceptually, how does the system of payment for environmental services actually work? What is the relationship between penalties for abusing a resource, and payments for good resource management?[4] Might a system of payments tend to deplete a conservation ethic based on altruism and the concept of stewardship? The model provided should be considered as a starting point, a thinking tool, for examining these issues.

The concept of payments for ecosystem services

In general the concept of payment for ecosystem services goes something like this:

An ecosystem, if well managed and cared for, will provide certain services -- for example, watershed protection. Often no one pays for such services, and they are

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[1] Interestingly both the providers of such services and the recipients of benefits could include any of these categories.

[2] The "clean development mechanism" of the Kyoto Protocol is a specific example of an international attempt to use payments for environmental services to both help development, and at the same time provide an environmental service in the form of carbon sequestration. For an introduction see UNFCCC (2003).

[3] I note that others believe this generic approach to be less useful. Tomich *et al* (2004) state "we need to decompose the broad concept of 'environmental services' into constituent components in order to be clear on the cause–effect chains underlying the provision of services."

[4] I have tried to present this paper and model to reflect a generic view of the problem. However, it may be easier to think of the problem in terms of hectares of land being used for different purposes and the effect on benefits derived from that land. Nevertheless, one should also consider that uses of the environment are not limited to land, and I am hopeful that the perspective used here might also apply to such things as river systems (e.g. water withdrawals and degradation of remaining water quality), and use of the atmosphere (e.g. carbon dioxide emissions and other pollutants).

typically taken for granted. As various land uses develop within the ecosystem, the ecosystem becomes degraded also degrading the ecosystem services.

In theory, if people are asked to pay for the service provided – e.g., high-quality water and flood protection -- this money can be paid back to those individuals who own, or use, the ecosystem lands which provide the benefits, thus giving these people an incentive to follow resource use approaches which protect, and restore the ecosystem.

An alternative view is that ecosystems, and the services they provide, belong to humankind, and resource users are morally obligated to use resources in a sustainable way. While appealing, this view may only be realistic in wealthy societies. The sad fact is that most resource users in the world have little incentive, monetary or otherwise, to alter their behavior without encouragement, including financial assistance.

There are a number of questions which might be asked:

> If the ecosystem services provided are normally recognized as freely available, then what is the effect of paying for them?
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> Does payment for ecosystem services create incentives for others to request, or demand, payments for similar ecosystem protection? Is this a good thing?
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> Who is it that actually owns the "ecosystem" in question -- private landowners or the public? What land use requirements/restrictions do private landowners have? Is the implication that, without payment, they can do whatever they want?
>
> Is there a concept of a land (or resource) stewardship? Does this concept have any legal standing? Will payments degrade this concept?
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> If payments are provided, who receives them? What requirements, if any, are attached to these payments?
>
> How can a society distinguish among the following: reward, payment, reimbursement, incentive, bribery, and extortion? Do these distinctions matter if the end result -- protection of the ecosystem and its services -- is attained?

Any reasonable policy should be able to provide incentives to support environmentally sustainable activities, but at the same time avoid providing perverse incentives which could undermine existing environmentally friendly attitudes and activities (for example see Pagiola *et al* 2004).

The idea of making such payments is often suggested in cases where economic pressures create incentives for intensive land use which is unsustainable. In these situations payments for environmental services are seen as a counterbalance to destructive economic pressures -- a way of explicitly providing cash value for a benefit that is normally taken for granted. The typical example is that of farmers who need to harvest their land more intensively in order to make a sufficient income to cover costs and provide a modest livelihood. This intensification leads to the degradation not only of

ecosystem services (e.g. watershed protection, or biodiversity) but degrades the agricultural usefulness and profitability of the land for future generations.[5]

Thus, the intended role of payments is not merely to reimburse land owners for environmental services provided, but to provide a counterbalance to economic pressures that force the adoption of ecologically damaging land uses. That is: payment for environmental services is a means to increase the value of sustainable land uses so that those uses can compete successfully against damaging use options (Pagiola *et al* 2003).

Some suggest the development of national scale aggregate indicators of ecosystem services (Meyerson *et al* 2005), but usually ecosystem services are thought of and measured on specific local areas (e.g. a particular area of tropical forest) and/or for a particular environmental service (e. g. carbon sequestration).

What are environmental services?

Existing schemes for payment of environmental services involve considerable amounts of money. Scherr *et al* (2004) report that:

> "Direct and indirect payments for ecosystem services combined are approximately the same magnitude of total annual investments in forest conservation by governments, philanthropic organizations and intergovernmental organizations, which is somewhere between US$2 and US$2.5 billion per year."

Some may dispute this figure because it includes the monetary value of items that some would consider uses rather than environmental services. Thus, at some point we may need to differentiate between "services" and "uses". The extraction of timber from a forest is a use of the forest, not an ecosystem service like flood control, aquifer recharge, water quality improvement, or carbon sequestration. Nevertheless, the distinction between resource uses and environmental services is not at all clear. The International Tropical Timber Organization Report cited above (Scherr *et al* 2004) assumes that non-timber forest products (e.g. rattan) are ecosystem services while timber production is considered a resource use.[6] On the other hand, most authors treat all "products" as resulting from resource use. Ultimately the concept of payment for environmental services tends to place a monetary value on all products and services of the environment, often including items generally considered to have non-monetary value.

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[5] This suggests that we may wish to include the provision of long-term sustainability within our definition of environmental services.

[6] Also mentioned in Scherr (2004) is the sale of shade-grown coffee. The total value of this should not be considered a payment for environmental services -- it's a payment for coffee. Only the additional price of shade-grown compared to normal coffee should be considered a payment for those services (usually biodiversity related benefits) resulting from the manner in which the coffee is grown, and paid by coffee consumers who value those benefits.

A model

The environment and the provision of ecosystem services

In this model *ecosystem status* is represented as a single stock affected only by flows which are *improving the ecosystem* and *degrading the ecosystem*. Degradation will occur if damaging resource uses become excessive. Recovery, in this model, is a natural process which may take a long time, but that time might be shortened via restoration activities which are driven by funding and the current level of environmental ethic.[7]

Benefits being provided by the ecosystem are influenced primarily by the way in which *ecosystem status* affects *changing environmental services*. There may a lag in the changes of these ecosystem services as changes in the ecosystem itself occur. Typically the use of environmental services are non-consumptive, and will not dissipate those services (e.g., scenic vistas or flood control), but such dissipation is possible, as in the case of over-pumping water from an aquifer (Figure 1).

Factors causing changes in resource use patterns

Any model designed to examine payments for ecosystem services must include profitability associated with destructive as well as nondestructive resource uses. Activities, such as timber extraction, can be carried out in an environmentally friendly, or a destructive, manner.[8] Market, as well as non-market social forces, determine the extent to which ecosystem friendly and unfriendly uses are implemented within a given environment. Payments for ecosystem services help to tilt the market forces more toward ecosystem friendly activities. Perhaps this is good, but we must also consider possible effects of such payments on non-market forces, especially an environmental ethic, which also helps to maintain ecosystem integrity.

Within the model, resource use can be either environmentally damaging or environmentally friendly. The relative profitability of each type of resource use is one, but not the only, factor determining the extent of its implementation within the environment. If environmentally friendly uses are more profitable these will gradually become more widely adopted. If environmentally damaging uses are more profitable those will become more widely adopted. Changes in the type of use may take time (e.g. time needed for trees to grow).

The changeover from one use type to another is also influenced by some threshold of profitability difference between the two uses. This threshold for change to occur can be thought of as incorporating transaction costs and start up costs associated with a new activity (Figure 2).

Also, as discussed below, the rate of change from one resource use to another is influenced by the level of environmentalism within the community of resource users.

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[7] Another formulation might assume that environmentally friendly activities are more directly involved in reestablishing ecosystem status.

[8] Obviously this is an oversimplification. An expanded model could include a number of different activity types with different levels of environmental friendliness.

This environmental ethic will have more influence when immediate economic pressures are minimal since under those conditions profitability is a less important concern. In the model, this realized environmental ethic operates by lowering the threshold needed to switch to friendly uses.

The role of payments and penalties

Payments[9] for environmental services can be used to make environmentally friendly uses a financially more attractive option. On the other hand, penalty payments (e.g. special taxes) for damaging land uses can make those damaging uses less profitable.

Within the model we want to investigate how such payments and charges can lead to environmentally friendly resource uses which in turn will help maintain the overall level of environmental services provided. Specifically we want to investigate how the application of payments and penalty charges will influence the type of resource use, especially if providing payments might degrade an environmental ethic which exists among resource users.

In theory, payments made are based on environmental services being provided, but in a severely degraded ecosystem such services may be minimal. Nevertheless, we still want to encourage environmentally friendly uses. To do this penalty payments can be charged to recover the value of ecosystem services lost to damaging uses, and this can be used as a source of funds for payments (Figure 3).

For practical reasons, penalty payments may be an impossibility, or may be capped at some fairly small fraction of total services that were lost, because users of the resource are unable to pay. Also, those currently using the resource may not be the ones responsible for damage already done to the environment. Note also that recipients of environmental services may not be able to pay for those services (e.g. poor people living in flood prone areas may not have funds to pay for watershed protection).

It is also possible, or even likely, that payments and penalties will be insufficient to significantly raise the relative profitability of sustainable uses above the profitability of damaging uses.

Do payments improve or degrade environmental ethic

In many cultures there is an underlying belief that living in harmony with our natural world has a value of its own. In one example from the late 1940s North American forester and conservationist Aldo Leopold (1949) said:

> "A land ethic… reflects the existence of an ecological conscience, and this in turn reflects a conviction of individual responsibility for the health of the land."
>
> "When the private landowner is asked to perform some unprofitable act for the good of the community, he today assents only with outstretched palm. If the act

[9] Payments can refer to the payments made by recipients of environmental services, and also to the payments received by resource users. Where the meaning may not be clear I will refer to the latter as payouts.

> costs him cash this is fair and proper, but when it costs only fore-thought, open-mindedness, or time, the issue is at least debatable."
>
> "… a system of conservation based solely on economic self interest is hopelessly lopsided. It tends to ignore, and thus virtually to eliminate, many elements in the land community that lack commercial value…" .

A model should address these possibilities: both the idea of an environmental ethic, and the possibility that payments might degrade this ethic.

As people work on conservation activities, including those activities for which they are paid, or at which they make a living, they can become more environmentally aware. If we plant trees, we develop a new appreciation for trees.[10]

An environmental ethic can increase the likelihood that resource users will switch to environmentally friendly activities. In the model, a strong realized environmental ethic causes a downward adjustment of the profitability needed to switch to environmentally friendly uses. This switchover is also a factor which can enhance environmental ethic.

If both environmental status and the community's environmental ethic are high, then there will be less need for payments for environmental services, and these payments could be reduced. Such a reduction may not always be desirable, particularly if resource users are still in financial difficulty and ecosystem services clients are able to pay (Figure 4).

In the model, up to some point, payments for environmental services enhance the underlying environmental ethic. If payments are excessive there is a degradation of the environmental ethic based on the idea that payments become viewed merely as a source of income, rather than a reward for pride in one's environment. Similarly penalty payments are accepted as reasonable unless they become excessive. Within the model an environmental ethic is considered as a community quality composed of the many individuals' views.[11]

Once payments for environmental services are made they come to be expected. If payments exceed what is expected, then the expected amount will increase, other things being equal. In the model, increased expectations of payment are tempered by the level of environmentalism. If environmentalism is high then the expectation of payments will be less (Figure 5).

In future versions it may be interesting to investigate other issues known to affect the desire for payments. Among these are: the awareness of possible payments, the question of who else is receiving payments nearby and in distant regions, and the awareness that other people benefit from the resource by receiving environmental services .

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[10] Cooperative environmental actions also build a communal environmental awareness which is well illustrated by the work of Mary Dudley in Idaho, Jane Goodall's global roots and shoots initiative, and Nobel prize winner Wangari Maathai's Green Belt Movement in Kenya (Leigh 2005).

[11] It would certainly be interesting to build a model with several sub-classes of users each with possible sub-classes of perceptions.

Expectation of payment is one factor influencing the level of payouts made for environmentally friendly uses. Payouts are also influenced by the amount of money being collected (from recipients of environmental services and from penalty payments on damaging land uses) and by the need for environmental improvement (Figure 6).

The underlying environmental ethic is tempered by reality in the form of financial need so that the *realized environmental ethic* may be less than the underlying values that people have. Realized environmental ethic will increase as income increases until it matches the underlying ethic. Such increases in income can be derived from both damaging or environmentally friendly uses. Thus perhaps it might be possible to have a fully realized environmental ethic even though the uses being applied to the environment are damaging (Figure 7) although presumably, in that case, the land use will subsequently change.

Table 1. Some model constants discussed in connection with initial tests of the model. Components marked in bold were changed as described in the text.

Model Component	Default Value	Units	Description
profitability of sustainable activities	100	$/(Year*units)	Normal profitability of environmentally friendly uses prior to taking into account payments for environmental services
basic profitability of damaging uses	135	$/(Year*units)	The basic profitability of damaging uses prior to considering any penalties
fraction change in profit needed	0.1	Dmnl	The baseline change in profit required in order for switches to another use type to be initiated
time needed to switch to damaging activities	5	Year	The amount of time needed to switch to damaging activities
time needed to switch to friendly activities	5	Year	The amount of time needed to switch from damaging to friendly activities
desired penalty fraction of lost payments charged	0.25	Dmnl	Fraction of lost environmental services that should be recovered from resource users carrying out damaging activities
actual penalty rate as fraction of damaging activity profitability	0.1	Dmnl	Maximum fractional charge recovered based on profitability of damaging activities
fraction of ecosystem services value to be paid	0.25	Dmnl	The fraction of the value of ecosystem services that is paid back to resource users who are using environmentally friendly activities
initial ecosystem status	30	env integrity	The initial value of the environmental integrity of the ecosystem in question (maximum is 100)
time needed for natural ecosystem change	10	Year	The mean time needed for ecosystem recovery
initial ethic	0.5	environmentalism	The initial value of environmental ethic

Preliminary model outcomes

Preliminary comments

Here it is interesting to note some of the peculiarities of this model, and perhaps of systems dealing with payments for environmental services in the real world. Recall that, in the model, payouts are funded based on the value of environmental services actually created, and penalties are based on environmental services actually lost. The amount that each resource use will receive or pay (i.e., payments per unit of the resource under each use type) will depend not only on the amount of ecosystem services provided or lost, but also on the number of units within which such activity is carried out.

As more of the ecosystem is switched to eco-friendly uses, ecosystem status increases toward a maximum. Ecosystem benefits, and associated payments, will approach a maximum as well. Consequently payouts provided per unit will decline lowering the profitability per friendly unit.

Also, because penalty payments charged for damaging activities make up a portion of the funds paid back to users carrying out friendly activities, there is an increase in the profitability of friendly activities when the profitability of damaging activities increases.

So the use of penalty payments which are charged as a fraction of damaging use profitability helps environmentally friendly uses remain competitive because any increase in the profitability of damaging uses automatically increases the payments supplementing friendly uses. However, time lags make these payment transfers less helpful than we might expect (see examples below).

This situation also highlights some differences that may exist between the model and the real world, particularly in the way that payments are funded and paid. In the model payments, and penalties, are based on known values for ecosystem services provided or lost. In the real world, although the idea is the same, actual implementation is much more difficult. Often ecosystem services are based on a flat payment per resource unit (for example per hectare of land) on which eco-friendly uses are being applied. The value of the services provided is generally a long-term gross estimate of environmental services provided, and in many cases the payments provided may not be linked to specific measured ecosystem services at all.

Also of interest is the fact that some ecosystem services may persist after the ecosystem has been degraded so that a dropping number of eco-friendly users can benefit from payments for environmental services due to environmental status in the recent past. This situation can result in a rise in profitability of eco-friendly uses even as the extent of these uses declines.[12]

Typical outcomes

Some basic model outcomes for 5 model runs are presented in Figure 8**.** These runs include situations where no payments for environmental services are made and no

[12] An additional, and un-modeled, effect is that some environmental services may increase in value as they become scarce.

penalties for damaging uses are collected, but where the relative profitability of friendly and damaging resource uses differ and are constant (runs 1-3). The outcome here is as expected. If one use is significantly more profitable than the other then that use will dominate the ecosystem within a few years.

Run 4 (which uses the values in Table 1) represents a situation where both payments and penalties are used, but where these are insufficient to push the ecosystem toward overall sustainable uses. The result of this run is similar to that in run 1 except that there are payments made and these cost money. Consequently the actual total benefit to resource users is diminished slightly because not all penalties collected are necessarily paid out.[13] With default (Table 1) settings the model is in approximate equilibrium with each type of use occupying about 50% of an ecosystem degraded to about 30% of its maximum status. Even though some payments for environmental services and penalties are being paid, these payments are insufficient to increase the profitability of eco-friendly uses sufficiently above that of damaging uses.

Run 5 represents the same situation as run 4 but includes a plus or minus 10%, pink noise, variability around the profitability of damaging activities. Run 5 represents only one of many possible outcomes where profitability varies over time. One challenge in designing systems which use payments for environmental services to maintain environmental integrity is to determine what payments and penalty policies will work best, and at reasonable cost, when the profitability of possible damaging (and/or eco-friendly) resource uses vary.

Note that even if only some minimal level of payments are made, the number of users opting for eco-friendly uses will drop until the remaining payment per unit is sufficient to prevent additional switching to damaging uses. Because there is a constant natural renewal of the environment, even when there is no sustainable use there is still some residual level of environmental services for which a payment could be made. Nevertheless, if no payments are made, and damaging use profitability is sufficiently high, all users will switch to damaging uses.

A more typical expectation from a system using payments for environmental services is that presented in Figure 9. In this case payments for environmental services have been raised sufficiently to raise the profitability of eco-friendly uses to the point where that use becomes dominant and ecosystem services increase. In this example the higher profitability of damaging uses is offset by a 10% tax on those uses plus payments for eco-friendly use funded by the tax plus a payment from ecosystem services beneficiaries amounting to 60% of the value of those services.[14]

Ultimately, in the model, increasing ecosystem services decrease the need for payments. In the real world such feedback may not be considered (and it can be turned off in the model). But since people paying for environmental services may also be poor, this sort of feedback may be important in some systems. That is: as the ecosystem approaches full

[13] Recall that payouts are determined by funds collected but also by expectation and environmental need (Figure 6).

[14] Although I have included both *annual value per ecosystem benefit*, and *fraction of ecosystem services value charged to recipients* in the model changing either of these has the same effect in the model.

functionality, payments for services could be lowered. The argument here is that the purpose of the payments is to get the ecosystem back to its fully functioning state.

Although the example shown in Figure 9 leads to a recovered ecosystem, if profitability fluctuates we find that there may still be periods of switchover to damaging uses (Figure 10). This switching occurs even though there is a percentage penalty tax on damaging uses which helps to fund friendly uses. As the level of damaging use increases the penalty tax increases providing more funds to raise payments for friendly uses. Also, as friendly uses start to decline the payout available is divided among fewer resource units which also increase profitability of friendly uses. Nevertheless these increases occur too slowly to prevent a partial collapse of the system toward damaging uses.

While raising the payments could solve this problem, we also want to avoid making payments excessive, particularly in cases where charging for the ecosystem services in question, e.g. clean water, might be a politically sensitive question (Anon 2005).

Raising penalty taxes may be another option, but this can cause other problems if profitability fluctuates sufficiently to cause resource use changes. Problems occur if penalties provide a large portion of the funds from which payouts to friendly users are made. As damaging use diminishes, the funds providing payouts to friendly uses will also diminish, potentially lowering the profitability of friendly uses unless other sources of funds are available. The amount of this decrease will depend on the fraction of payment that is sourced from penalties. During periods of high profitability of damaging use, the system can revert to a degraded ecosystem (Figure 11), and recovery from that can take several years. Some detail of these delays is illustrated in Figure 12. Some of these delays can be overcome by adjusting penalty payments downward as the ecosystem recovers so that as the ecosystem recovers penalty payments play a smaller share of payouts (Figure 13) but this is not always successful.

It appears reasonable to base payouts on penalty payments because feedback then automatically increases eco-friendly profitability as damaging profitability increases. However delays prevent this approach from being 100% effective. This is probably also true in the real world: by the time we see damaging uses on the ground it is too late to take action. There is a need to predict the switchover prior to it happening, and to take actions which will more rapidly make friendly options more attractive in the face of rising damaging use profitability.

Seemingly, if we wish to use a payment system to favor eco-friendly uses without over-taxing the recipients of ecosystem services then a mixture of penalties and payouts might be appropriate. Penalty payments are useful for moving the system away from damaging use, but at the point where eco-friendly uses become dominant the role of penalty payments in funding payouts needs to be decreased and the role of payments for environmental services increased.[15] This also makes sense since we cannot charge fees

[15] The role of penalties is not widely discussed in the payments for environmental services literature. This may be because this literature deals primarily with situations where resource users are assumed to be less financially secure than the recipients of environmental services. However this is not always the case. One counter example would be the situation where holiday villas of the wealthy are constructed in a formerly forested watershed, causing flooding which affects poor downstream farming and urban communities. In

for environmental services in cases where the ecosystem has already been degraded, and ecosystem services are minimal. In such a case our remaining option is to use penalty payments on damaging uses (or use funding from other sources). Also, we can not charge for damages where damages are no longer occurring, so as the ecosystem recovers charges for ecosystem services should provide a larger share of the costs of payouts for eco-friendly use.

Environmental ethic plays a role in all of the above examples by making the switchover to eco-friendly uses occur at a lower economic threshold. The growing eco-friendly use then reinforces ethic. We see this effect more directly in a simple example where environmental ethic is increased by 20% for a five year period after which the increase is stopped. This might be similar to the effect of an environmental "awareness program" carried out in local communities. This change in ethic is sufficient to cause a long term switchover to eco-friendly uses, but such change can only occur when profitability of the two uses is similar (Figure 14). This circumstance might be created via the use of payouts for environmental services.

More importantly, we may wish to investigate the role of payments introduced into a system that has none. This is illustrated in Figure 15. Here a balanced system is upset when damaging use profitability starts to increase. A system of payments is initiated a few years later to prevent further destruction. Although there is a temporary diminishing of ethic caused by the implementation of payments where none were previously used, this effect is quickly overpowered by the (assumed) enhancement of ethic caused by the long period of switch-over to eco-friendly uses.

Conclusions and Ideas for Further Investigation

Payments for environmental services present a challenging and interesting subject which can be addressed with system dynamics modeling. The model presented here may differ somewhat from the real world, particularly in that funding for payments in the model are linked to environmental services actually provided, whereas in the real-world such links may be less well-defined. Nevertheless the concept of payments for environmental services requires such links.

It is important to remember that we wish to find policies that will adjust the system outcome toward our goals regardless, within reason, of what happens. In this case we desire policies that protect and restore ecosystem status regardless of higher profitability of damaging uses. It appears that, under some circumstances, this goal may be attained through a system of payments for environmental services, and reaching the goal is more likely if policies also maintain or enhance environmental ethic.

Payouts can tilt the system toward ecologically friendly uses. Penalties on damaging uses can help fund payouts and provide an additional restraint on damaging uses. If either of these is high then eco-friendly uses will dominate. That is, even with penalties only, and no payouts, the system will move to 100% friendly uses, although this results in a lower overall income. Typically a system of payments for environmental services can only

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such a case it would seem reasonable that taxes on villa construction could be used to supplement income of farm and forest activities and discourage sale of such land for further villa construction.

work when the difference in profitability between friendly and damaging uses is relatively small and the payment system is sufficient to bridge that gap.

Under some circumstances temporary crashes occur when profitability varies, because the payment system is slow to respond compared to the changeover to damaging use. In this model, payments are based largely on the value of services being created and penalties on the amount of services that have been lost. Because changes in the level of environmental services lag behind change in the resource use pattern, changes in payout and penalty amounts are also delayed. In some case this delay is sufficient to allow damaging uses to rise.

Overall, the model provides useful insights into this type of system, but future versions may need to address some additional issues. In the real world the adoption of one particular resource use type may accelerate its own adoption. For example if some farmers switch to growing chilies then other farmers may also do that as local marketing capacity for chilies improves. The model presented here does not (yet) allow that sort of influence.

It is also possible that the value of ecosystem services will decrease as those services increase. Although the model has an (optional) feedback similar to this, decreasing payments as the environment recovers, there is no specific decrease in value of services provided as those services increase. One example might be the marketing of products from the wildland gardens (Janzen 1998). If large areas are made available as wildland gardens, the value of each "biodiversity product" might decrease. On the other hand, if demand for such biodiversity products increased as the products became more widely known, then the value of those products might increase. This type of effect will depend on the specific case being examined.

The model also does not address any influence resulting from the resource users' knowledge that they are providing a useful additional service. Formal or informal community recognition of the environmental services provided may influence environmental ethic. Without specific knowledge it is difficult to include this relationship in the model. Perhaps when environmental services are very high they are taken for granted. Perhaps if the ecosystem is completely degraded, the value the community places on environmental services will be zero. It is possible that the costs of replacing lost environmental services influences a community's awareness of that lost value. Only if the community is aware that the environment can provide such services will they support environmental causes which might support resource users' better management of the ecosystem.

The role of environmental ethic is included in the model primarily as an effect which increases the likelihood of switching to eco-friendly uses. That is, it lowers the threshold for switching to friendly uses. While this approach may be reasonable for a variety of cases, it is not always correct to assume that profitability is the primary goal of resource users. In a study in the rural USA, only 23.5% of farmers who received payments for environmental services wanted to maximize profits. Soil and water conservation was the most important goal of 14%. Other desires included maintaining a rural lifestyle (23.5%) and ensuring that the farm would be passed on to family members (20.6%) (Lant *et al* 2001). Clearly, the role of profitability is considerably lower in cases where

environmentalism and other factors dominate resource decisions. Thus the model presented here is limited to cases where profitability is a major concern, but that concern is influenced by environmental ethic. Nevertheless, in cases like that cited above, it may be that payments allow resource users to shift their goals away from purely economic considerations.

While the model can illustrate how ethic might interact with payments, it is only through fairly tricky field inquiries that the way in which real people respond to payments can be determined. Another issue is the role of payments vs the concept that environmental services are a common good (or even a human right… e.g. clean water and clean air). A model cannot answer these questions.

Explicit direct payments for conservation performance are thought to be more effective in reaching conservation goals than indirect approaches promoting "sustainable development" (Ferraro 2001; Ferraro and Kiss 2002). Payments for environmental services are closer to direct payments than are other interventions such as those which attempt to develop alternate livelihoods. Like direct payments, which are linked to attainment of specific conservation goals that the resource owner must meet, payments for environmental services are linked to the provision of certain environmental services. While direct payments require an external source of funding, the selling of environmental services provides funding for a payments program. In general, these two concepts are similar, differing in the type of service provided, pure conservation vs. useable services, and who pays for them.

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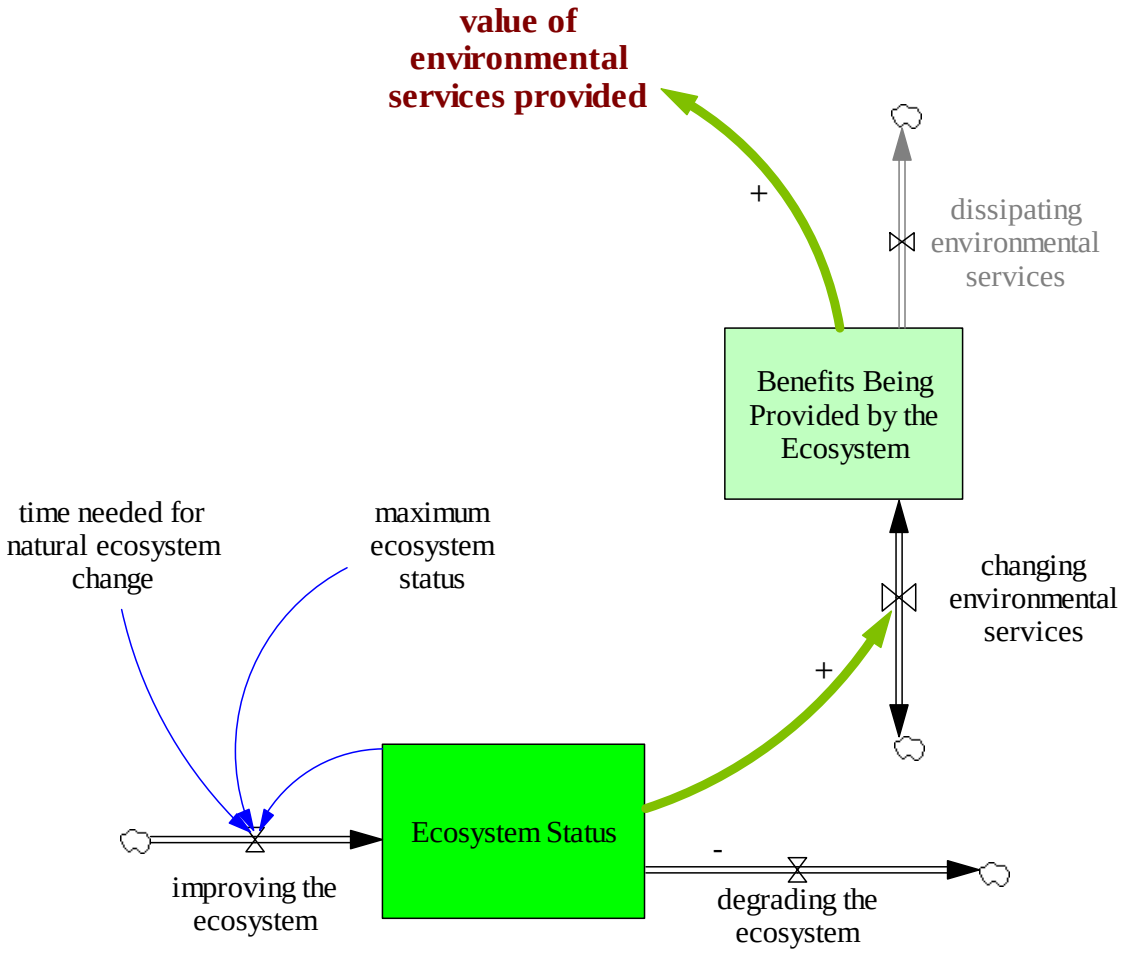


Figure 1. The relationship between ecosystem status and benefits provided by the ecosystem (Note: All figures omit some model components).

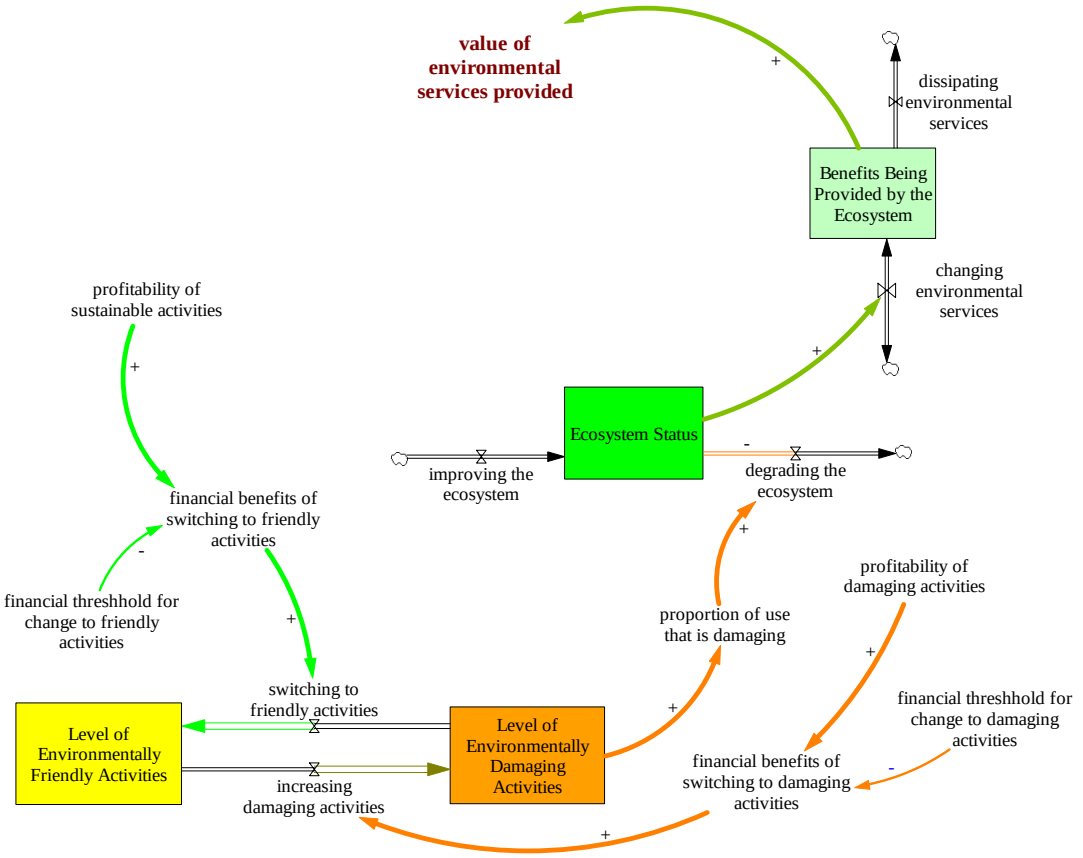


Figure 2. The profitability of sustainable and damaging activities influences the extent to which they are carried out. Environmental degradation will increase as the level of damaging activities increases (Note: From a modeling perspective the two stocks representing the activities could be represented as a single stock).

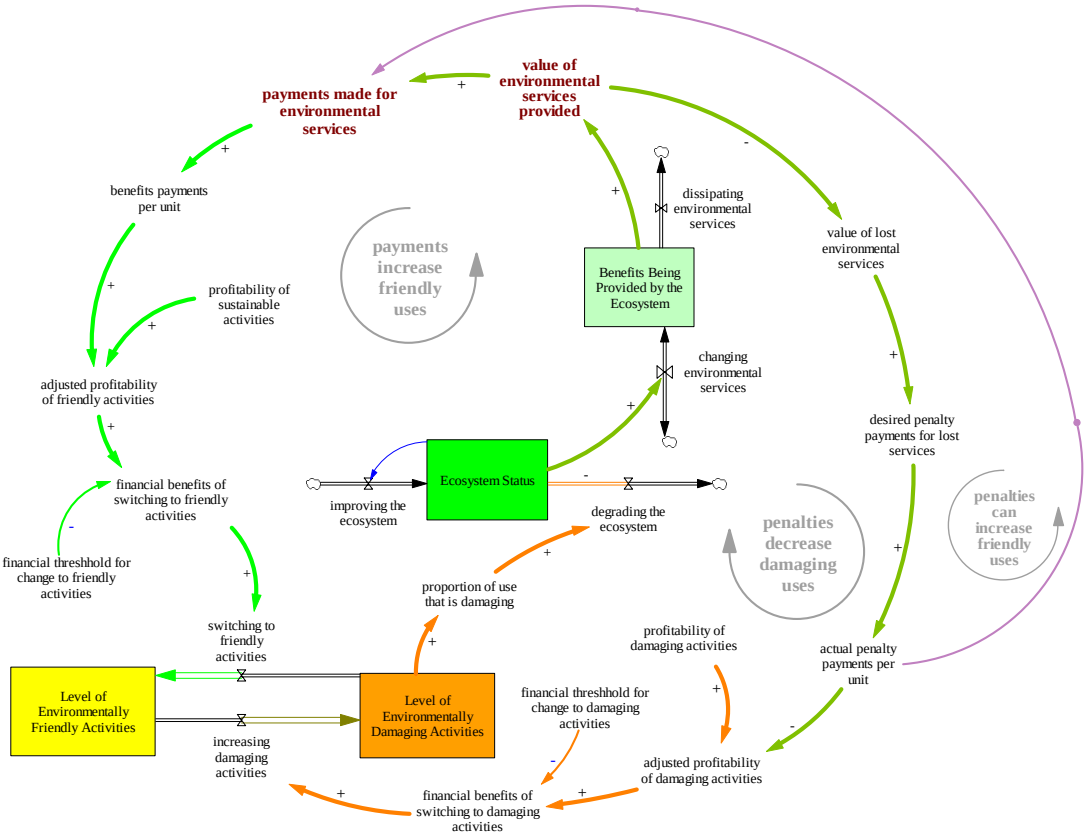


Figure 3. Payments for environmental services can be used to increase profitability of environmentally friendly uses, making them more competitive with damaging uses. Penalty payments can make damaging uses less profitable, and such payments can be used to partially fund payments made for environmental services as well. Note that payments for environmental services are not necessarily equal to the full value of environmental services provided.

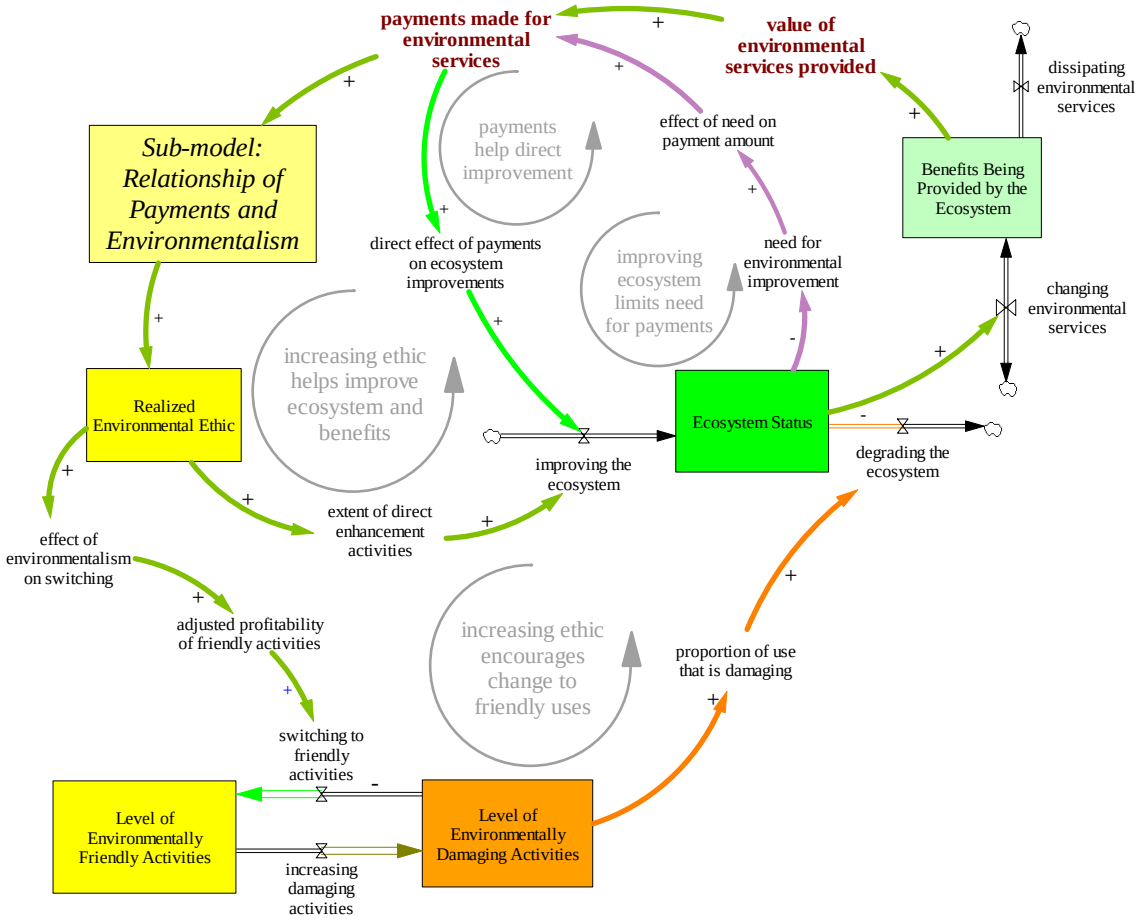


Figure 4. An increased environmental ethic will increase the switchover rate to environmentally friendly activities, and can also enhance direct improvements to the ecosystem. Payments for environmental services can also directly enhance ecosystem improvements, but improved ecosystem status will diminish the necessity of these payments if the primary intent is to maintain a healthy ecosystem.

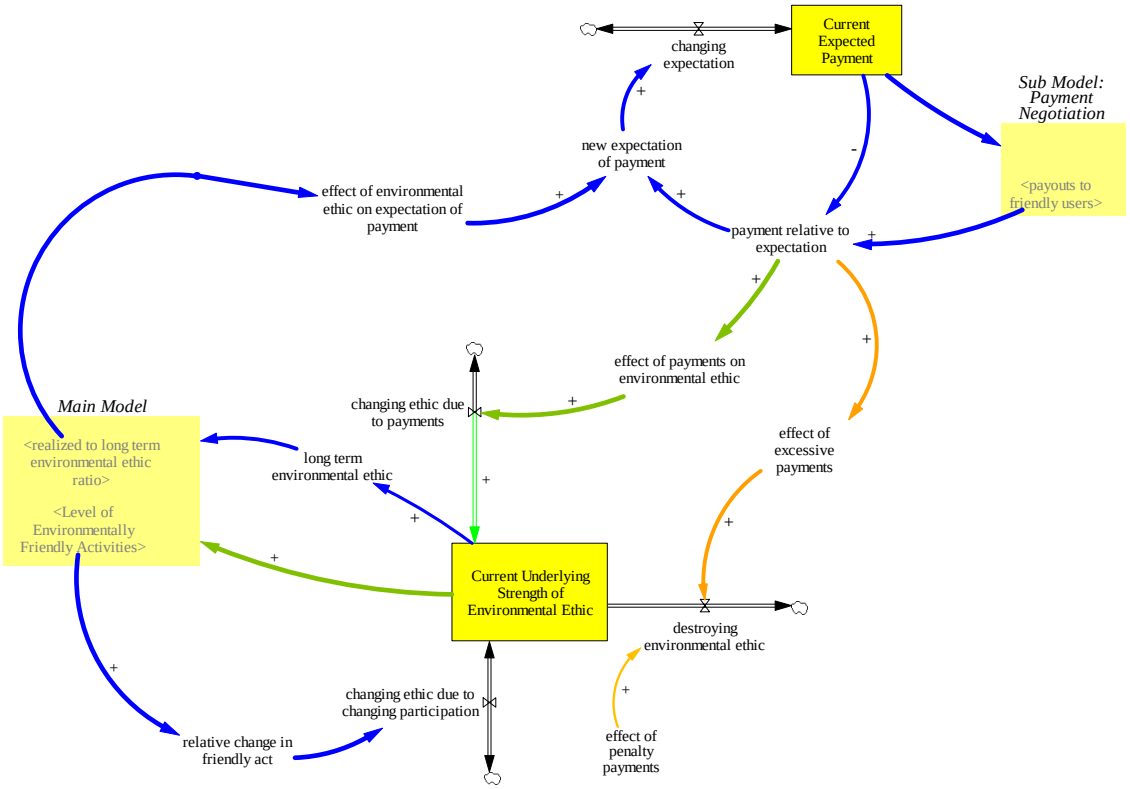


Figure 5. Possible relationships between payments for environmental services and environmental ethic. Up to some point payments will enhance environmental ethic, but excessive payments will destroy it. The point at which this switchover will occur is dependent on expected payment which is influenced by the level of recent payments, as well as on the level of environmental ethic. Feedback from expected payment to actual payments represents negotiations between resource users and those representing the recipients of ecosystem services. Environmental ethic is also influenced by relative changes in the implementation of environmentally friendly uses.

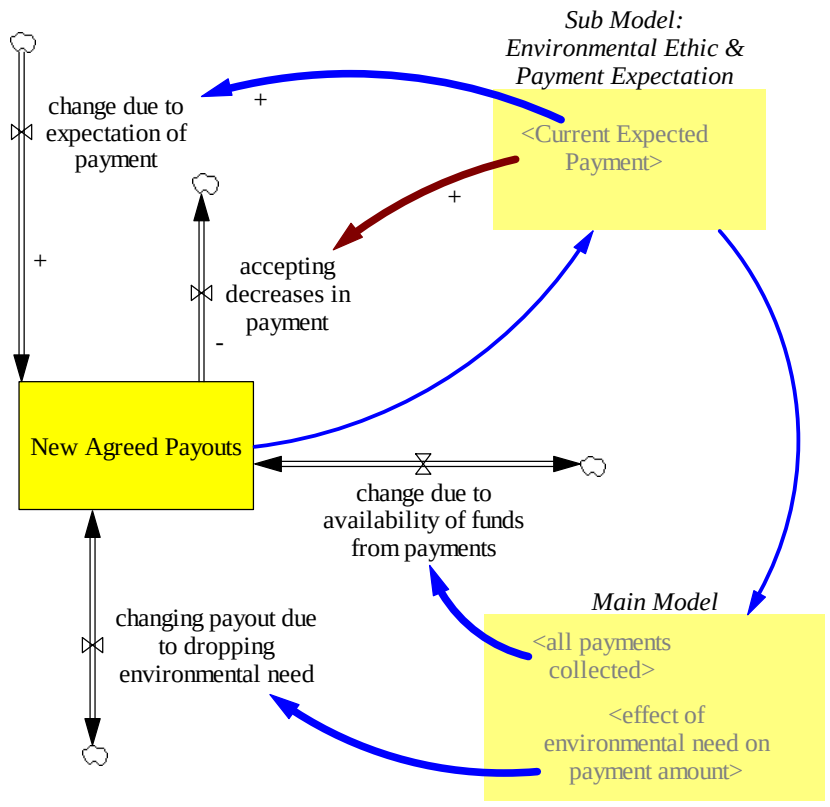


Figure 6. New agreed payouts to resource users employing environmentally friendly approaches are dependent on the expected level of payment, the availability of funding, and the level of need for ecosystem improvements.

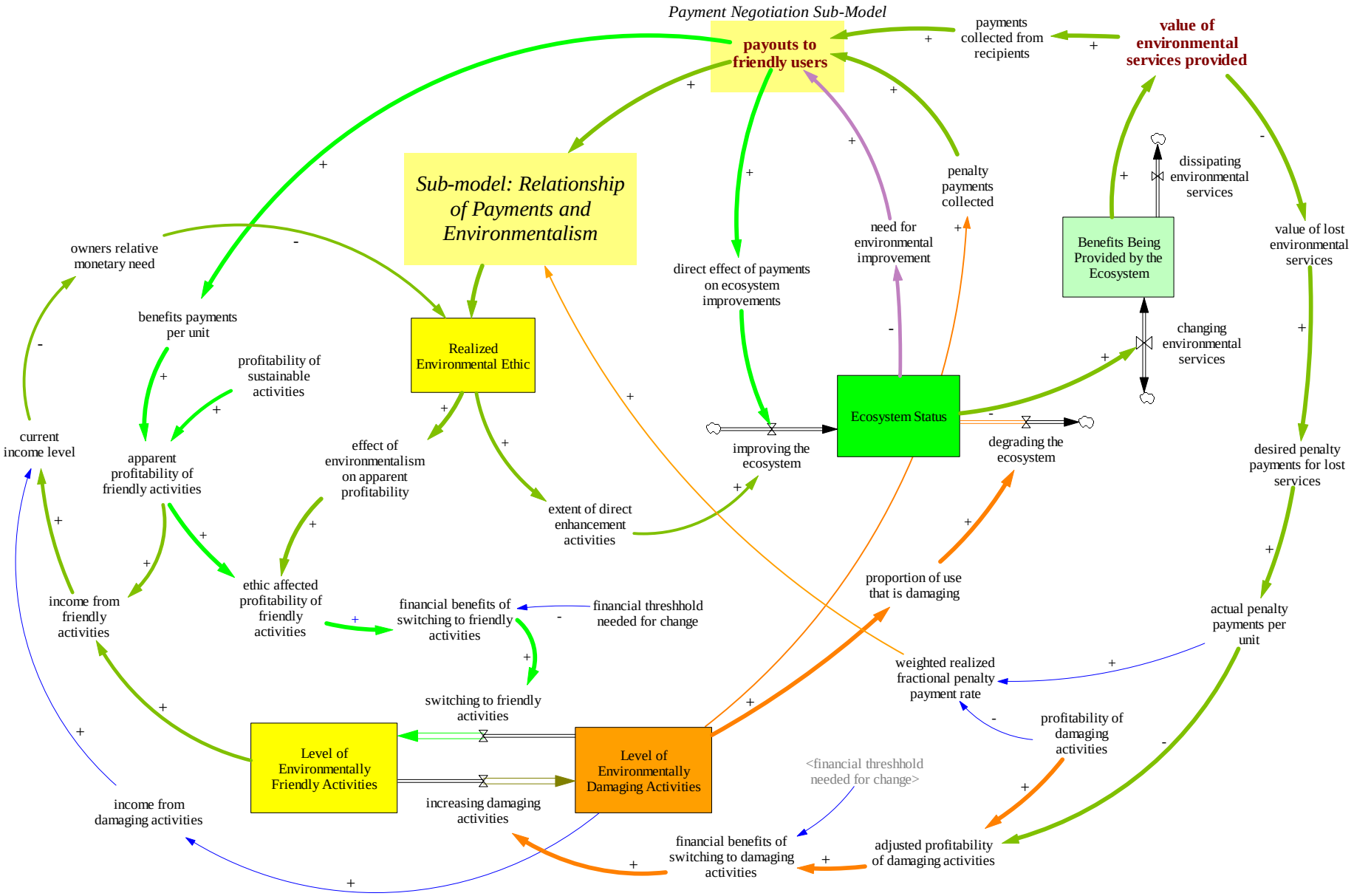


Figure 7. A causal loop diagram of the main model. See figure 5 for details of the portion of the model describing the relationship between payments and environmentalism.

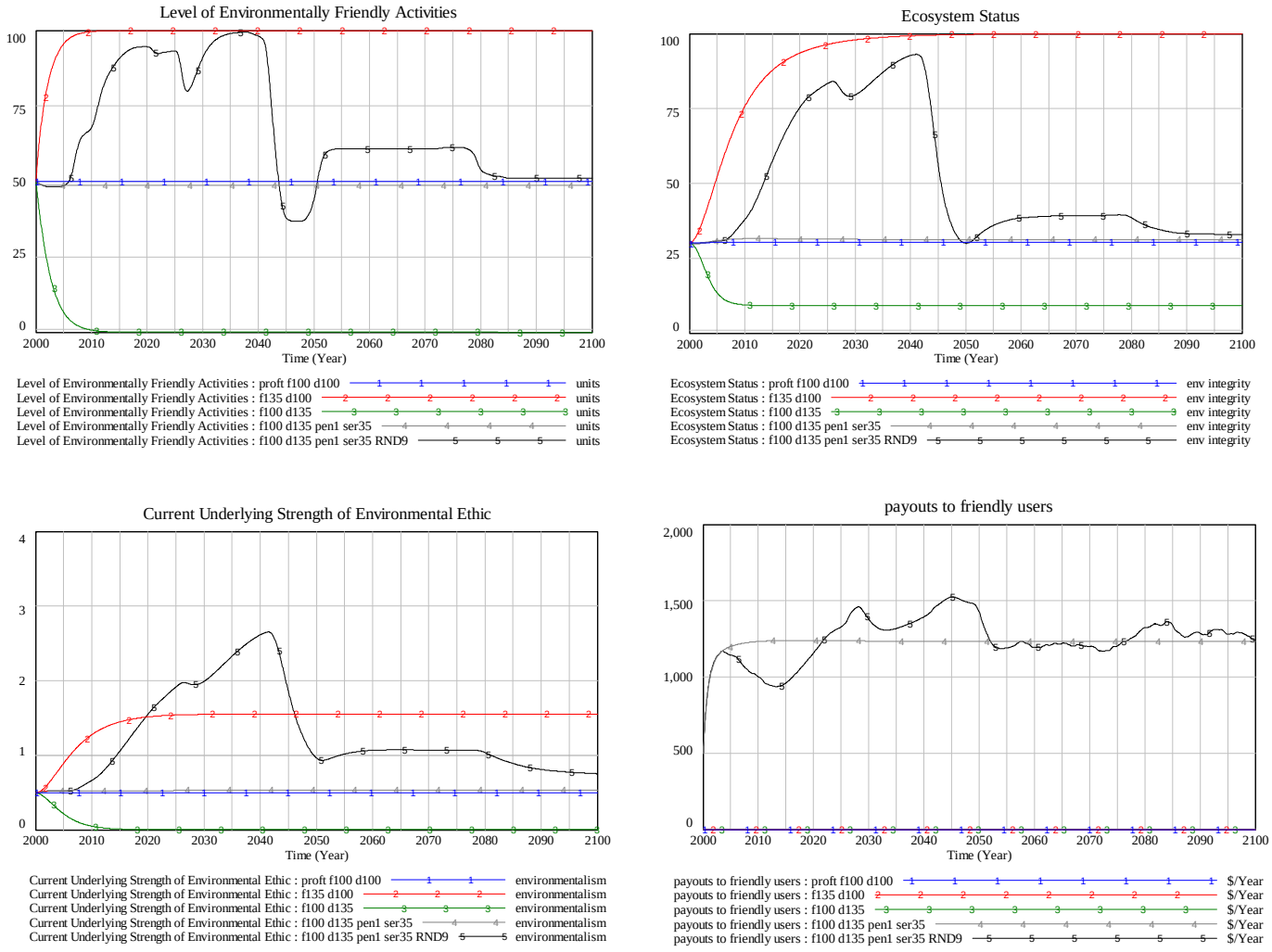


Figure 8. Results from some basic runs of the model.

Runs 1-3: No payments or penalties.

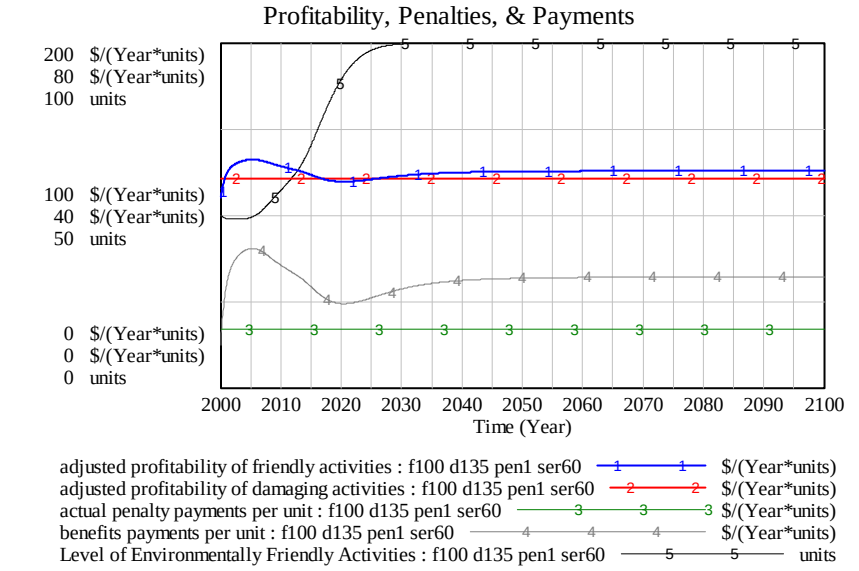
Run 1: both uses have a profitability of 100 $/unit.
Run 2: Profitability differs: friendly 135 $/unit, unfriendly 100 $/unit
Run 3: Profitability differs: friendly 100 $/unit, unfriendly 135 $/unit

Run 4-5: Payments to friendly users are expected.

Payments are funded from charge of 25% of ecosystem services provided plus from a penalty charge of 10% of basic damaging use profitability.

Profitability differs: friendly 100 $/unit, unfriendly 135 $/unit.

Run 4: No other external influence on profitability.
Run 5: Profitability of damaging use with one possible stream of random normal (pink noise) with a standard error of +/- 10%. (Sterman 2000)



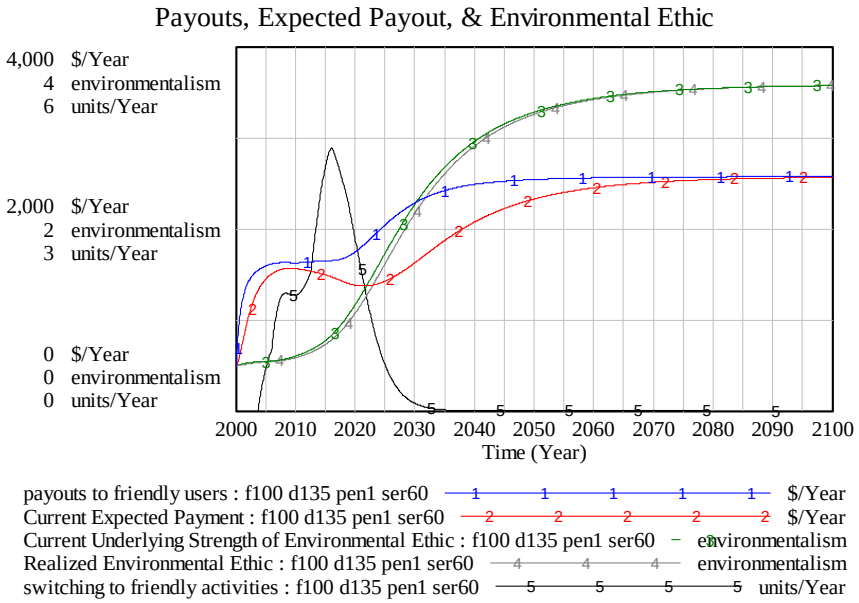


Figure 9. This example is similar to run 4 except that the fraction of environmental services value that is recovered in the form of payments is raised to 0.60. This is sufficient to raise the profitability of eco-friendly uses so that there is more switchover to that use. Higher damaging use profitability is offset by a penalty and friendly use profitability is supplemented with a payment partly funded with penalty payments. As friendly uses increase the total payments are spread over more users and profitability drops somewhat, but this is offset by an increase in environmental services. Collection of payments is later lowered as need for environmental improvement diminishes.

Growth in environmental ethic (lines 3 + 4 lower fig) is increased by payments somewhat above expectations and by the switchover to environmentally friendly uses.

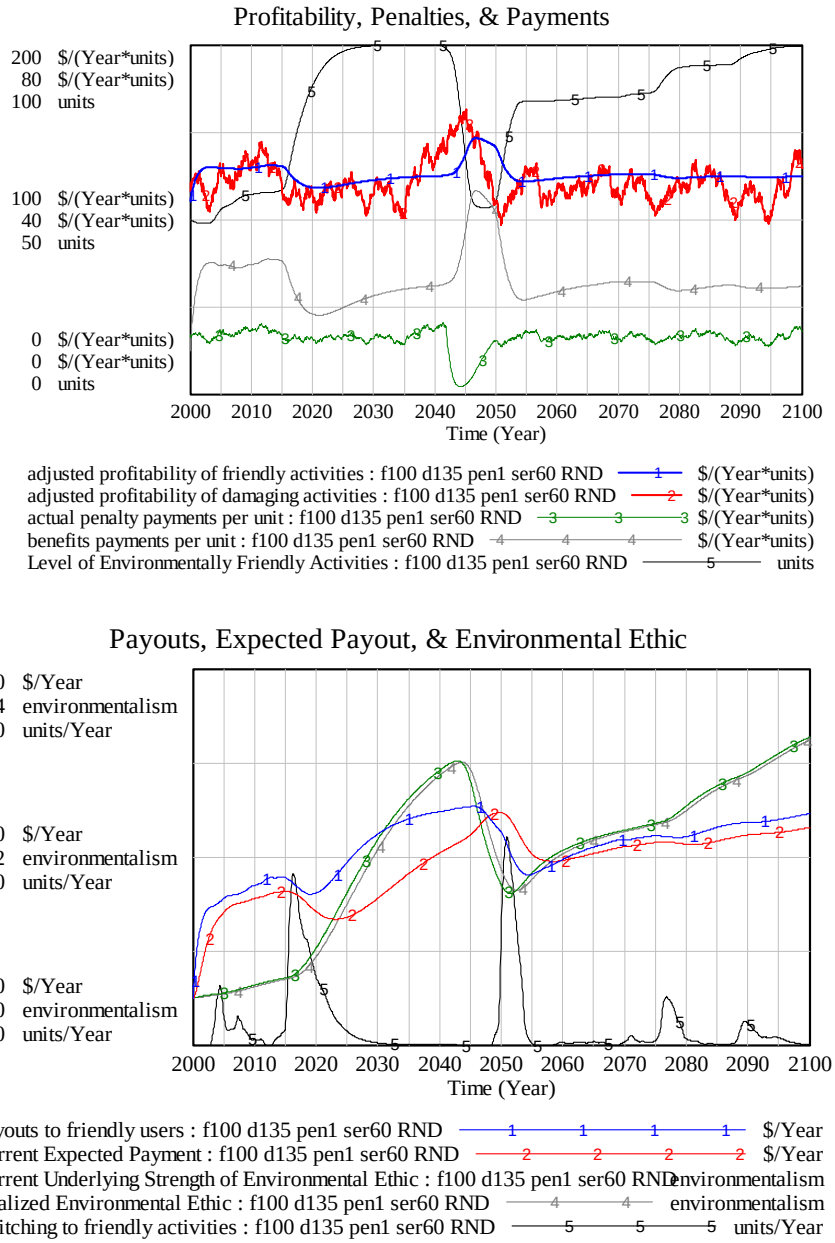
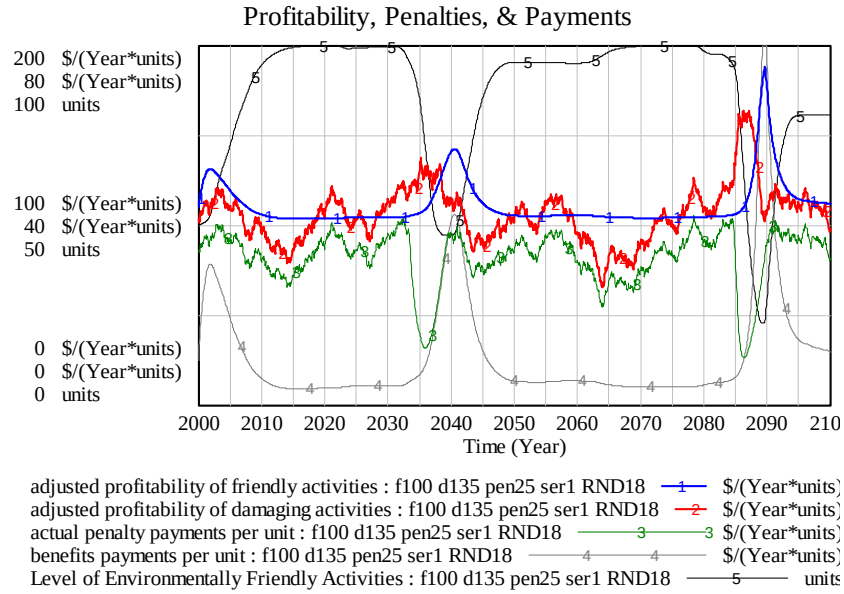


Figure 10. The outcome illustrated here results from the same settings as in Figure 9 but with an example random component added to damaging use profitability. When damaging use profitability remains high for several years the extent of that use increases. This occurs even though payouts compensate to increase friendly use profitability (upper graph lines 1+2, 2040 to 2055) . This situation fails to increase friendly use profitability quickly enough to prevent a decrease in overall environmental status. Profitability changes for two reasons: a) as damaging use increases fewer eco-friendly units share existing payouts, b) as damaging use increases tax penalties on damaging uses increase and contribute to higher payouts. Nevertheless these changes may occur too slowly to prevent the switch to damaging use and a drop in ecosystem status.



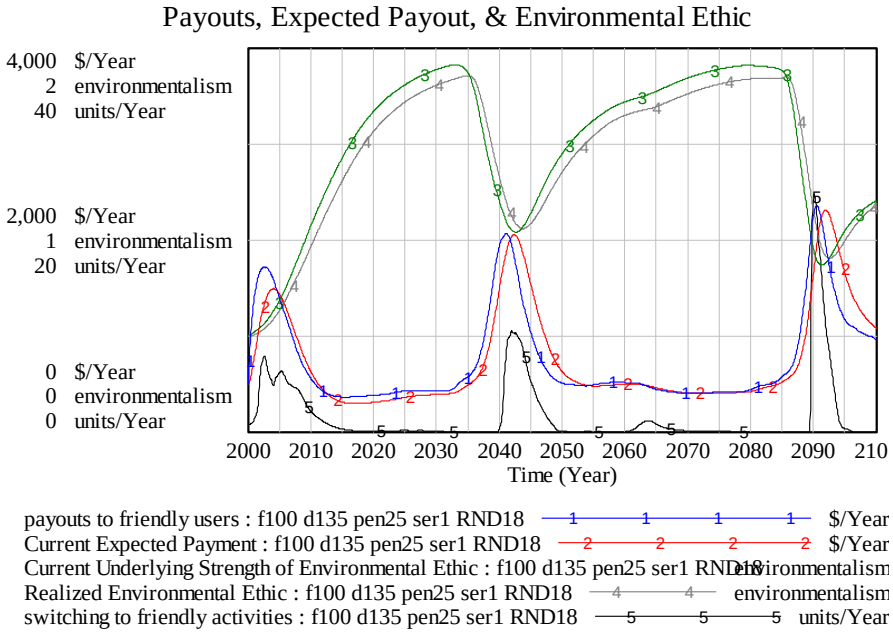


Figure 11. In this example payments made by recipients of environmental services are decreased to 10% of the value of services while the penalty rate paid by damaging uses is increased to 25% of damaging use profitability. As in other examples this money is then available for payments made for eco-friendly uses. A problem arises: as more use becomes eco-friendly there is less penalty money for making payments. Under those circumstances it is easier for the system to switch back to damaging uses if damaging use profitability rises due to external price changes. Also, as damaging use increases, penalties per unit drop at first because of lags in the causal connections leading to diminished ecosystem services.

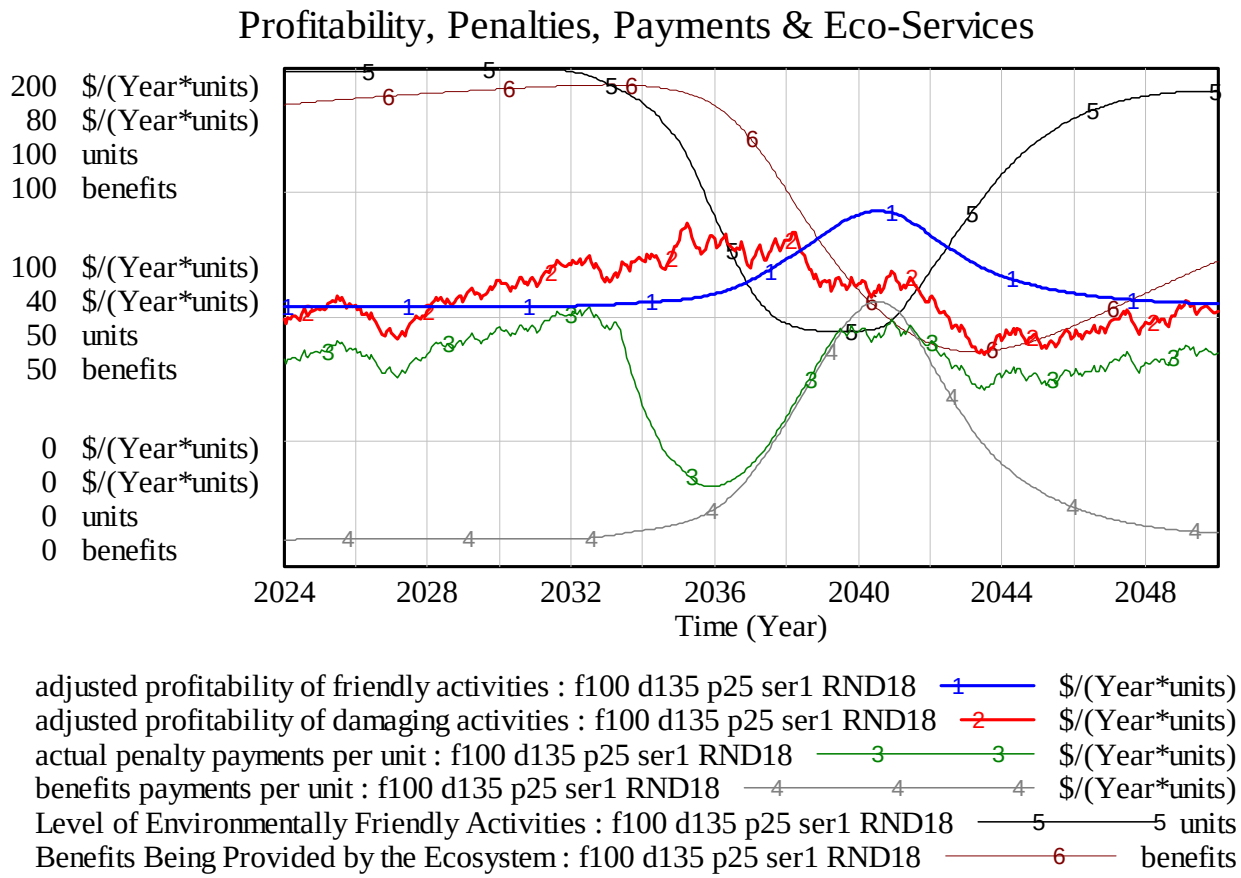


Figure 12. Detail from Figure 11 illustrating how, in the model, delays prevent the rapid readjustment of payments to support eco-friendly uses. Random price changes increase damaging use profitability (red line 2) above friendly use profitability (blue line 1) causing friendly use (area below line 5) to switch to damaging use (area above line 5). Benefits from the ecosystem (line 6) drops slowly so the value of lost ecosystem damage remains low while units of damaging use increase. This lowers penalty per damaging unit (line 3) allowing profitability of damaging use to remain higher than friendly use. As friendly use drops, payments received per unit (line 4) increase and this increase is eventually supplemented by rising penalty payments (line 3). These factors then push friendly use profitability above profitability of damaging use, and ecosystem benefits gradually recover.

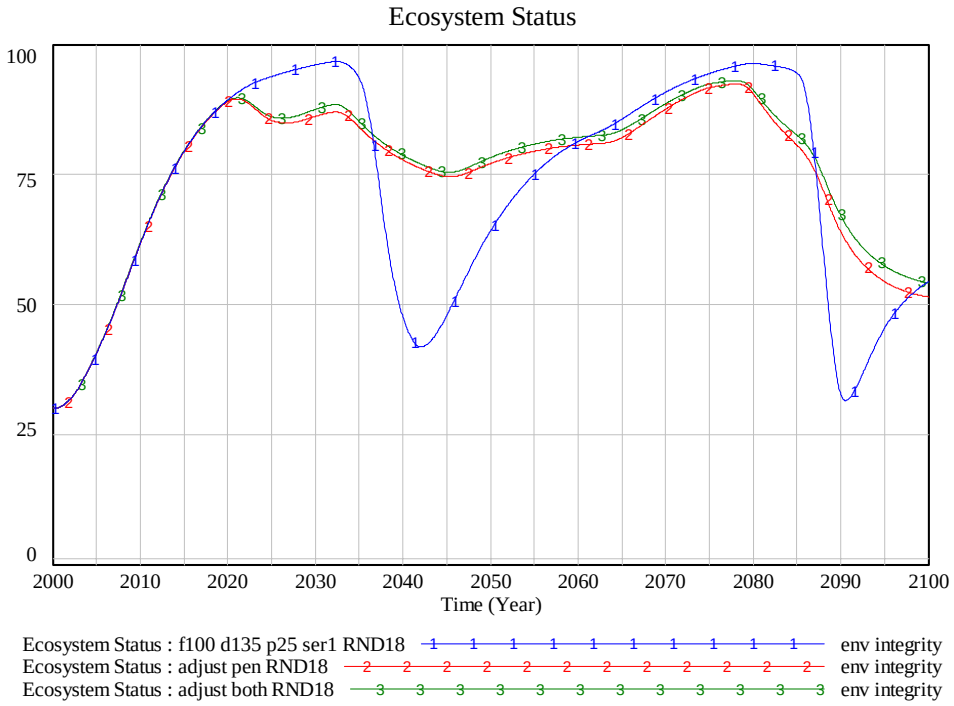


Figure 13. Lowering dependence on penalties as a source of payout funds as the ecosystem approaches full status can sometimes prevent system crashes. This is the same example as in the previous figure (blue line 1), also showing the result of lowering the penalty rate as the ecosystem nears full recovery (red line 2). The additional effect of maintaining payments as the ecosystem recovers (see page 10) is also shown (green line 3). Nevertheless, such "crashes" may be partly due to unrealistic assumptions in the model (compared to the real world). See text.

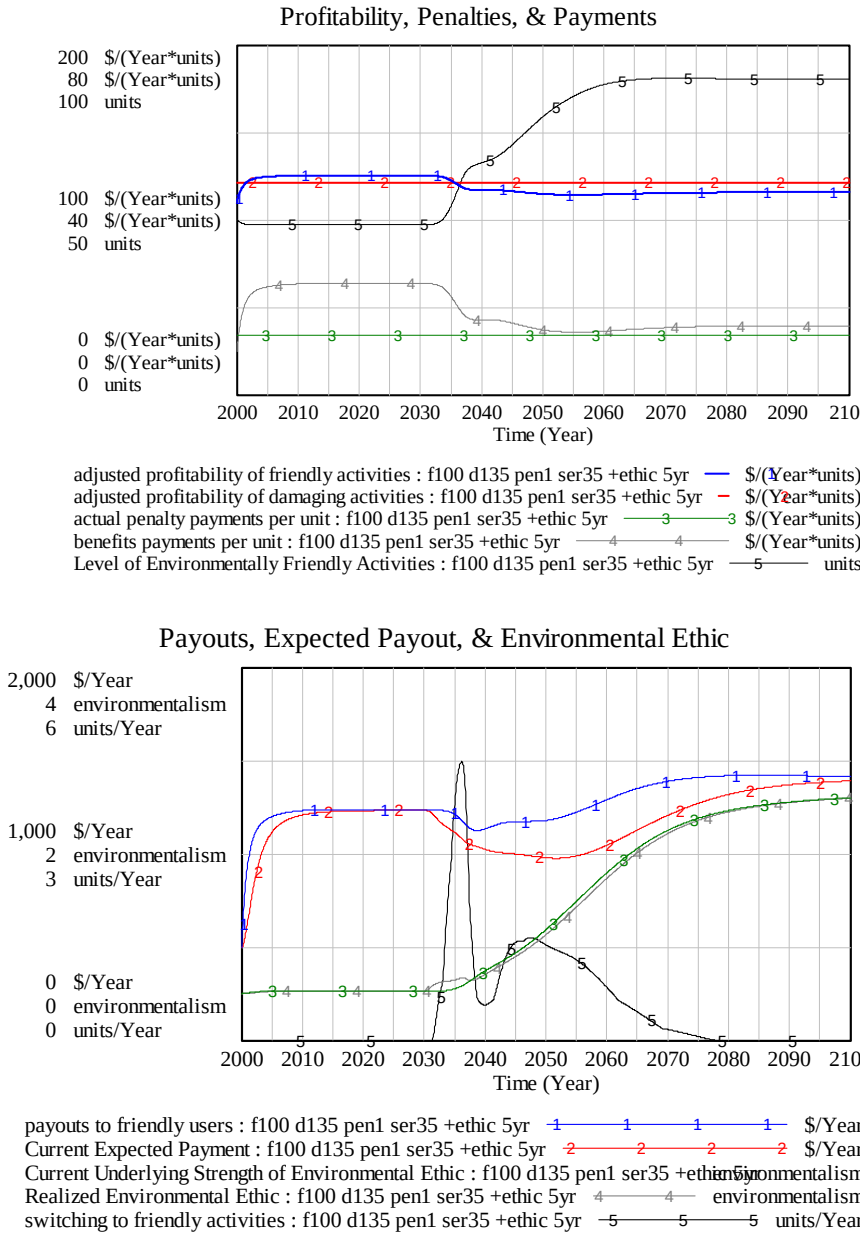


Figure 14. This simple test of temporarily boosting environmental ethic illustrates how a temporary boost in ethic could have a long term positive effect on the environment, and the services it provides. Here ethic was boosted by 20% (raising it from 0.5 to 0.6) during 2030 to 2035, with a 1 year phase in and out (line 4 lower figure). Under the starting circumstances this was sufficient to initiate a long term switch over to environmentally friendly uses. This effect can only occur if the profitabilities (including payments and penalties) of the two uses are similar.

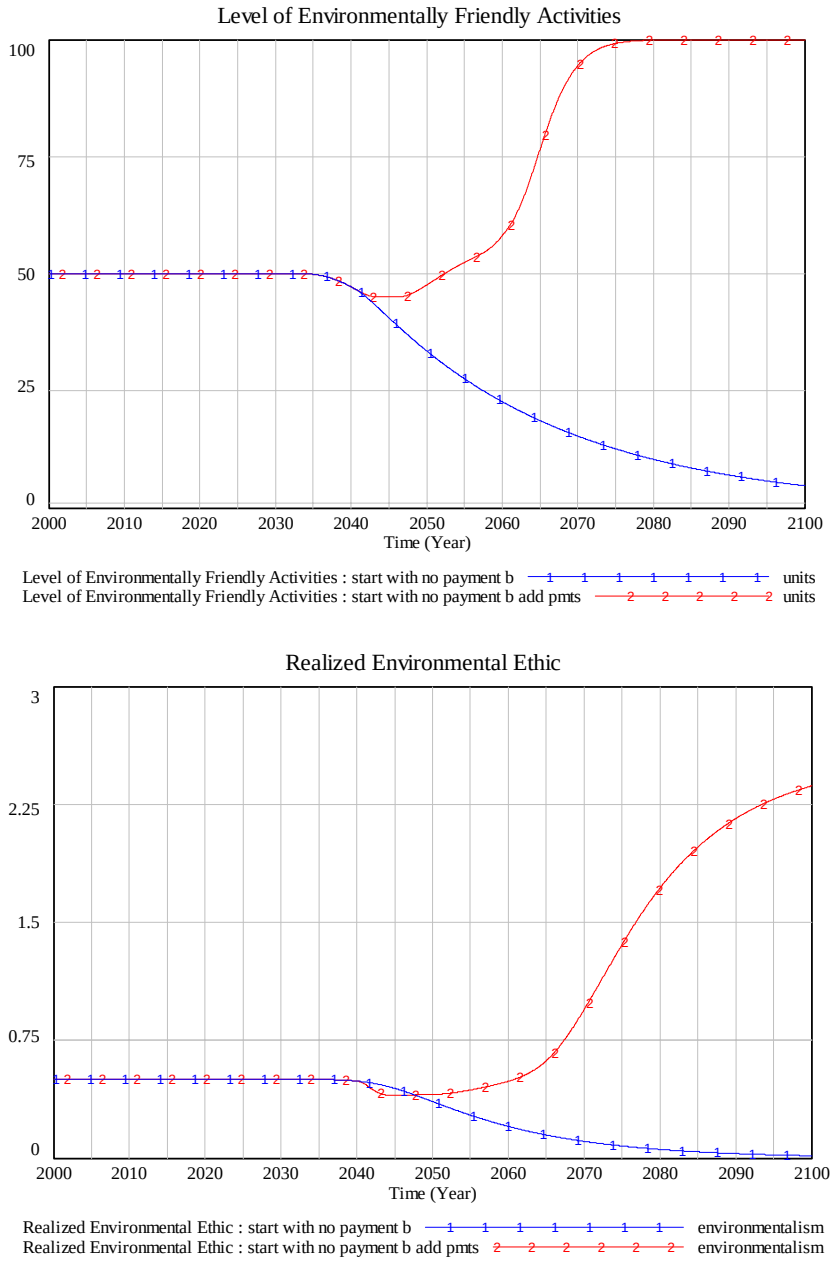


Figure 15. A declining ecosystem can be rescued by implementing a system of payments for environmental services. Blue lines (labeled 1) represent a case where profitability of damaging use increases from 135 to 160 $/unit/year from 2025 to 2040 with no system of payment implemented. The red lines (labeled 2) include payments for eco-services of 25% and penalties of 7% starting in 2040 and phased in over 5 years. Although not readily apparent here, initially payments cause a drop in environmental ethic of about 10% below the alternative of no payments, and this decrease lasts for a few years. Eventually the system recovers and ethic rebounds to significantly higher levels. The prime cause of this rebound is the, assumed, idea that switching to friendly uses also promotes environmental ethic.