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# Using environmental bonds to regulate the risks of GM crops: problems and prospects

**Siân MOONEY[1] and David GERARD[2]**

[1] Department of Agricultural and Applied Economics, P.O. Box 3354, University of Wyoming, Laramie, WY 82071, USA
[2] Center for the Study and Improvement of Regulation, Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA 15213, USA

**We examine the characteristics and limitations of the existing system of tort liability for addressing potential environmental damages from GM crops and consider whether environmental bonding could be used to address these risks. We find that in the case of GM crops, a bonding mechanism would complement some of the strengths of tort liability. Specifically, the bonding mechanism provides some protection against bankruptcy, and also shifts the burden of risk toward life science companies that develop the technology. These factors could encourage additional early research by life science firms. However, a bonding mechanism adds to the regulatory apparatus, and would likely increase administrative costs, over tort liability, for public and private parties. Nevertheless, an attractive possibility is that the cumulative outcomes of bonding, *e.g.,* shifting the risk burden, providing a measure of bankruptcy protection, and introducing an additional regulatory component, would mitigate some of the political and social objections to the environmental release of GM crops.**

**Keywords**: environmental bonding / tort liability / genetically modified crops / environmental regulation

## INTRODUCTION

There has been enormous growth in the use of biotechnology in food crop production. In 1999 approximately 100 million acres were planted to genetically modified (GM) crops, four times more than the area in 1997 (James, 1998). Despite this growing use, concerns have been raised in both the popular press (*e.g.*, Bonham, 1999) and scientific articles (Butler et al., 1999) regarding the potential for the widespread release of GM crops to result in environmental damage. In part, this view is fostered by concerns that GM crops are being released without adequate knowledge of their long term environmental impacts (Mander and Goldsmith, 1996; Butler et al., 1999) or, in some countries, without procedures to deal with environmental problems that may occur (Hruska and Lara Pavón, 1997). Currently the decision to release a GM crop within the United States (US) is based on an assessment of the risks of environmental, health and other damages (Mooney and Klein, 1999). Although a large research effort is underway to understand these risks, there are widely different opinions regarding the probability and magnitude of environmental damage.

Potential environmental damages from GM crops could be localized, affecting individual landowners, or widely dispersed, affecting the welfare of society as a whole. Markets for environmental amenities are often incomplete or non-existent, and as such the positive or negative environmental effects of biotechnology may not be effectively internalized in private decisions. A central issue in the design of environmental regulation is choosing an appropriate instrument for internalizing these external environmental costs. The economically efficient regulatory instrument will be a function of the nature of the potential external effects, and industry characteristics (Baumol and Oates, 1988; Shavell, 1984a; Weitzman, 1974).

* Corresponding author:
Tel.: + 1-307-766-2389; fax: + 1-307-766-5544; e-mail: smooney@uwyo.edu

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In the US, GM crops are regulated in a similar way to conventional crops in the sense that once the crop has passed *ex ante* permitting, testing and tolerance requirements, there are no statutory remedies for public or private parties that are damaged by users or manufacturers of an approved GM crop. Instead, harm is addressed using *ex post* tort actions based on liability rules (Lewis, 1997). The economic purpose of tort liability is to induce potential injurers to internalize externalities by compensating the victim (Cooter and Ulen, 1997). The potential for costly legal suits and damage awards provide the incentive for firms to reduce risks associated with their product.

However, there are many situations when tort liability may not effectively deter risky behavior. For example, when; (1) there is a long latency period between the use of a technology and the realization of the harm; and (2) total damages exceed the assets available to the defendant (Shavell, 1986; Ringleb and Wiggins, 1990). Experience with oil spills from the Exxon Valdez or cases of endangered species' habitat restoration illustrate that environmental damages can be costly (or impossible) to mitigate and may occur at a time much later than the initial deleterious actions.

In this paper we discuss the general characteristics and limitations of the existing system of tort liability, and examine the potential for using environmental bonding to reduce the risks associated with the environmental release of GM crops. We consider whether environmental bonding is a suitable incentive to address risks in the biotechnology industry, and finish by considering whether environmental bonds could be a substitute for, or complement existing tort liability[1].

We find that in the case of GM crops, a bonding mechanism would complement some of the strengths of tort liability. Specifically, the bonding mechanism provides some protection against bankruptcy, and also shifts the burden of risk toward life science companies that develop the technology. These factors could encourage additional early research by life science firms. However, a bonding mechanism adds to the regulatory apparatus, and would likely increase administrative costs, over tort liability, for public and private parties. Nevertheless, an attractive possibility is that the cumulative outcomes of bonding, *e.g.,* shifting the risk burden, providing a measure of bankruptcy protection, and introducing an additional regulatory component, would mitigate some of the political and social objections to the environmental release of GM crops.

[1] Kolstad, Ulen and Johnson (1990) consider *ex ante* remedies, such as bonds, as substitutes for *ex post* tort liability if the optimal level of externality reductions can be obtained at a lower cost; they note, as does Shavell (1984b) that in some cases, *ex ante* and *ex post* regulation can be simultaneously used – that is, as complements – to address externalities.

## POTENTIAL BENEFITS OR DAMAGES FROM THE ENVIRONMENTAL RELEASE OF GM CROPS

Much of the concern surrounding the environmental release of biotech crops focuses on their promise of environmental (ERS, 1999), production and other benefits verses the potential for environmental damage[2]. A common genetic modification to agricultural crops is the addition of genes from the soil bacterium *Bacillus thuringiensis (Bt)* to create resistance to certain insect pests or gene modification to obtain tolerance to specific herbicides (modifications that provide other benefits are discussed in Marks et al. (1999)). Crops with "built in" resistance to insect pests can reduce the application of insecticides (ERS, 1999) and potentially decrease environmental externalities such as chemical residues and deaths of non-target organisms. Herbicide tolerant crops enable producers to use herbicides more effectively and kill weeds with fewer chemical applications (ERS, 1999). It is anticipated that genetic engineering can be used to make crops resistant to major diseases and environmental stresses that traditionally have caused large losses, thereby not only stabilizing yields but also reducing the use of fungicides and other agents that inhibit the onset of diseases.

Environmental damages could occur as a result of unintended, non-target, impacts of genes within GM crops that convey herbicide resistance and insect tolerance (Tabashnik, 1994; Hurley, Babcock and Hellmich, 2001; Barton and Dracup, 2000). It is possible that GM crops could out-cross with weedy relatives, transferring herbicide and insect resistance to these species making them difficult to control[3]. A range of other undesirable consequences including altered: community structure; food chain composition; genetic and biologic diversity have also been suggested (Rissler and Mellon, 1996; Adam and Köhler, 1996; Saat, 1996).

[2] Several questions are summarized in Dale and Moyes (2000), Johnson (2000) and Krimsky and Wrubel (1996).

[3] Shelton, Zhao and Roush (2002) discuss some of the conditions necessary for these events to occur.



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There are many reported instances of weeds that have become resistant to conventional herbicides; for example; Heap (1999a) reports 216 herbicide resistant weeds worldwide in 1998, of which 74 resistant weeds are present in the US and 24 in Canada (Heap, 1999b). Resistance to *Bt* by common pests could alter community structures and have unintended effects on their predators. Insect resistance to *Bt* has been documented by Martinez-Ramirez et al. (1995) and Hama, Suzuki and Tanaka (1992) among others. Several recent studies have examined the potential hazards from *Bt* crops for non-target organisms (Sears et al., 2001; Zangerl et al., 2001).

## TORT LIABILITY AND ENVIRONMENTAL BONDS

The problem of dealing with environmental risks is characterized by Shavell (1986) as a choice between *ex post* liability for harm and *ex ante* regulation. In a stylized theoretical framework, these alternatives are substitutes – two different approaches to dealing with risk. In practice, however, there are numerous cases where the two approaches complement one another (Kolstad, Ulen and Johnson, 1990). For example, manufacturers are subject to *ex ante* safety regulations, yet compliance with regulations is not a blanket defense against *ex post* liability for design flaws. It is in this spirit that we examine the prospect of environmental bonds for GM crops.

Both conventional and GM crop varieties can result in environmental damages (Beringer, 2000; Barton and Dracup, 2000); but the level of knowledge regarding the potential for accidents and the extent of damages is generally lower for the new technology. Because of this, the size of regulatory penalties in response to negative environmental externalities is uncertain. Kolstad, Ulen and Johnson (1990) have demonstrated that the larger the uncertainty in the legal standard, the more likely it is that a potential injurer will take less than the socially optimum level of care. It is possible that environmental damages arising from the use of GM crops could be very costly to mitigate, and occur both over short and long time horizons. These differences between conventional and GM crops suggest that a different mix of regulatory remedies could be required for each technology type.

Under tort liability, a damaged party can bring suit under common law to recover damages. The reliance on *ex post* liability as a deterrent does not require firms to demonstrate that their products are "risk free", but in most cases firms will have to meet some safety criteria prior to introducing them into a market. Once the products are released however, there is no mandatory *ex post* evaluation of risks or damages under a liability rule. Firms remain liable for any damages caused by their products, but the onus of further risk analysis will fall upon the potentially harmed parties. If a party has been harmed by a product, they must identify the harm, demonstrate who produced the harm and quantify the damages in monetary terms. The transactions costs associated with these activities can be substantial, and will fall mostly on the harmed party. These costs are a potential constraint on the effectiveness of liability provisions. In the case of GM crops, the burden of proof will lie with landowners, consumers and other groups affected by any adverse change. Liability provisions work best when the costs of identifying the source of the harm and quantifying the damages are low.

A second concern with tort liability is that the deterrent effects will be insufficient if the firm lacks enough assets to cover damages. In effect, the firm's assets are the upper bound on liability. In this case the firm is said to be *judgment-proof*, and the threat of *ex post* damage awards will not provide adequate deterrence against the risky activity (Shavell, 1986). A related concern is the timing of any damages. If damages are noted after a long time delay it is possible that the firm producing the product may no longer be in business and will be unable to pay.

Environmental bonds are a means of addressing activities with uncertain future costs. In cases where there is potential for environmental damage, an individual firm, manufacturer or third party posts a bond with a regulatory authority as an incentive to comply with some contractual or regulatory agreement. If the terms of the agreement are met, the bond is released; if the terms are not met, the bond is forfeited and its proceeds go toward remedial actions. In the case of mining, for example, firms post bonds to ensure post-mining site reclamation. When the firm demonstrates that the site has been reclaimed, the bond is released. Bonds provide the firm with a direct monetary incentive to improve product safety and/or comply with environmental regulations. Environmental bonds have been examined as an instrument to resolve water quality problems (Weersink and Livernois, 1996); agricultural non-point source pollution, coal mining (Shogren et al., 1993), hardrock mining (Gerard, 2000), the generation of space debris (Macauley, 1992) as well as a wide variety of other situations (Carman, 1997; Cornwell and Costanza, 1994). There has, however, been no investigation of the suitability of environmental bonds to address potential environmental harms from GM crops.



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Bonding requires *ex ante* and *ex post* examination of risks. Like any *ex ante* regulation, firms must demonstrate that its commodity meets safety criterion (*e.g.*, no offsite impacts) before marketing the product, and it is during this phase that the bond amount is determined. The process of setting the bond amount provides a preliminary estimate regarding the costs of potential environmental damages. Bonds also have other advantages. A large bond could encourage firms to conduct additional safety research before releasing their product. Bonds shift at least part of the financial burden for remediation to the party that caused the harm and finally bonds can resolve some of the judgment proof problem by ensuring that some funds are available for mitigation (Perrings, 1989; Costanza and Perrings, 1990). Unlike tort liability, the bond provides damaged parties with partial protection against default risk because, if the agent fails to perform, the bond is forfeited and used to remedy the performance failure.

Similar to tort liability, the deterrent effect of bonding is strongest when it is easy to identify and assign blame for damages. Despite their potential for deterring risky behavior, bonds also have a number of characteristics that can limit both their scope and their effectiveness (Shogren et al., 1993); these are discussed in the following sections.

## ENVIRONMENTAL BONDS FOR GM CROPS

Using examples from the coal mining industry, Shogren et al. (1993) propose several conditions that favor the effective implementation of environmental bonds. These are: (1) well-known damage valuations; (2) a high probability of detecting environmental damage; (3) few parties; (4) a fixed time horizon; (5) a well-defined agreement (*e.g.*, both parties have the same definition of environmental damage); (6) a low bond value relative to company assets; and (7) no irreversible effects. These conditions are discussed below in relation to the case of environmental bonds for the release of GM crops.

### Bond the manufacturer or individual producer?

An important question for implementing environmental bonds is who should post the bond; manufacturers of GM crops (life science companies) or the individual producers growing GM seed? Shogren et al. (1993) suggest that bonding is more successful when the value of the bond is low relative to company assets. In comparison to life science companies, individual agricultural producers have relatively limited assets. An environmental bond could cause binding liquidity constraints for some producers[4]. In other cases the financial burden could affect access to credit markets. In some instances, a third party surety may agree to cover the amount of the bond reducing liquidity constraints. However the producer would still be required to pay an annual premium (typically one to five percent of the face value of the bond), and the bond is an accounting liability that will adversely affect the producers' credit. Life science companies are better candidates to post the bond for two reasons. First they have "deeper pockets" and are less likely to experience liquidity constraints than an individual producer. Second, commercialization of biotech products has led to considerable industry consolidation (Marks et al., 1999), resulting in a life science industry that is dominated by relatively few large players worldwide; meeting the condition of "few parties" suggested by Shogren et al. (1993)[5].

In general, requiring that suppliers take responsibility for the potentially negligent actions of their customers creates a serious monitoring problem in the principal-agent relationship. However, in the case of GM crops, the manufacturer has presumably made assurances that the product will not be ecologically disruptive in virtually any form.

### Remaining Conditions

The remaining conditions for successful bonding namely; damage valuation; damage detection; time horizon and irreversibility, are discussed in the context of the life science industry structure. Regulators, manufacturers and producers have the least information about the potential costs of environmental damage from GM crops when

[4] The United States General Accounting Office (1988) contains a good discussion of the influence of liquidity constraints on coal mining activities.

[5] Because bonding requirements create financial burdens on firms, it is possible that these requirements would put small firms out of business, leading to industry consolidation. Indeed, small coal mines found it difficult to secure bonds following the enactment of the Surface Mining Control and Reclamation Act in the US. A second-order effect of bonding requirements would be on the nature and rate of technological innovation and diffusion. However, there are no clear theoretical or empirical conclusions on the relationship between market structure and technical change (Jaffe et al., 2001). The underlying assumption of our discussion is that bonding requirements are not likely to be the source of further consolidation in the life sciences industry.



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they are first released, thus setting a bond value is difficult. If the damages are overestimated the bond value will be set too high, creating liquidity and other problems. If the bond amount is set too low firms face insufficient incentives to engage in appropriate risk management activities. One solution is to employ a sequentially determined bond as suggested by Perrings (1989). Under a sequential bond scheme an initial bond value is set for a short period of time during which additional testing and data collection can take place. If subsequent testing demonstrates that damages are more risky (or likely to be more costly) than first anticipated the bond value can be increased[6]. Conversely, if the additional information suggests damages are less likely (or not likely to be costly), the bond value could be reduced or dispensed with entirely.

Some of the potential adverse effects of GM crops could be recognized by direct observation. For example, pervasive weediness or the build up of insecticide resistance within pests could be identified through visual inspection and confirmed with further testing. Life science companies have employed slightly different genetic modifications for traits such as herbicide tolerance and pest resistance into agricultural crops. Because of this, regulatory agencies (or landowners) can use genetic testing to pinpoint which life science company is the cause of harm. This characteristic is important to implementing bonds and tort liability and allows damages to be attributed to the party causing the damage. Thus GM crops could meet the "detectable damage" condition proposed by Shogren et al. (1993), further any damage is attributable to a specific life science company.

A bond with a fixed time horizon is desirable for several reasons. First, the firm knows for what period of time their capital will be tied up. Second, it facilitates choosing a discount factor and last a fixed time horizon makes it more likely that a third party will post a bond. Earlier in this paper, we discussed that the timing of damages from any environmental release (to the extent they occur at all) are uncertain. Again, we propose that a sequentially determined bond could be employed. Although this would not provide the firm with a fixed time horizon for the life of the bond, it would provide information regarding capital commitments for each stage of bond value determination.

A well-defined agreement between both parties is an obvious limitation of bonding, because the motivation for regulation or product bans is that, *a priori,* we do not have good agreement concerning the long-term impacts. However, parties to a bond can undertake activities that work toward a common understanding. One solution is to inventory possible future states of nature and list these as a condition of the bond. This will clarify the conditions that trigger bond forfeiture or return.

The bond amount is a function of the potential future damages from GM crop release. The larger the assets held by a firm, the lower the percentage of these assets represented by a given bond amount. Arguably, life science companies have significantly more available resources than individual agricultural producers, reducing their likelihood of bankruptcy or liquidity constraints[7]. However, the wide geographic dispersion of this technology, both nationally and internationally increases the potential for an adverse event occurring. Damage over a wide area could make the value of the bond very large indeed. There is no consensus for setting the size of the bond relative to potential damages. For example, there are arguments for setting the amount below the expected value of damages, at the expected value of damages, or at an amount equal to the worst-case scenario (Gerard, 2000). If a bonding scheme for GM crop damages is to be workable in practice, the bond amount cannot cause binding liquidity problems.

The last condition discussed by Shogren et al. (1993) is irreversibility. Although GM crops could cause irreversible environmental damage, monitoring and testing prior to and during the bonding period could reduce this probability by facilitating early detection and clean up. The potential for irreversible damages will be dependent on the specific genetic trait adopted and the release sites.

## DISCUSSION

In the previous section we examined each condition for successful bonding in the context of the GM industry structure. Several conditions are difficult to meet because

[6] In November 2001, the Department of Environmental Quality increased the bond value for several mines in Montana following the bankruptcy of Pegasus Gold Corp in 1998 and the subsequent experience with clean up costs (Billings Gazette, 2001).

[7] This raises an interesting issue as firms that would not be affected by the liquidity constraints of posting a large bond are unlikely to be significant default risks (*e.g.*, Exxon did not go bankrupt as a result of its compensatory and punitive damages after the Valdez spill).



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of poor information, a situation common with many new technologies. However, despite these difficulties we contend that it would be possible to use environmental bonds as an incentive to increase protection against environmental damages. Bonding and tort liability result in incentive systems with different characteristics. For example, the protection offered against default risk, the parties having the burden of proof in the event of damages and their administrative costs. But are bonds likely to provide better incentives to internalize externalities?

The effectiveness of tort liability is limited if the firm goes out of business or becomes insolvent before damages are discovered. In contrast, a bond protects against this risk, even if the firm is no longer operating. However, in cases where damages appear after a long latency period the bond could already have been released. In this case, bonds offer no advantages over tort liability for GM crop regulation. In fact, if the firm is still solvent and in business, it will be possible to extract some compensation through tort liability.

The timing (or existence) of administrative costs differs between a bonding and tort liability system. Both incentives require some study of economic costs; however under a liability rule these are not incurred until damages take place, while under a bonding mechanism these will be paid for up front to determine the price of the bond. For example, there are costs associated with estimating the magnitude of expected damages; costs of securing a third party to post annual bond premiums and; the opportunity cost of capital held for the bond among others. An advantage of a liability rule over bonding is that costs are incurred only from the point in time that any environmental damage is identified, and not before. If environmental damage from GM crops is easily identified and traceable to the manufacturer, this provides a strong incentive for companies to engage in safety research. An environmental mishap would be likely to increase public demands for stringent regulation of future GM product development and implementation, bolstering the incentive for biotech firms to remediate any damages[8]. The broad and often negative publicity in the popular press regarding biotech innovations (Kalaitzondenakes and Marks, 1999; Marks et al., 2002) provides a powerful incentive for the company to engage in clean up.

Different administrative costs between liability and bonds change the parties that bear the costs of the burden of proof. Under the tort liability rule, harmed parties bear the costs of establishing that damage occurred, while under the bonding rule the party posting the bond bears the burden of creating assurances that harm will not occur. It is possible that such a financial undertaking by life science companies could be beneficial in terms of their public relations with consumers uncertain about biotech products. Additional study is required to examine this possibility.

## CONCLUSIONS

It is clear that environmental bonds could be used as an incentive to encourage additional care from life science companies in the case of the environmental release of GM crops. However, an environmental bonding scheme is unlikely to provide a "silver bullet" to solve regulatory questions surrounding the environmental release of GM crops and is not a substitute for existing tort liability rules. Bonding may provide some middle ground between the extremes of the debate surrounding the environmental releases of GM crops, *i.e.,* a complete ban on environmental releases or unfettered use rights governed only by the deterrent effects of tort liability.

In many respects tort liability and environmental bonds are complements for GM crop release; meaning that they work well when both are used together. Neither the bond nor tort liability is likely to be effective if there are long latency periods between GM crop release and subsequent environmental damages. Both incentives utilize the deterrent effect of financial penalties (court ordered compensatory damages or bond forfeiture) as incentive mechanism, and both are likely to be effective under similar conditions. The major differences are (1) the bond partially insures against a default risk; (2) the burden of proof is redistributed from the plaintiff under the liability rule to the defendant under bonding; and (3) bonds can potentially introduce additional scrutiny of product risks in the early stages of market adoption. These features are advantageous for GM crop release in the current situation of environmental concern. In particular the additional incentive for life science companies to engage in additional research related to environmental safety may reduce some of the political and social objections to the environmental release GM crops. The uncertainty associated with damages also creates uncertainty in the legal standard and reduces the care exhibited by firms. An environmental bonding scheme, particularly during the early stages of GM release could encourage firms to increase their safety research, and in part mitigate this concern.

[8] Shavell (1984a) discusses the relative costs of private tort regulation *versus* public safety regulation.



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