Cotton Concentration Report

An Assessment of Monsanto's Proposed Acquisition of Delta and Pine Land

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Executive Summary

On August 15, 2006, Monsanto announced that it would acquire the Delta and Pine Land Company (DPL). DPL is the eleventh largest seed company in the world, sells over half of the cotton seed in the U.S., and holds a pivotal position as the only major cotton seed firm that is not also a biotechnology trait provider. Monsanto dominates the market for biotechnology traits in cotton and other crops, and is also the largest seed firm in the world. The proposed merger deserves close scrutiny, particularly in light of the extraordinarily high degree of concentration already existing in the cotton industry.

Cotton Industry Already Highly Concentrated Pre-Merger

Cotton seed: Just three firms sell 92% of U.S. cotton seed to farmers (Section 2.1.1, Figure 1, Appendix 1), a much higher concentration than other major crops (Appendix 2)
Biotechnology traits: Over 87% of U.S. cotton is biotech. 96% of biotech cotton contains Monsanto traits, and 95% contains ***only*** Monsanto traits (Section 2.1.2, Figure 2)
Research and development: Monsanto has similar dominance in R&D for future cotton traits, accounting for 94% of the experimental biotech cotton planted in the U.S. from the year 2000 to present (Section 3.4.3, Appendix 5)
Cotton farms: The average size of U.S. cotton farms more than doubled from 1987 to 2002. One of every five cotton farms ceased operations in just the five years from 1997 to 2002 (Section 2.1.3, Figure 3).

Market Power and Anticompetitive Effects

High cost of cotton seed: The cost of cotton seed has risen 3.4-fold from 1995 to 2005, due primarily to rising technology fees charged for biotech traits (Section 2.2, Figures 4 & 5, Table 1, Appendix 3). The value added by biotech traits does not justify these steep premiums (Section 2.3), as the trend of increasing cotton yield since 1930 has not accelerated during the biotech era (Appendix 4)
Limited choice: Farmers have fewer choices of quality conventional cotton seed, and fewer choices of cotton varieties with one trait vs. two, as cotton seed firms and trait providers aggressively pursue "increased technology penetration" to maximize profits (Sections 2.4 & 2.5, Figures 7& 8)

Agronomic, Environmental Consequences of Monsanto's Trait Monopoly

Crop failures: Monsanto's biotech cotton has failed numerous farmers since its introduction, often resulting in sharp drops in yield. Near-total reliance on any agricultural technology, including one company's limited set of biotech traits, is unwise (Section 2.6)
Resistant weeds: The dramatically increased use of glyphosate-based herbicides (e.g. Roundup) associated with Roundup Ready cotton and other crops has fostered a rapid and dangerous development of weeds resistant to the herbicide, a threat to the cotton industry compared by one expert to the boll weevil (Section 2.7)
Other impacts: Recent scientific studies suggest that excessive use of glyphosate, which has increased six-fold from 1992-2002, is linked to plant disease, crop mineral deficiencies, reduced yields and (in the case of Roundup) amphibian mortality, and may pose a long-term threat to the productivity of American agriculture (Section 2.8).

Anticompetitive Effects of the Merger

Oligopoly to duopoly? USDA data show that the number of significant cotton seed firms other than the top three has declined by more than half from 2003 to 2006. Bayer's rising market share since 1999 is concentrated in the Southwest, and has not diversified other regional seed markets. A divested Stoneville may well be uncompetitive and ripe for takeover, possibly resulting in a cotton seed duopoly controlling over 90% of the market (Section 3.1).

Reduced choice: Monsanto's commitment to "increased technology penetration" would likely lead to accelerated phase-out of DPL's conventional cotton varieties, which comprised 40% of conventional lines planted in 2006, and fewer high-quality "generation one" and "single-trait" options, reducing choices for farmers (Sections 3.2 & 3.3).

Increasing cotton seed prices: Monsanto's pledge to "invest in penetration of higher-margin traits in DPL offerings" would accelerate the steep rise in cotton seed prices (Section 3.3, Table 2)

Consolidation of trait monopoly: DPL is the only seed firm among the top four (Bayer, Monsanto-Stoneville, Dow-Phytogen) that is not also a trait provider. Acquisition of DPL by Monsanto would likely result in exclusion of non-Monsanto traits in over half of U.S. cotton, extending Monsanto's current trait monopoly in cotton (Section 3.4) and other crops (Section 3.5) well into the future. It would also exacerbate the adverse agronomic and environmental impacts of trait monopoly in all crops. The high failure rate in agricultural biotechnology means that conduct-based solutions, such as compulsory licensing agreements to force Monsanto to deploy competitors' traits in DPL germplasm, are risky and likely to fail to achieve their competitive ends (Section 3.11).

Other Likely Impacts of the Merger

Organic cotton: The booming market in organic cotton is threatened by transgenic contamination, herbicide spray drift damage, and potentially by decreased conventional seed availability. The proposed combination would exacerbate such risks for organic cotton growers in the U.S. and overseas, and potentially reduce U.S. consumers' choice of organic cotton products (Section 3.7).

Seed sterility: DPL holds major patents on seed sterility technology (i.e. Terminator), a biological means to eliminate the millennia-old farmer's practice of saving and replanting seeds. Monsanto is known for aggressive prosecution of farmers who (allegedly) save its patented seeds. The merger would increase the likelihood that internationally-condemned Terminator cotton and other crops will be introduced, to the detriment of the world's farmers (Section 3.8).

International impacts: Monsanto is known for questionable business practices to promote its interests overseas, including illegal actions such as bribery of Indonesian government officials, which resulted in SEC prosecution and a $1.5 million fine in 2002. Acquisition of DPL's substantial international cotton seed business would give Monsanto, already the world's largest seed firm (Appendix 6), additional scope for such activities (Section 3.9).

Conclusion and Recommendations

The proposed combination would negatively impact farmers through reduced seed choices, increased seed prices, rising production costs and increased reliance on one company's technology well into the future. The merger would also increase the cotton industry's already near-total dependence on one company's herbicide-tolerance traits, exacerbating glyphosate-resistant weeds and potentially endangering the productivity of American agriculture through the effects of excessive glyphosate use. Finally, acquisition of DPL would invest Monsanto with more power to pursue questionable business practices overseas, and increase the likelihood of introduction of internationally-condemned sterile seed technology.

The Center for Food Safety and International Center for Technology Assessment call on the Department of Justice (DoJ) to unconditionally oppose the proposed acquisition of Delta and Pine Land by Monsanto, and to oppose future acquisitions leading to increased concentration in the cotton seed industry. We also urge the U.S. Dept. of Agriculture to increase funding for public-sector development of affordable, conventional seed varieties neglected by the private sector and to deny applications by entities seeking to field test any seed sterility technology.

1. INTRODUCTION

The Center for Food Safety (CFS) and International Center for Technology Assessment (ICTA) have conducted an independent assessment of the proposed acquisition of Delta and Pine Land Company by the Monsanto Company. CFS and ICTA are sister non-profit public interest groups with more than a decade of experience in the legal, agronomic, environmental and public health issues raised by agricultural biotechnology.

On August 15, 2006, the Monsanto Company announced its intention to acquire the Delta and Pine Land Company (DPL) for $1.5 billion in cash (Monsanto 2006a). Monsanto previously attempted to acquire DPL in 1998, but abandoned its bid in December 1999 (Kilman 2006) due to stiff conditions imposed by antitrust regulators (Kaskey 2006). DPL countered that Monsanto did not try hard enough to win approval, and sued the company for $2 billion in damages. The current agreement requires Monsanto to pay DPL up to $600 million if regulatory approvals are not obtained (Pollack 2006). After the transaction was dropped, a Department of Justice official testified that the Antitrust Division would have opposed the merger because it "would have significantly reduced competition in cotton seed biotechnology to the detriment of farmers" (Nannes 2001).

Monsanto has proposed to divest its Stoneville cotton seed business in order to gain approval of the merger (Monsanto 2006a). Monsanto first acquired Stoneville in 1997, divested it in 1999 as part of its prior attempt to acquire DPL (Fernandez-Cornejo 2004, Table 20, ft. 4), then re-acquired it from Emergent Genetics, Inc. in 2005 (Monsanto 2005b). Stoneville accounts for about 12 percent of the U.S. cotton seed market.

The proposed merger deserves close scrutiny for many reasons, particularly in light of the extraordinarily high degree of concentration already existing in the cotton industry. Delta and Pine Land is the eleventh largest seed company in the world (ETC 2005), the biggest cotton seed firm in the U.S., and holds a pivotal position as the only major cotton seed seller that is not also a biotechnology trait provider. Monsanto dominates the market for biotechnology traits in cotton and other major crops, and is also the largest seed firm in the world (ETC 2005). Our analysis suggests that the merger would result in:

1) Increased cotton seed prices;
2) Reduced choice of conventional and some types of biotech cotton seed;
3) Consolidation of Monsanto's virtual trait monopoly in cotton and other crops well into the future; and
4) Adverse agronomic and environmental effects, as well as increased production costs, stemming from Monsanto's near-monopoly in herbicide-tolerance traits

The merger could also result in:

5) Increased concentration in the cotton seed market;
6) Harm to organic cotton growers, and reduced choice of organic cotton products for consumers;
7) Harm to farmers in the U.S. and elsewhere by facilitating the introduction of sterile seed technology ("Terminator"); and
8) Increased scope for Monsanto to pursue illegal and questionable business activities overseas, to the detriment of the world's farmers.

We first examine the recent history and current state of the cotton industry (Section 2). This helps inform our analysis of the likely impacts of the proposed combination between Monsanto and Delta and Pine Land (Section 3). The conclusion (Section 4) is followed by recommendations (Section 5).

2. CURRENT STATUS OF THE COTTON INDUSTRY

2.1 Cotton Industry Already Highly Concentrated

The cotton industry is by most measures the most highly concentrated of any major crop industry. Below, we briefly discuss four major aspects of this concentration: cotton seeds, biotechnology traits in cotton, research and development for biotechnology traits in cotton, and cotton-growing land.

2.1.1 Concentration in cotton seeds

Over the past 16 years, the market in cotton seeds has become highly concentrated. Appendix 1 shows some degree of competition from 1970 to 1989, with the top four private suppliers selling from 46 to 70% of total cotton seeds sold to farmers. The "top four" market share rose rapidly in the 1990s, reaching the 90% level in 1996. Concentration increased still further from 2000-2006, with just the top ***three*** firms – Delta and Pine Land, Bayer and Stoneville – controlling on average 91% of the market. In 2006, the combined market share of the top three stood at 92% (Figure 1). Based on available data, concentration in cotton seed exceeds that in other major crops, such as corn and soybeans, and by a considerable margin (Appendix 2).[1]

Major factors driving this concentration include (see Appendix 1 and Fernandez-Cornejo 2004, Table 20)):

1) The virtual disappearance of public sector (university) breeding efforts, from 12-25% of cotton seed sold to farmers in the 1970s and 1980s, to less than 1% today;
2) Numerous mergers and acquisitions, such as DPL's acquisition of Lankart and Paymaster brands in 1994 (SEC 1996) and Sure-Grow in 1996; and Stoneville's acquisition of Coker Pedigreed Seed and McNair in 1990, Brownfield Seed and Delinting Co. in 2000, and Germain's Cotton Seeds in 2001 (SEC 1997, Stoneville 2001);
3) The rise of biotechnology and utility patents on biotech traits and plants, which prompted large chemical-biotechnology firms to vertically integrate through acquisition of cotton germplasm, as seen with Monsanto's acquisition and re-acquisition of Stoneville in 1997 and 2005; Bayer's acquisition of Aventis CropScience in 2001 (Bayer 2001), AFD Seed in 2005, and California Planting Cotton Seed Distributors (CPCSD) in 2006 (Bayer 2006); and Dow's joint-venture with J.G. Boswell, Phytogen, in 1998 (DFP 2005).

2.1.2 Concentration in cotton traits and research and development

Biotechnology traits are specific properties conferred on a crop variety through the process of genetic engineering. As shown in Figure 2, the market in biotechnology traits (hereinafter "traits") deployed in cotton seed is even more concentrated than the cotton seed market, with the top three trait providers accounting for the traits in 100% of biotech seed planted in 2006. Yet market share is far from evenly distributed even among these few competitors. In 2006, over 96% of biotech

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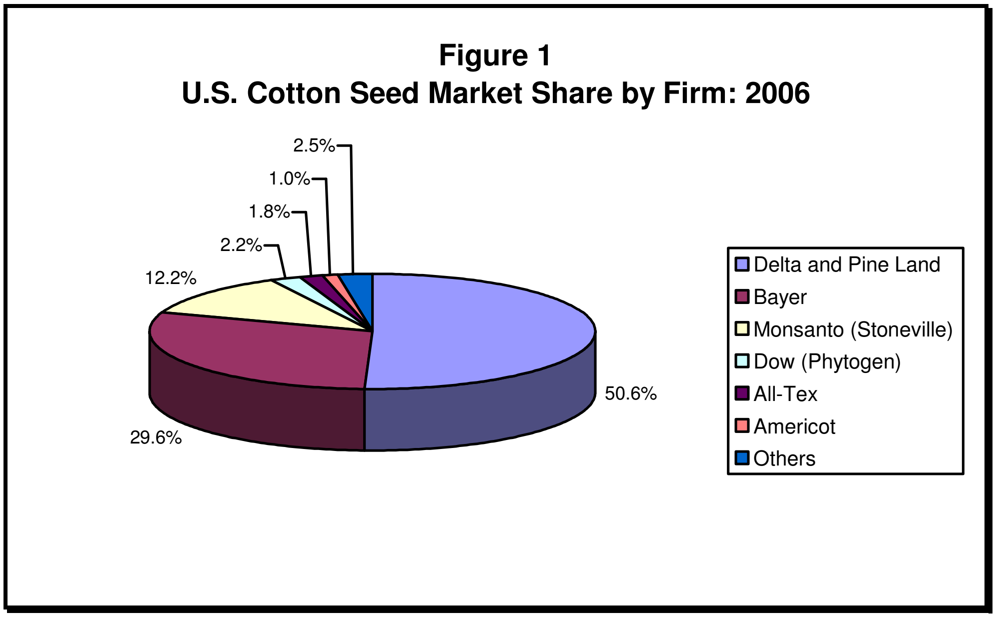
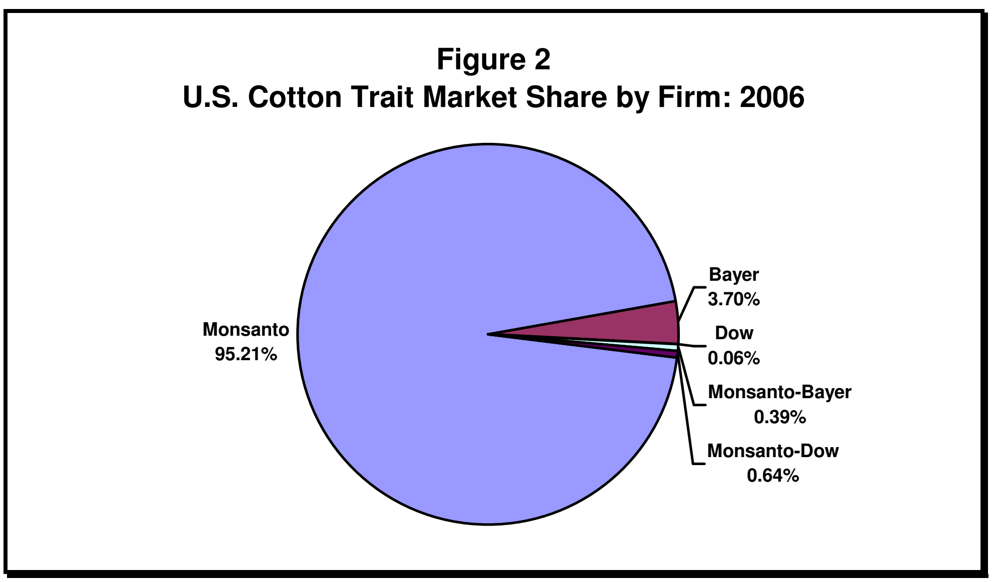
[1] In this report, we focus on "upland cotton," which accounts for about 97% of U.S. production. The remaining 3% is American Pima or extra-long staple, grown primarily in California, and used mainly for high-value products such as sewing thread and expensive apparel (USDA ERS 2006a).

cotton planted in the U.S. contained Monsanto traits, and 95% contained ***only*** Monsanto traits. Cotton with only Bayer (3.7%) or only Dow (0.06%) traits accounted for less than 4% of biotech cotton, with roughly one percent stacked with traits from Monsanto and either Bayer or Dow.[2]



Share of U.S. upland cotton planted to varieties sold by the given firms. Based on data from: USDA AMS (2006). Notes: DPL's share includes Paymaster & Sure-Grow brands; Bayer's share includes AFD Seeds and California Planting Cotton Seed Distributors (CPCSD).



Share of upland biotech cotton in the U.S. planted to varieties containing only Monsanto traits (95.21%), only Bayer traits (3.70%), only Dow traits (0.06%) or a mix of traits from the given firms. Based on data from: USDA AMS (2006).

[2] Unless otherwise noted, all statistics on conventional and biotech cotton varieties planted from 2003 to 2006 are derived from government data in "Cotton Varieties Planted" reports for the relevant year, based on surveys conducted by the U.S. Dept. of Agriculture's Agricultural Marketing Service. See USDA-AMS (2003-2006) in the Bibliography.

Interestingly, the market in cotton traits was once at least slightly less concentrated. In 1998 and 1999, Bayer's herbicide-tolerant Buctril cotton (resistant to the herbicide bromoxynil) had a 13% share of biotech cotton (calculated from May et al 2003, Table 1).

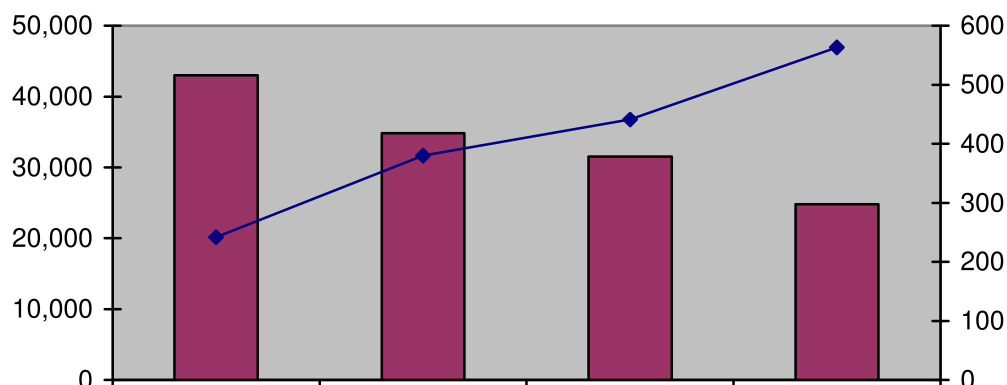
Research and development (R&D) efforts are also highly concentrated. Here too, Monsanto has overwhelming dominance, with 94% of experimental biotech cotton acreage since the year 2000 (see Section 3.4.3 and Appendix 5).

2.1.3 Concentration in cotton farms

Finally, the rise of biotechnology in cotton has also been accompanied by accelerating concentration of cotton-producing land in fewer hands. Figure 3 shows a drop in the number of cotton farms from 1987 to 1992, followed by a smaller decline through 1997, the beginning of the biotech era. In just the following five years, the number of cotton farms declined steeply by over 21%, representing a loss of one of every five U.S. cotton farms. Cotton farm size has also risen dramatically, particularly since 1997, when the size of the average cotton farm already exceeded that of any other major field crop. In addition, the percentage of cotton farms 500 acres or larger has increased from 12% in 1987 to 29% in 1997 (Meyer and MacDonald 2001).

While the declining number and increasing size of cotton farms is a long-term historical trend (in 1949, 1.1 million presumably mixed crop farms harvested an average of 24 acres of cotton each) (USDA ERS 1996), biotechnology has helped facilitate consolidation over the past decade, as discussed further below.

Figure 3
Number and Average Size of U.S. Cotton Farms: 1987 to 2002



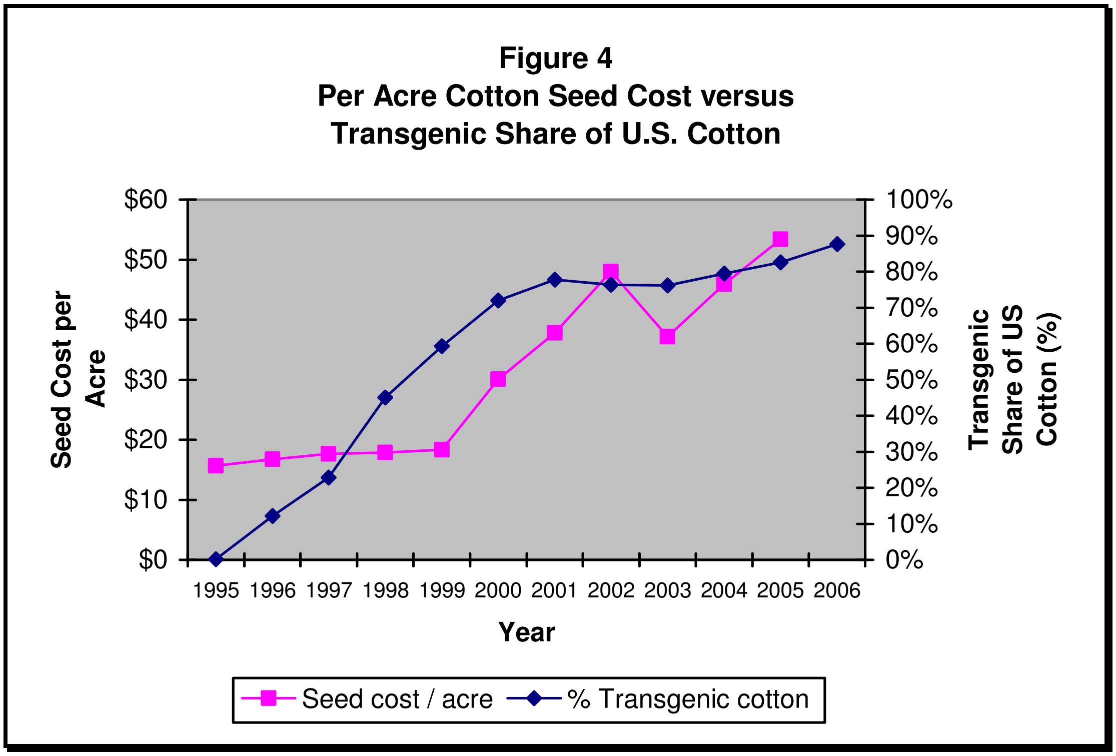
	1987	1992	1997	2002
No. of Farms	43,000	34,812	31,493	24,805
Average size	242	380	441	563

No. of Farms — Average size

Average size of farm calculated by dividing number of cotton acres planted in U.S. by number of cotton farms for each year. Cotton acres for all years from USDA's NASS at: http://www.nass.usda.gov/QuickStats/, last accessed 2/19/07. Select "Crops," then "Cotton, All," for "All States, United States" for 1987 to 2002. For number of farms in 1992, 1997 and 2002, see USDA Census (1992, 1997 and 2002); for 1987, see Meyer & MacDonald (2001).

2.2 Cotton Seed Price Increase with the Rise of Biotechnology

The increasing use of transgenic cotton since 1995 has been accompanied by a dramatic rise in cotton seed prices paid by farmers. Historical price data from USDA show that the per acre cost of cotton seed has risen 3.4-fold in just the eleven years from the start of the biotech era in 1995 to 2005, when transgenic varieties accounted for 83% of U.S. cotton (Figure 4). The proportion of overall on-farm operating expenses attributable to seed expenditures increased nearly three-fold in the same brief time span (data not shown).



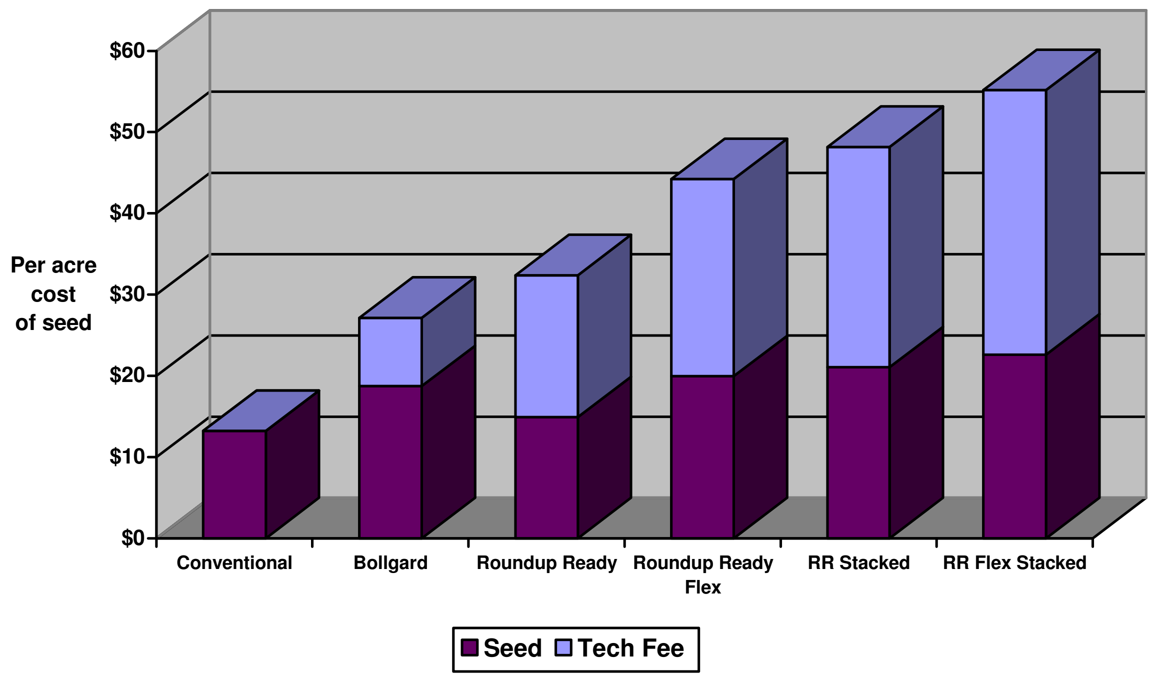
Sources: Per acre seed cost data from USDA ERS 2007a and 2007b. For biotech share of US cotton for 1995-2002, see May et al (2003), Table 1; for 2003-2006, see USDA AMS (2003-2006).

A comparison of present-day prices for conventional and transgenic cotton seed shows that biotech traits are indeed primarily responsible for this rapid price increase. Appendix 3 plots the prices of 140 varieties of cotton seed sold in the Lubbock, Texas area in 2006, broken down by conventional and various biotech trait categories. The data show that the average per acre cost of transgenic cotton seed ranges from two to over four times as much as that of conventional seed. (We will discuss these findings in more detail below). The price differential is attributable primarily to "technology fees" charged by trait providers. Figure 5, based on prices for the same 140 varieties portrayed in Appendix 3, shows that technology fees comprise from 31% to 59% of the overall price paid by farmers for cotton seed. Technology fees increase with a) newer generation traits; and b) number of incorporated traits. Table 1 shows that the price of cotton seed rises roughly 40% when a second transgenic trait is "stacked" with a first; and for a variety with second generation versus first generation trait(s).[3] A farmer pays on average nearly twice as much for a second

[3] Note that seed prices vary considerably based on numerous factors: region, time of purchase, package deals with chemicals, etc.

generation variety with two traits as for a first generation variety with one trait.[4] At present, biotech cotton is limited to one or two (stacked) traits, though three or more are possible in the future, as we are starting to see in the corn seed market, with so-called triple-stack corn (Gullickson 2006).

Figure 5
Technology Fees as Proportion of Cotton Seed Price



Based on Plains Cotton Growers (2006). Values shown are averages for 134 of the 140 varieties listed in the worksheet (conventional: 21; Bollgard: 2; RR: 39; RR Flex: 15; RR stacked: 26; RR Flex stacked: 31). The six LibertyLink varieties were excluded because no separate tech fee component was listed for these six varieties.

Cotton seed providers are actively transitioning the cotton varieties they offer from conventional to biotech, from one to two biotech traits, and from first to second generation traits. For instance, the short-term goals cited in a 2004 Delta and Pine Land presentation to investors (DPL 2004, slide 6) are:

* "Increased technology penetration (share, stacked traits vs. single trait);" and
* "Accelerated transition to MON [Monsanto] second generation traits."

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[4] The term "generation 2" was originally used to denote promised biotech crops with "output" traits desirable to consumers, such as enhanced nutrition, versus "generation 1" crops with "input" traits of interest to farmers, such as herbicide tolerance (HT) and insect resistance (IR). However, the biotech industry has failed to make a commercial success of any true generation 2 "output" trait biotech crop. Monsanto chooses to call its Roundup Ready Flex and Bollgard II traits "second generation" even though they are merely variations on the original generation 1 input traits, Roundup Ready and Bollgard.

Table 1 Per Acre Cost of Biotech Seed by Trait and Generation			
	One Trait (HT)	Two Traits (HT/IR)	**Price Rise 1 → 2 traits**
First Generation	Roundup Ready $31.91	Roundup Ready / Bollgard I $45.20	**42%**
Second Generation	Roundup Ready Flex $44.02	Roundup Ready Flex / Bollgard II $61.90	**41%**
Price Rise 1st gen. → 2nd	**38%**	**37%**	**94%***

Source: Jones, MA (2006). HT = herbicide tolerance; IR = insect resistance. Per acre seed prices based on 38 inch rows and 4.0 seed/ft. Variety not specified. Prices quoted for Virginia, N. & S. Carolina with 25% discount.
* 94% signifies the price rise from 1 trait/first generation to 2 traits/second generation.

What is the nature and magnitude of the value added by biotech traits? Does this added value justify the substantial price premiums of biotech versus conventional cotton seed? Is increased technology penetration being driven solely by farmer demand? These questions are addressed in the following two sections.

2.3 Biotechnology Trait Premiums and Added Value

Conventional wisdom has it that the added value of biotech cotton seed fully justifies its two-to four-fold increased price over conventional seed. It is said that farmers wouldn't pay these high premiums if the seeds didn't deliver added value commensurate with their added cost; they would buy conventional seed, instead. However, the extreme concentration in both cotton seeds and traits at least suggests the possibility that market power might be restricting farmers' choice of both conventional and biotech seeds and thus artificially raising prices. An assessment of this possibility, provided in Section 2.4, requires a basic understanding of added value in the context of biotech traits deployed in cotton.

In 2006, almost 88% of U.S. cotton was transgenic (USDA AMS 2006). Nearly three-fourths of transgenic cotton acreage was planted to so-called "stacked" varieties modified for both of two traits: herbicide tolerance (HT) and insect resistance (IR). Varieties with HT alone comprised one-fourth and those with IR alone comprised less than 1% (Figure 6). HT and IR are the only biotech traits available in cotton.

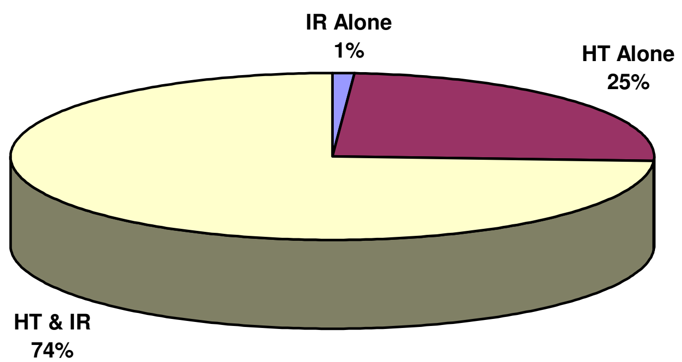
2.3.1 Herbicide tolerance

Herbicide tolerance permits the cotton plant to survive application of a single herbicide that would otherwise kill the [non-biotech] plant, thus allowing "over-the-top" application of the herbicide to more easily kill nearby weeds without killing or severely injuring the cotton plant itself.[5] HT cotton

[5] "Over-the-top" is one form of "post-emergence" herbicide application, or spraying after the cotton seed has "emerged" or sprouted. The alternative herbicide regime more common with conventional, non-HT varieties is called "pre-emergence." That is, a herbicide that retains its activity for weeks is applied to the soil before the cotton plant

permits greater flexibility in the timing of herbicide applications, allows for herbicide use over greater time spans, and in general simplifies weed management by reducing the number of different weed killers applied. The chief advantages cited for HT cotton are convenience and ability to cover more acres (i.e. reduced labor inputs per acre) (Duffy 2001), both of which are of particular value to larger farmers (Benbrook 2005, p. 9). Thus, HT cotton has helped facilitate the shift to fewer and larger cotton farms noted above.

Figure 6
Breakdown of Traits in Biotech Cotton in the U.S.: 2006



HT = herbicide tolerance; IR = insect resistance. Percentages represent total share of biotech upland cotton planted in the U.S. in 2006 to varieties with the given trait(s). Source: USDA AMS (2006).

Monsanto's HT cotton traits, Roundup Ready and Roundup Ready Flex, comprised 96% of HT cotton in 2006. Both Roundup Ready versions are engineered to survive spraying with glyphosate-based herbicides, sold by Monsanto under the name of Roundup.[6] The remaining 4% of HT cotton acreage contained Bayer's LibertyLink trait, which confers tolerance to glufosinate, sold by Bayer under the name of Liberty. Monsanto's dominance in herbicide-tolerant cotton is attributable to three major factors:

1) The effectiveness of glyphosate, an extremely broad-spectrum herbicide (i.e. it kills a broader range of weed species than most other weed killers), and the popularity of the Roundup Ready system with many farmers;
2) The low cost of glyphosate, due to Monsanto's "brilliant strategy of dropping its price years ahead of patent expiration [in 2000] and tying its use to the early growth of genetically modified crops" (Barboza 2001), as well as subsequent competition from low-cost generic manufacturers of glyphosate;

actually sprouts so as to suppress "weed competition" in the critical early life of the cotton plant. Pre-emergence herbicides are also used, though to a lesser extent, with HT cotton.

[6] Generation 1 Roundup Ready cotton permits over-the-top application only during the early seedling stage, after which time spray shields are required to direct the herbicide to the base of the plant, so-called "post-directed" application. Note that post-directed applications are also used with conventional cotton. Generation 2 Roundup Ready Flex cotton permits over-the-top application of higher doses of glyphosate throughout the growing season (Bennett 2005).

3) Aggressive acquisition of high-quality germplasm in which to incorporate its traits, as well as licensing agreements for incorporation of its traits in other firms' germplasm.

The dominance of Roundup Ready cotton has driven a many-fold increase in the use of glyphosate and reductions in the use of other herbicides. The growing reliance on this single herbicide has led to rapid development of glyphosate-resistant weeds, which is beginning to seriously erode the value of this technology (see Section 2.7).

2.3.2 Insect resistance

Insect resistance involves introduction of a gene encoding an insecticidal protein from a soil bacterium (known as *Bt*) into the tissues of the cotton plant, and protects cotton from some (but by no means all) cotton pests, thus reducing the use of insecticides. However, the value added by the IR trait is limited by several factors. First, most IR cotton[7] is highly effective only against the tobacco and pink bollworm caterpillars, but only partially effective against "some of the most damaging insect species," such as cotton and American bollworms (May et al 2003); it provides no protection against other pests such as the boll weevil, stink bugs, plant bugs and mirids (Caldwell 2002). Because farmers continue to spray for these latter pests, IR cotton often provides only a modest reduction in the number of insecticide applications (NAS 1999, p. 114). Secondly, to the extent that insecticide applications are reduced on IR cotton, this ironically often results (over years) in larger populations of the pests not affected by the built-in insecticide, which can then lead to increased chemical applications in later years and erosion or even reversal of the original benefit. For instance, Bt cotton growers in China, who originally benefited through reduced expenditures on insecticides, found themselves applying more (and paying more for) insecticides than non-transgenic cotton growers by year seven due to such secondary pest problems (Connor 2006). Similar problems, though not so severe, have been reported in North Carolina (Caldwell 2002) and Georgia (Hollis 2006).

Cotton with Monsanto's Bollgard or Bollgard II cotton traits comprised 99% of IR cotton planted in the U.S. in 2006, with Dow AgroScience's Widestrike accounting for the rest.

2.3.3 Yield

One often hears unqualified assertions that biotechnology increases crop yields. Yet this is simply not the case. As recently noted by a USDA researcher, biotechnology does ***not*** increase the plant's genetic yield potential, the only meaningful sense in which such claims could be true:

> "Currently available GE [genetically-engineered] crops do not increase the yield potential of a hybrid variety. In fact, yield may even decrease if the varieties used to carry the herbicide-tolerant or insect-resistant genes are not the highest yielding cultivars." (Fernandez-Cornejo & Caswell 2006, p. 9)

These higher-yielding cultivars have been developed over decades with conventional breeding. USDA data reveal a nearly four-fold increase in average cotton yield from 1930 to the early years of the biotech era in 1998, due to conventional breeding in combination with the introduction of

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[7] As used here, "IR cotton" signifies any cotton with the IR trait; as shown in Figure 6, the IR trait nearly always comes in cotton varieties "stacked" with HT.

fertilizers and pesticides (Fernandez-Cornejo 2004, pp. 5-6).[8] Appendix 4 illustrates this trend of increasing yield, and shows that it has not accelerated since 1995, during biotech cotton's rise to dominance, with five years of yield increase offset by six years of yield decline.

Yields of cotton or any crop are influenced by many complex, interacting factors beyond the plant's genetic yield potential. These include soil quality, the amount and timing of rainfall, temperature, severe weather events, insects, weeds and disease. Of great importance, too, is a farmer's management skills and preferences in responding to the particular challenges s/he faces in a given year. Though generalizations are hazardous, studies tend to show that IR cotton has helped farmers reduce yield losses from damage by bollworms (but not other pests) in some areas and situations where bollworm infestation is heavy (e.g. lower Southern states), but has no yield impact in other areas where bollworms are not so troublesome (e.g. upper Southern states). Likewise, most studies of HT cotton have shown no yield gains, while others suggest lesser yield reductions from weed competition versus conventional varieties (see USDA ERS 2001, pp. 11-12 for a review of studies). Of course, additional income from any increased yield must exceed the additional cost of traits (see Table 1) for biotech seed to be profitable for farmers. This hurdle becomes higher as biotech seed premiums rise with stacked and newer generation traits (Figure 5, Appendix 3).

Farmer preferences are also important. For instance, growers who prefer mechanical tillage and/or pre-emergence herbicides for weed control, or organic methods to control insects or weeds, may find little use for biotech traits, as would growers in areas less plagued by bollworms and weeds. Others who like the traits may still not find them worth the steep premiums, and prefer conventional seeds for cost reasons. Clearly, it is of vital importance for farmers to have access to a wide variety of seeds, including conventional varieties, to meet the particular challenges confronting him/her in any given situation, using the methods s/he prefers.

2.3.4 Pesticide use

The most comprehensive independent study to date, based on USDA data, demonstrates that adoption of biotech cotton in the U.S. has led to a 3.7% increase in pesticide[9] use on cotton from 1996 to 2004. A decrease in insecticide use attributable to IR traits has been swamped by a bigger increase in herbicide use facilitated by herbicide-tolerance traits (Benbrook 2004, Appendix Table 11). The ***cost*** of the increased use of pesticides has been largely offset by the declining price of glyphosate, the chief herbicide used on cotton. The declining cost of glyphosate-based herbicides – from $40-45/gallon in the 1990s to $12-16/gallon in 2005-06 (Brown 2006a, slide 46) – is extremely important to keep in mind, as it is largely responsible for steady or declining expenditures on pesticides despite increasing amounts applied as biotech cotton share rises.[10]

Even in the case of IR traits, however, any cost savings from reduced insecticide expenditures must be balanced against the IR trait premium; where bollworm infestation is low, conventional seeds often prove more profitable (Caldwell 2002).

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[8] Though it is difficult to disentangle the various factors, by one account 67% of the increased yield of cotton from 1936-1960 was attributable to conventional breeding (see Fuglie et al 1996, cited in Fernandez-Cornejo 2004, pp. 5-6).
[9] The term "pesticides" encompasses both herbicides (weed killers) and insecticides.
[10] USDA data show a constant, roughly $60/acre, expenditure on "chemicals" applied to cotton from 1997-2005, though these figures appear to be uncorrected for inflation (see USDA ERS 2007b).

2.3.5 Summary of added value

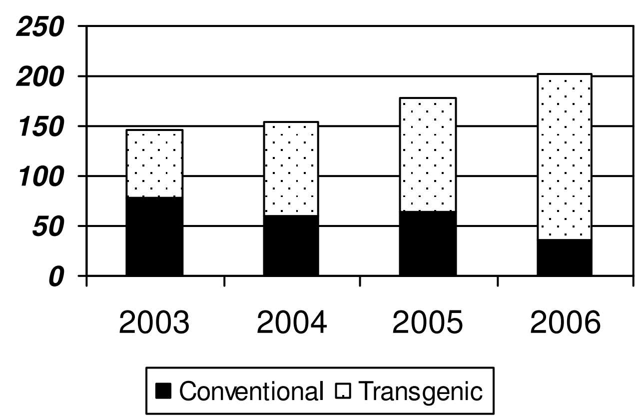
To sum up, biotech cotton has provided added value to many farmers, but this value is highly dependent on the particular region and situation, as well as farmer preference. In general, it can be said that cotton with the HT trait has simplified weed management through greater convenience, lower labor requirements and a decrease in the number of herbicides used. Cotton with the IR trait has slightly reduced insecticide use, and reduced yield losses where bollworm infestation is heavy. Offsetting these advantages are the overall increase in pesticide use, the rise in glyphosate-resistant weeds (Section 2.7), the growing problems with secondary insect pests, and facilitation of the trend to fewer and bigger cotton farms. As discussed further below, the first two problems are exacerbated by near-exclusive reliance on one company's HT traits to the exclusion of other methods of weed control.

These limitations to the value added by biotech traits raise a simple question. Is farmer demand alone responsible for the 88% adoption rate of seeds that cost two to four times as much conventional varieties? Or are other factors at play?

2.4 Biotech versus Conventional Seed: Farmers' Choice?

While biotech seeds are popular with many farmers, there is evidence that some growers purchase them for reasons other than added value. For instance, anecdotal reports suggest that some cotton farmers choose Roundup Ready (RR) cotton varieties to protect their cotton from damage due to glyphosate spray drift from an RR cotton-growing neighbor's field (Arax and Brokaw 1997). Given the ubiquity of RR cotton (82% of total U.S. cotton acreage in 2006), this explanation could apply to a large number of RR cotton farmers, who might otherwise choose to grow conventional varieties. Studies simulating glyphosate spray drift confirm that it can damage cotton (Thomas et al 2005; Lyon & Keeling; Muzzi 2004). Arkansas state officials are considering regulations to minimize glyphosate drift damage to non-RR crops (Bennett 2007). This "defensive" reason for purchase of more expensive RR seeds is not added value, but rather a costly consequence of sloppy weed control practices by neighbors. Farmers who buy RR seeds for this reason say they prefer paying the price premium to the time and hassle of paperwork involved in lodging crop insurance claims to obtain reimbursement for spray drift damage to a conventional cotton crop, not to mention the uncertainty of reimbursement.

Figure 7
Number of Conventional and Biotech Cotton Varieties Planted: 2003 to 2006



Source: USDA AMS (2003-2006).

Another explanation given by cotton growers for purchasing biotech cotton is that seed firms are offering fewer and fewer high-quality conventional cotton varieties. This explanation is supported by independent experts. For instance, Donnie Miller, associate professor with the Louisiana State University AgCenter, stated that one of the "bigger problems" facing cotton growers is that fewer conventional varieties are being developed and released (Bennett 2005). Similarly, Texas cotton consultant Francis Krenek says that some farmers in his area are constrained to use Roundup Ready cotton because in many cases, certain desirable seed varieties are only available in versions that carry the RR trait (PANUPS 2006).

These assessments by farmers and independent cotton experts are confirmed by hard data. First, the number of conventional varieties planted has fallen steeply since just 2003, from 78 to 36. The percentage of planted varieties that are conventional has fallen even more steeply, from 53% in 2003 to just 18% in 2006, reflecting both reduced conventional and increased transgenic cotton seed offerings (Figure 7). This dramatic decline in the availability of conventional seed occurred during a period when the transgenic share of U.S. cotton acreage increased only modestly, from 76% to 88%.

The top three firms (DPL, Bayer and Monsanto's Stoneville) offer a disproportionately small share of the planted conventional cotton varieties, 54% over the past four years, despite seed sales responsible for over 90% of 2006 cotton acreage. For instance, Stoneville's conventional varieties declined from 5 in 2003 to just 2 in 2006, while the number of its planted biotech varieties climbed from 11 to 32 over the same time period. DPL had 21 conventional lines planted in 2003, shrinking to 15 in 2006. The number of planted varieties from Bayer fell from 15 in 2003 to 6 in 2006.[11]

Nearly half the conventional varieties planted from 2003 to 2006 came from smaller suppliers, and the number of smaller cotton seed suppliers (i.e. other than DPL, Bayer and Monsanto's Stoneville) listed in USDA data covering virtually 100% of planted upland cotton has declined from 16 in 2003 to just 6 in 2006. This all portends continuing reductions in the availability of conventional cotton seed.

Equally important is the lower quality of the few conventional varieties that are still being offered. The top firms either do not offer conventional versions of their top-selling transgenic cotton varieties, or only limited supplies of the same. As noted in Section 2.3, biotech traits are limited to herbicide tolerance and insect resistance. All other characteristics – such as boll size, fiber quality, disease resistance, and above all, yield – are properties of the specific germplasm, not biotechnology.[12] This means that farmers who want the desirable, non-biotech attributes of the best varieties (especially high yield) may have no alternative but to purchase costly biotech seed, whether or not they want the HT and/or IR traits at all, or at least at the substantial premium over conventional seeds.

One indication of the lower quality of conventional varieties offered by industry leaders is the steeply falling acreage planted to them. For instance, U.S. cotton acreage planted to all DPL's conventional varieties declined from 6.36% in 2003 to just 1.47% in 2006. Acreage planted to all of Stoneville's few conventional varieties over the same time period is negligible, roughly 0.3% of U.S. cotton in 2003 to less than 0.1% in 2006. The decline in acreage planted to DPL's and Stoneville's conventional varieties in this four-year period is more than twice as steep as the overall decline in conventional acreage, from 23.78% of U.S. cotton in 2003 to 12.36% in 2006.

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[11] For purposes of comparison, the numbers for Bayer include conventional varieties offered by Bayer (Fibermax) and by AFD Seed in both 2003 and 2006, even though Bayer only acquired AFD Seed in 2005.

[12] This assumes no adverse consequences from the genetic modification process. Actually, there is some suggestive evidence that fiber quality may be lower in certain biotech varieties (Edmisten 2000), but this issue lies beyond the scope of this report and will not be addressed here.

Many popular varieties of cotton are offered only in biotech versions. For instance, Stoneville's ST 5599 BR has been a leading variety since at least 2003. "BR" designates it as Monsanto's Bollgard/Roundup Ready IR/HT stack; Stoneville does not appear to offer a conventional version of this line (i.e. "ST 5599" is absent from USDA data). DPL's enormously popular DP 555 BG/RR (also Bollgard/Roundup Ready) was the top-selling cotton variety from 2003 (8.68% of planted cotton acreage) to 2006 (17.3%). According to University of Georgia cotton expert Steve M. Brown, DP 555 BG/RR is popular chiefly because it outyields other varieties by 100-300 lbs./acre (personal communication). No conventional version of this variety is listed in USDA data, nor is one listed on DPL's website. It seems likely that at least some farmers would buy conventional versions of these top-selling cultivars, if only they were made available.

The evidence from other cultivars suggests they would. For instance, in 2006, DPL's conventional lines DP 5415 and DP 5690 were planted on slightly more combined acreage (0.76% of all cotton) than their Roundup Ready counterparts DP 5415 RR and DP 5690 RR (0.67%). Despite this demand, DPL's website no longer lists conventional DP 5415 or DP 5690, suggesting they will not be sold in 2007, while the Roundup Ready versions are still being offered.[13] This would be entirely consistent with DPL's goal of "increased technology penetration." A similar comparison is unavailable for Monsanto's Stoneville, because there do not appear to be conventional variants of any of Stoneville's transgenic lines.

Another example comes from Bayer CropScience, the number two supplier of cotton seed with 30% of the U.S. market (Fibermax, AFD Seed and CPCSD brands). Bayer does not feature a single conventional cotton variety in its "2006 Fibermax Variety Guide," merely noting in fine print that three conventional Fibermax lines "are available for 2006 in limited supply. Please contact your local seed dealer for additional information" (Bayer Fibermax 2006). It is surprising that Bayer would have limited supplies of these varieties, since two of them were the top-selling conventional varieties offered by ***any*** company, planted on 7.14% of U.S. cotton, or over 1 million acres, in 2006.

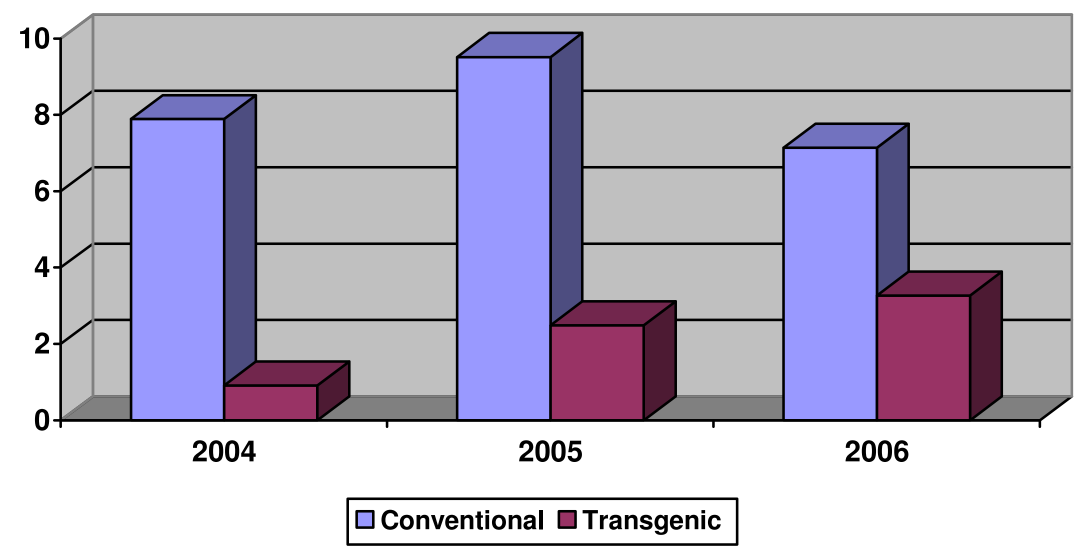
Why would Bayer have limited supplies of these two popular conventional varieties, designated FM 958 and FM 832? One possible explanation is that Bayer did not produce enough seed because it did not expect them to be so popular. Yet this seems unlikely, given the fact that FM 958 and FM 832 represented an even greater share of cotton planted in 2004 and 2005, as shown in Figure 8. Figure 8 also demonstrates that farmers prefer the conventional versions of each line to their biotech variants (FM958B and FM 832B with the IR trait; FM 958LL and FM 832LL with HT). This strongly suggests that the increasing acreage planted to the biotech variants is attributable to Bayer's intentional limitation of conventional supplies. In other words, farmers who want the desirable properties of FM 958 and FM 832, but cannot obtain the conventional versions due to limited supplies, have no recourse but to purchase the more expensive biotech variants. Per acre price data show that the herbicide-tolerant biotech variants are nearly twice as expensive as the

[13] For availability, see http://www.deltaandpine.com (last accessed 12/28/06). Select "Cotton Varieties" tab at the top, then "conventional" for each of the given regions to confirm the absence of DP 5415/5690; select "Roundup Ready" to confirm that DP 5415/5690 RR are still being offered. For percentages of DP 5415 & 5690 varieties, see USDA AMS (2004-2006). Note that the 0.76% figure for conventional DP 5415/5690 represents over 113,000 of the 14.95 million acres of upland cotton planted in the U.S. in 2006 (USDA NASS 2007).

corresponding conventional versions: $33.26 versus $18.09 for FM 958, and $31.48 versus $17.45 for FM 832 (Plains Cotton Growers 2006).[14]

Together, Bayer (73%) and DPL (13%) account for 86% of conventional cotton acreage. The remaining 14% of conventional cotton seed planted in 2006 was supplied by regional cotton suppliers: Phytogen, mainly in California (7.2%); and All-Tex (2.6%), Americot (2.5%) and Beltwide Cotton Genetics (1.4%), mainly in Texas. These smaller firms, with limited seed varieties adapted to the growing environments of their regional markets, are unlikely to be able to meet farmer demand for high-quality conventional varieties in most areas of the country. The public sector, which once might have met this lower profit margin-market, virtually disappeared in 1992 (see Appendix 1).

Figure 8
Percentage of U.S. Cotton Planted to Bayer's Two Top Conventional Lines vs. Biotech Variants of the Same Lines: 2004-2006



Combined percentage of U.S. upland cotton planted to Bayer's conventional FM 958 and FM 832 versus combined percentage planted to 2 biotech versions of each line from 2004-2006. Despite the popularity of these two top-selling conventional varieties with farmers, Bayer announced "limited supplies" of both for 2006. Based on data from USDA AMS (2004-2006).

Conventional upland cotton seed was planted on 1.85 million acres in 2006, representing nearly one-eighth of the 14.95 million upland cotton acres planted.[15] Thanks to oligopolistic market power, many farmers may soon have little choice but to plant biotech cotton, whether or not they want biotech traits at all, or at least at the prices at which they are offered. Indeed, it appears this is already happening. The elimination of more affordable conventional cotton seed is not only unfair to farmers, it has troubling implications for the future of the U.S. cotton industry.

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[14] Per acre price data were not available for the insect-resistant versions of the two lines.
[15] 12.36% of planted upland cotton acreage was conventional (USDA AMS 2006). 14.95 million acres of upland cotton were planted in 2007 (USDA NASS 2007).

2.5 Single-Trait versus Stacked Cotton

Nearly three-fourths of biotech cotton planted in 2006 was stacked with two traits, HT and IR (Section 2.3, Figure 6). According to some experts, many farmers are being constrained to purchase cotton with two traits when they want only one. Keith Edmisten, associate professor and cotton specialist at North Carolina State University, explains that some of his state's growers would prefer to purchase HT-only cotton,[16] but end up buying HT/IR varieties because the better quality (e.g. higher-yielding) cultivars come only in stacked, not HT-only, versions. University of Georgia cotton expert Steve M. Brown agrees that the available cotton varieties with the Roundup Ready (Flex) trait alone tend to be lower-yielding than stacked Monsanto varieties (personal communications).

DPL and Monsanto are committed to "increased technology penetration" (DPL 2004) and "accelerate[d] biotech trait penetration" (Monsanto 2006b) for "increased returns from technology to the business" (DPL 2004) – in other words, higher profit margins. We have discussed several tactics employed by companies to implement this strategy: phasing out or limiting supplies of desirable conventional varieties, and offering the best cultivars only in biotech versions, or only in stacked versus single-trait versions. As a result, farmers often purchase, and pay more for, technology they do not need or want.

2.6 Biotech Cotton Failures

While many farmers have been satisfied with biotech cotton, others have experienced erratic performance. Cotton bearing the traits of market-leader Monsanto has been plagued by numerous failures since the introduction of insect-resistant Bollgard cotton in 1996 and glyphosate-tolerant Roundup Ready cotton in 1997.

For example, farmers in Texas, Oklahoma, Louisiana and Mississippi who planted Bollgard cotton in 1996 were surprised to find that cotton bollworms thrived in up to 50% of their fields, even though the cotton was supposed to be immune to these pests (Lambrecht 1998; Consumers Union 1999). As a result, farmers who had already paid a premium for "bollworm-resistant" cotton had to purchase and spray insecticides, or risk losing their crop (Benson et al 1997). These first Bollgard cotton varieties also exhibited poor germination, late maturity, lower yield, and other defects. The failures were so severe that the cotton growers filed a class action suit against Monsanto; according to the plaintiffs' attorney, Monsanto paid the farmers a substantial sum in an out-of-court settlement (Consumers Union 1999). A second generation of Bt cotton (Bollgard II) with better resistance to bollworms was introduced in 2003. Yet Bollgard II cotton varieties are predicted to facilitate increased infestations of pests unaffected by the built-in insecticides, such as stink bugs (Yancy 2004).

Roundup Ready (RR) cotton has also failed farmers repeatedly. In 1997, growers in Mississippi, Arkansas, Tennessee, Louisiana, Texas and Missouri reported that the cotton-bearing bolls on their RR cotton simply dropped off, or were deformed, causing substantial yield losses (Lambrecht 1998; Chattanooga Times 1997; Kerby & Voth 1998). The director of Mississippi's Bureau of Plant Industry, Robert McCarty, stated that only Monsanto varieties seemed to fail, over an area totaling 30,000 acres (Meyerson 1997). While Monsanto blamed cold, wet weather for the cotton failures,

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[16] The chief reason is that North Carolina farmers must usually spray for stink bugs whether or not their cotton has the IR trait (see Section 2.3.2), and so would prefer not to waste money on the IR trait premium. In addition, some growers wish to avoid planting "refuges" of non-IR cotton, a requirement for growers of IR cotton imposed by the Environmental Protection Agency to slow development of insects resistant to the built-in insecticide(s).

arbitrators at the Mississippi Seed Arbitration Council decided otherwise, issuing a non-binding resolution calling on Monsanto to reimburse three farmers $1.94 million for their damages (NYT 1998), which Monsanto refused to do (Steyer 1998). Monsanto and Delta and Pine Land eventually pulled five varieties of Roundup Ready seed due to substandard quality (Lambrecht 1998), and Monsanto paid 55 Mississippi growers an estimated $5 million in compensation (NYT 1998).

In 1998, 190 growers in Georgia, Florida and North Carolina reported similar problems with Roundup Ready cotton (Augusta Chronicle 1999, Edmisten 1998). Andrew Thompson of Georgia reported losing nearly a quarter of his crop, costing him $250,000.

Farmers and cotton experts say Monsanto rushed its RR cotton to market, without giving university researchers (May et al 2003, p. 1596) or even a USDA scientist opportunity to test it. USDA geneticist William Meredith was denied seeds to test at a government lab, because in order to obtain the seeds, he would have had to sign an agreement with Monsanto not to test them. "You need a good referee in the ball game, which is what I am," he reportedly said. "But some of the Monsanto people thought they knew all they needed to know about cotton" (as quoted in Lambrecht 1998).

In 2005, there were once again widespread yield losses with Roundup Ready cotton, this time in Texas (PANUPS 2006). Many of the cotton bolls fell off, others were misshapen, still others didn't open before harvest, and so could not be picked by machine. These are all symptoms of Roundup damage, and scientists have confirmed that under certain conditions RR cotton is not immune to glyphosate (Cerdeira & Duke 2006). As with the failures of Bollgard cotton cited above, farmers experienced double losses: from payment of large premiums for a non-performing trait, and lost income from large drops in yield. These farmers also filed suit against Monsanto to recover their losses; at this writing, the outcome is still pending.

There are likely many more incidents of this sort that have gone unreported by farmers. Defective RR cotton that is damaged by Roundup early in the season may recover later, and in some cases yield may not be affected (Jones & Snipes 1999). Monsanto also has a program to reimburse farmers for defective cotton, but only when stringent conditions are met. While these conditions vary by region and seed supplier, they can include having planted at least 70% of one's total acreage with cotton bearing Monsanto's trait(s); near total loss of the crop (yield $<$ 150 lbs./acre, or less than one-fifth the 2006 national average yield of 798 lbs./acre), and exclusive use of Monsanto's more expensive Roundup brand of glyphosate (Smith 2004). Many farmers who do not meet these conditions have likely suffered losses without compensation. Substandard performance and outright failure of Monsanto biotech cotton has been frequently reported in India and Indonesia as well (see Section 3.9).

Other Roundup Ready crops have exhibited similar problems. For instance, RR soybeans have been observed to perform poorly during hot, dry conditions, and are more subject to "stem-splitting" (Coghlan 1999), which can result in higher yield losses relative to conventional soy. In both Brazil and Paraguay, RR soy was reported to suffer greater yield losses than conventional soy during drought conditions over the past two years (FoE International 2007). Benbrook (2001) discusses a number of additional agronomic problems with RR soybeans.

The sometimes erratic performance of biotech cotton and other biotech crops underscores the need to maintain vigorous breeding programs for continued production of high-quality conventional seed, which as described above is on the decline.

2.7 Glyphosate-Resistant Weeds

Monsanto provides the traits deployed in 95-96% of U.S. transgenic cotton (Figure 2), representing 82-83% of U.S. cotton overall. Such extreme market power is undesirable in any industry, as it tends to hamper innovation, restrict choice and raise prices. In agriculture, however, this high degree of concentration can also have grave agronomic consequences. In this and the following section, we discuss the adverse effects of increasing reliance on use of a single herbicide, glyphosate, fostered by Monsanto's virtual monopoly in transgenic cotton traits.

Farmer adoption of glyphosate-tolerant, "Roundup Ready" cotton has led directly to a 753% increase in glyphosate use on cotton in the U.S. from 1997 to 2003 (Steckel et al 2006). Just as overuse of an antibiotic breeds resistant bacteria, so overuse of glyphosate has spawned rapidly growing populations of weeds the chemical is no longer able to kill, except perhaps at greatly increased rates of application.

North Carolina weed scientist Alan York has called it "potentially the worst threat [to cotton] since the boll weevil," the devastating pest that virtually ended cotton-growing in the U.S. until an intensive spraying program eradicated it in some states in the late 1970s and early 1980s (Minor 2006). And York isn't alone. University of Georgia weed scientist Stanley Culpepper has found over 100,000 acres of Georgia cotton infested with glyphosate-resistant pigweed that survives up to twelve times the normal rate of Roundup (Laws 2006c).

Glyphosate resistance in weeds has developed with incredible rapidity over just six years, corresponding with the period of widespread introduction of Roundup Ready cotton and soybeans. In contrast, there was only one confirmed glyphosate-resistant weed in the U.S. in the 22 years from 1976, when Monsanto first introduced the chemical in the U.S. (Monsanto 2007), through 1998.[17] Concern began building in 2001, when a farm journal reported:

> "Resistance to glyphosate (Roundup) is emerging all around the world, potentially jeopardizing the 2.5 billion dollar market for genetically modified herbicide tolerant crops" (Farmers Weekly 2001).

According to a joint statement by ten prominent weed scientists (Boerboom et al 2004):

> "It is well known that glyphosate-resistant horseweed (also known as marestail) populations have been selected in Roundup Ready soybean and cotton cropping systems. Resistance was first reported in Delaware in 2000, a mere 5 years after the introduction of Roundup Ready soybean. Since that initial report, glyphosate-resistant horseweed is now reported in 12 states and is estimated to affect 1.5 million acres in Tennessee alone."

The list of confirmed glyphosate-resistant weeds in the U.S. now stands at seven, with the latest addition (giant ragweed) reported in January 2007 (Ohio Farm Bureau 2007). A number of additional weed species are under investigation for resistance (Roberson 2006), and the acreage affected is growing rapidly. An online farm journal recently devoted an extensive special edition,

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[17] The sole resistant weed by 1998 was rigid ryegrass in California. See website of The Weed Science Society of America. http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=12&FmHRACGroup=Go

with contributions from leading weed scientists across the country, to glyphosate-resistant weeds (Crop News Weekly 2006).

Farmers have several options to deal with such weeds. They can:
1) Apply more glyphosate (resistance is not an all-or-nothing phenomenon, and is defined as the ability to survive the normal rate of herbicide application, not absolute immunity).
2) Switch to an herbicide with a different "mode of action"
3) Stop planting Roundup Ready crops and applying glyphosate every year in order to lessen the "selection pressure" that accelerates development of glyphosate-resistance.
4) Switch from no-till or conservation tillage to conventional tillage

Option 1 – using more glyphosate – is probably the most common response. While this can be effective in the short-term, it leads to a vicious cycle of escalating resistance, followed by still more glyphosate use. Monsanto's introduction in 2006 of a "second generation" Roundup Ready cotton known as Roundup Ready (RR) Flex may well facilitate this misguided approach. RR Flex is engineered to withstand higher application rates of Roundup than first generation RR cotton, and to permit application throughout the growing season, rather than only in the early growth stages as with original RR (Bennett 2005). Producers who adopt RR Flex cotton in the hopes of better controlling resistant weeds will not only pay for more glyphosate, but also spend roughly 40% more for RR Flex (see Table 1).

Weed scientists recommend use of different herbicides (option 2) to stem development of resistant weeds, but often in combination with heavier applications of glyphosate (Yancy 2005). An Arkansas weed scientist estimated that the state's growers would have to spend as much as $9 million to combat glyphosate-resistant horseweed in 2004 (AP 2003). The alternative is even more expensive. Left unchecked, horseweed can reduce cotton yields by 40-70%. Larry Steckel, weed scientist at the University of Tennessee, estimates that on average, glyphosate-resistant pigweed will cost cotton growers in the South an extra $40 or more per acre to control (Laws 2006a). This represents a substantial burden, as cotton farmers' average expenditure on ***all*** pesticides (insecticides and herbicides) was $61 per acre in 2005 (USDA ERS 2007b).

Option 3 – reducing glyphosate use through growing non-RR cotton or non-RR crops in rotation with RR cotton – is also recommended (Yancy 2005), but is becoming progressively more difficult with the declining availability of quality conventional seed,[18] and the continuing paucity of non-RR biotech varieties. The only non-RR HT trait planted commercially is Bayer's LibertyLink (LL).[19] Only nine varieties of LL cotton were planted in 2006, representing only 4% of cotton acreage, versus a total of 149 varieties with RR or RR Flex, comprising 82% of U.S. cotton.

Option 4 is to physically remove the weeds through mechanical tillage or hand weeding. Mechanical tillage, once common, has been on the decline for years as farmers switch to "no-till" or conservation (minimal) tillage practices in order to reduce labor costs and fuel expenditures, as well

[18] While farmers of course could grow RR cotton without using glyphosate, it would represent wasted expenditure on the premium (technology fee) paid for the trait. In other words, payment of the premium is a strong inducement to make use of the trait through application of glyphosate.
[19] USDA data list two varieties of bromoxynil-tolerant cotton in 2006, one from Stoneville and one from Bayer, but their aggregate acreage amounted to less than 0.05% of U.S. cotton. Stoneville reportedly retired all of its bromoxynil-tolerant cotton seed offerings after the 2004 season (Robinson 2004).

as decrease the soil erosion that often accompanies plowing. The rise of glyphosate-resistant weeds is beginning to reverse this trend.[20] For instance, acreage under conservation tillage in Tennessee dropped by 18% in 2004, as farmers turned back to the plow to control glyphosate-resistant horseweed; Tennessee counties with the largest cotton acreage experienced the largest decline in conservation tillage, from 80% to just 40% (Steckel et al 2006). It is estimated that resistant horseweed has reduced the area under conservation tillage in Arkansas by 15%, with similar trends reported in Missouri and Mississippi (Ibid). In particularly bad cases of glyphosate-resistant pigweed in Georgia, the necessity of hand-weeding can cost growers $92 an acre (Laws 2006a).

The over-reliance on a single herbicide fostered by Monsanto's near-monopoly in cotton traits is confronting cotton and other growers with an extremely serious agronomic problem. Aside from non-chemical weed control methods used in organic cotton production, the only real solution is use of herbicides other than glyphosate. But this is unlikely as long as glyphosate-tolerant, Roundup Ready cotton comprises over 80% of US cotton. In fact, over-reliance on Roundup Ready crops and glyphosate has dampened research into new herbicides, meaning none are on the horizon (Mueller et al 2005, p. 925; Yancy 2005). Meanwhile, growers will increasingly turn to older, more toxic herbicides, such as paraquat and 2,4-D, to control glyphosate-resistant weeds (Roberson 2006).

A growing body of research suggests other serious consequences of farmers' growing dependence on glyphosate and Roundup Ready crops.

2.8 Glyphosate Use Linked to Plant Disease, Mineral Deficiencies and Reduced Yield; Roundup Toxic to Amphibians

Overall glyphosate use in the U.S. increased six-fold from 1992 to 2002, due largely to the widespread introduction of Roundup Ready soybeans and cotton (Cerdeira & Duke 2006, p. 1633); area planted to Roundup Ready corn is growing as well (Monsanto 2006c). RR versions of these crops are increasingly grown in rotation, meaning that each year, more prime cropland is sprayed more frequently with glyphosate, with increasing rates applied in many areas to control resistant weeds. While glyphosate is generally regarded as less toxic than many weed killers, a growing body of research suggests that continual use of this chemical may make RR plants more susceptible to disease and prone to mineral deficiencies than conventional crops, as well as reducing their yields. In addition, recent studies suggest that Roundup is much more toxic to amphibians than previously thought.

When Roundup is sprayed on RR crops, much of the herbicide ends up on the surface of the soil, where it is degraded by microorganisms. However, some is absorbed by the plant and distributed throughout its tissues. Small amounts of glyphosate "leak" from the roots of RR plants and spread throughout the surrounding soil (Motavalli et al 2004; Kremer et al 2005; Neumann et al 2006). This root zone is home to diverse soil organisms, such as bacteria and fungi, that play critical roles in plant health and disease; and it is also where the roots absorb essential nutrients from the soil, often with the help of microorganisms.

The presence of glyphosate in the root zone of RR crops can have several effects. First, it promotes the growth of certain plant disease organisms that reside in the soil, such as *Fusarium* fungi (Kremer

[20] Some attribute the rise of conservation tillage to adoption of RR crops, yet a USDA expert notes that the steep rise in conservation tillage (at least in soybeans) came from 1990-1996, before their introduction, and that the share of soybean acres grown with conservation tillage stagnated after 1996 (Fernandez-Cornejo & McBride 2002, p. 29).

et al 2005). Even non-RR crops planted in fields previously treated with glyphosate are more likely to be damaged by fungal diseases such as Fusarium head blight, as has been demonstrated with wheat in Canada (Fernandez et al 2005). This research suggests that glyphosate has long-term effects that persist even after its use has been discontinued. Second, glyphosate can alter the community of soil microorganisms, interfering with the plant's absorption of important nutrients. For instance, glyphosate's toxicity to nitrogen-fixing bacteria in the soil can depress the absorption of nitrogen by RR soybeans under certain conditions, such as water deficiency, and thereby reduce yield (King et al 2001). Some scientists believe that this and other nutrient-robbing effects may account for the roughly 6% lower yields of RR versus conventional soybeans (Benbrook 2001).

Other research shows that Roundup Ready crops themselves are less efficient at taking up essential minerals such as manganese through their roots (Gordon 2006), and that glyphosate inside plant tissues can make such minerals unavailable to the plant (Bernards et al 2005). The resultant mineral deficiencies have been implicated in various problems, from increased disease susceptibility to inhibition of photosynthesis.

While much of this research involves RR crops other than cotton, similar impacts are likely with cotton, given the heavy use of glyphosate common to all RR crops. In addition, it should be recalled that many farmers rotate RR cotton with RR soy and to a lesser extent with RR corn.

Finally, recent studies (Relyea 2005a, 2005b) demonstrate that common versions of Roundup herbicide that contain a surfactant (i.e. POEA, or polyethoxylated tallowamine) to aid penetration of the active ingredient (glyphosate) into plant tissue are extremely toxic to the tadpoles and juvenile stages of certain species of frogs, killing 96-100% of tadpoles after three weeks exposure and 68-86% of the juveniles after just one day.

2.9 Inadequate Regulatory Oversight

While the U.S. Dept. of Agriculture's Animal and Plant Health Inspection Service (APHIS) is primarily responsible for assessing the potential environmental impacts of biotech crops, it has by many accounts failed to do its job. A National Academy of Sciences committee identified numerous regulatory deficiencies in 2002 (NAS 2002), and since then several federal courts have ruled against APHIS for failure to adhere to U.S. environmental laws with respect to biotech crops (e.g. CFS et al vs. Johanns et al 2006; CTA et al vs. Johanns et al 2007). In February 2007, the U.S. District Court for Northern California ruled that APHIS must perform an environmental impact statement on Roundup Ready alfalfa, which APHIS de-regulated in 2005 despite having failed to prepare one. Among the Court's concerns was the potential for RR alfalfa to increase the prevalence of glyphosate-resistant weeds, a concern that APHIS ignored:

> "The Court notes, however, that it is unclear from the record whether any federal agency is considering the cumulative impact of the introduction of so many glyphosate resistant crops; one would expect that some federal agency is considering whether there is some risk to engineering all of America's crops to include the gene that confers resistance to glyphosate" (Geertson Seed Farms et al vs. Johanns et al 2007, pp. 16-17).

The growing dependence of American farmers on the use of glyphosate poses long-term risks to the productivity of U.S. agriculture and the environment, risks which U.S. regulators are largely ignoring. There is little hope of breaking this dangerous dependence as long as Monsanto maintains a near-monopoly in transgenic HT traits with its Roundup Ready crops.

3. ASSESSMENT OF THE PROPOSED MERGER

To assess the impacts of the merger, one must compare the likely effects on the cotton seed and traits industry of DPL as a subsidiary of Monsanto versus as an independent entity, informed by an analysis of existing trends, as described above.

In our view, the merger must be evaluated in terms of its potential impacts on: 1) Concentration in cotton germplasm; 2) Availability of quality conventional seed; 3) Cotton seed prices; 4) Concentration in biotech traits; 5) Production costs and the productivity of American cropland; 6) Growers of other major crops; 7) Grower and consumer choice for organic cotton seeds and products; and 8) Introduction of DPL's seed sterility technology, known as Terminator. We also believe that potential international impacts of the merger deserve consideration. Finally, we will discuss the feasibility of conduct-based solutions to address anti-competitive effects of the merger.

3.1 Further Concentration in Cotton Seed

As discussed in Section 2.1.1 and portrayed in Appendix 1, concentration in the cotton seed market has increased dramatically since 1970, and especially since the early 1990s. Top four market share reached 90% by 1996, while top ***three*** market share has averaged 91% since the year 2000. Despite these facts, some still try to argue that there are more competitors in the cotton seed market today than in 1998, when Monsanto first attempted to acquire DPL, and imply that the merger should be permitted for this reason (e.g. Leonard 2006). This argument is without merit for several reasons. First, it seems to rest exclusively on Bayer's rising market share since 1999. Yet competitiveness is not ensured by having three rather than two firms controlling 90% or more of the national market. More relevant is that the number of smaller suppliers (i.e. other than DPL, Bayer and Stoneville) with sales appreciable enough for listing in USDA data fell by more than half in just the last four years, from 16 in 2003 to 6 in 2006.[21] Second, Bayer's seed sales are concentrated heavily in the Southwest, particularly Texas, and thus the company's rising market share has done little or nothing to increase competition in other regions. Indeed, DPL's market share in the important Southeastern (SE) and South Central (SC) markets[22] has actually increased during the years of Bayer's rise, from 81% (SE) and 61% (SC) of acreage planted in 2003 to 86% (SE) and 73% (SC) in 2006.

Another argument presented by proponents of the proposed acquisition is that it would not change overall market concentration, provided Monsanto divests Stoneville (Leonard 2006). This assumes, however, the viability of Stoneville as an independent entity. Sandy Stewart, Associate Professor and Extension Cotton Specialist with the Louisiana State University AgCenter, has questioned whether a divested Stoneville would be competitive in 2008 (Laws 2006b). Without the advantage of affiliation with the world's largest seed and traits firm, Stoneville might well be ripe for takeover. The history of the cotton seed industry is rife with takeovers (Appendix 1). Stoneville could

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[21] Based on USDA AMS reports, 2003-2006, which lists market share by brand rather than supplier. The number of suppliers is arrived at by subtracting brands known to be owned by another supplier. Of 21 brands listed in 2003, Paymaster and Sure-Grow are owned by DPL, leaving 19 suppliers, or 16 other than the top three. Of the 13 listed brands in 2006, we subtract Paymaster and Sure-Grow as well as AFD Seed and California Planting Cotton Seed Distributors (the latter two purchased by Bayer in 2005 and 2006, respectively) to arrive at 9 suppliers, or 6 suppliers other than the top three. Note also that USDA AMS figures show generally declining market share for the "Miscellaneous" category comprising all suppliers too small for listing in its reports: from 1.36% of upland cotton acreage planted in 2003 to just 0.68% in 2006.

[22] The Southeastern market comprises Alabama, Florida, Georgia, N. & S. Carolina and Virginia. The South Central market comprises Arkansas, Louisiana, Mississippi, Missouri and Tennessee.

succumb to the fate of Lankart, Paymaster, Sure-Grow, AFD Seed and others. For instance, in 1993, Paymaster's 29% market share in cotton seed was more than double Stoneville's current 12%. DPL acquired the company the following year. If the merger goes through, Stoneville might well become an attractive target for Bayer, which has acquired at least two cotton seed firms in the past two years. If Bayer were to acquire a divested Stoneville, the virtual oligopoly of three in cotton germplasm would become a duopoly: Monsanto-DPL would control 51%, and Bayer-Stoneville 42%, of the cotton seed market, for a top two market share of 93%. This enhanced market power would likely hasten the already precipitous exit of smaller cotton seed firms from the market.

3.2 Declining Availability of Conventional Cotton Seed

The discussion above clearly shows a decline in the number and quality of conventional cotton seed varieties planted, despite continued demand from farmers. Among the top three, Monsanto's Stoneville has gone furthest in purging conventional cotton lines from its offerings, with only two varieties planted to negligible acreage in 2006. These two unpopular varieties represent only 6% of 34 planted Stoneville varieties, whereas conventional varieties comprise a more than 3-fold larger share of planted varieties from other cotton seed firms. Judging by its conduct with Stoneville, it seems reasonable to assume that post-merger, Monsanto would similarly reduce the number of conventional seed varieties offered by DPL. This assumption is strengthened by Monsanto's announced strategy, in a presentation to investors on the DPL acquisition, to "accelerate biotech trait penetration" (Monsanto 2006b). Increased trait penetration would come at the expense of conventional seed offerings. Given the fact that DPL's 15 non-transgenic lines comprise over 40% of conventional cotton varieties planted in 2006, the merger would likely further restrict farmers' ability to choose quality conventional cotton seed.

3.3 Accelerated Rise in Cotton Seed Prices

As discussed above, cotton seed prices have risen dramatically with the advent of biotechnology. Relative to industry-wide figures for 2006, Stoneville offers slightly higher percentages of the highest price seed categories – stacked varieties and varieties with 2nd generation traits (data not shown) – both of which increase the average price of its seed (see Figure 5 and Table 1). In its presentation to investors, Monsanto announced its intention to ***"invest in penetration of higher-margin traits in Delta and Pine Land offerings"*** (Monsanto 2006b). Since DPL currently sells more than four times as much cotton seed as Stoneville, Monsanto's pursuit of this policy with an acquired DPL would lead to an acceleration of the already steep rise in cotton seed prices.

Table 2: Potential for Further Trait Penetration in Cotton Seed

	Type of Cotton Seed								
	Conventional (no traits)		One trait	Two traits		Only generation 1 trait(s)	Only generation 2 trait(s)	Mixed generation 1 and 2 traits	Non-Monsanto single trait
% of 2006 acreage	12.36								
% of 2006 biotech acreage			25.90	74.09		78.17	8.13	9.94	3.76
TOTALS			100%			100%			

Calculated from data in USDA AMS (2006).

The potential for seed price increases can be gauged by breaking down the composition of 2006 cotton acreage by: a) conventional versus biotech; b) one versus two traits; and c) generation 1 versus generation 2 traits (Table 2). First, replacement of conventional varieties with biotech cultivars offers the greatest per unit potential for increasing profit margins/prices, since no tech fees at all are collected on these seeds. As shown in Appendix 3 and Figure 5, single-trait cotton seed is on average twice the price, and stacked cotton roughly four times the price, of conventional seed. Second, the potential for increasing prices through trait stacking is limited, but still substantial, with 26% of 2006 biotech cotton acreage from seeds bearing just one trait. As shown in Table 1, companies charge roughly 40% more for seed with two traits versus just one. The greatest potential for increasing the price of cotton seed, however, lies in replacement of popular first-generation traits with their second-generation counterparts (this applies only to Monsanto), which also entails a price increase of roughly 40% (Table 1). Bollgard II was introduced in cotton in 2003, Roundup Ready Flex in 2006 (Monsanto 2007). 78% of 2006 biotech cotton acreage was planted to varieties containing only generation 1 trait(s), 8% to those with only second-generation trait(s), and 10% to stacked varieties with mixed generation 1 and 2 traits. Replacement of first generation with higher-margin second-generation traits in seeds planted to upwards of 78% of biotech cotton acreage represents a large profit potential, which as indicated above Monsanto intends to exploit post-merger in DPL cotton seed offerings.

Another portent of increased seed prices is provided by University of Georgia cotton expert, Steve Brown, who already predicts cotton seed prices rising from $44 to a range of $80-$120 per acre (Brown 2006a, slide 46). It is unclear whether or not this $80-120 figure accounts for the price-increasing effects of the proposed combination.

3.4 Reduced Availability of Cotton with Non-Monsanto Traits

As a subsidiary of Monsanto, only one (3%) of Stoneville's 32 biotech cotton varieties planted in 2006 carried a non-Monsanto trait, versus 17 of 135 (13%) biotech varieties with non-Monsanto traits for the rest of the industry. This one variety – bromoxynil-tolerant cotton BXN 47 – was planted to negligible (<0.05%) acreage.[23] In other words, biotech varieties with non-Monsanto traits are more than four times more common in cotton seed sold by Stoneville's competitors (chiefly Bayer and Phytogen). If Monsanto were allowed to acquire DPL, one would expect it to pursue the same policy (exclusion of competitors' traits) with its new subsidiary's germplasm. In 2006, all 46 of DPL's biotech cotton varieties carried Monsanto traits. Yet over the past few years, DPL has taken significant steps to diversify its future biotech trait offerings, steps which could easily be undone in the event of a merger. Below, we examine DPL's diversification efforts and the broader field of experimental biotech traits being developed in cotton.

3.4.1 Cotton with Syngenta's VipCot insecticidal protein:

In 2004, DPL acquired global licenses to incorporate VipCot insecticidal proteins developed by Syngenta in its cotton varieties, in return for $47 million to be paid over three years (DPL-Syngenta 2004). Though DPL expected to market limited quantities of VipCot-containing seed in 2006, this did not come to pass. In 2006, DPL acquired Syngenta's global cotton seed business, including cotton germplasm in the U.S. In the company's 2006 press release, commercial introduction of VipCot-containing cotton varieties was pushed back 2-3 years, to 2008-09, "subject to receiving regulatory approvals" (DPL-Syngenta 2006). Syngenta received USDA clearance for VipCot in 2005

[23] In 2004, Emergent Genetics, Inc., then owner of Stoneville, announced a phase-out of bromoxynil-tolerant cotton varieties (Robinson 2004).

(USDA APHIS 2005), but since 2004 has obtained only a series of time-limited provisional approvals from the Environmental Protection Agency (EPA) for the VipCot insecticidal protein VIP3A (for the first, see EPA 2004).[24] The latest provisional approval expires on May 1, 2007 (EPA 2006), at which point Syngenta might seek a renewal of the temporary exemption from EPA, or apply for final clearance. Marketing of VipCot is unlikely to proceed without final clearance from EPA.

The merger could only reduce DPL's incentive to market cotton containing VipCot, given the fact that VipCot (assuming final EPA clearance) would compete with its new owner's latest IR trait, Bollgard II, or other new IR traits Monsanto develops to complement or succeed Bollgard II.

3.4.2 Cotton with DuPont's GAT herbicide tolerance

In 2006, DPL obtained licenses from DuPont to deploy an experimental dual herbicide-tolerance trait known as Optimum GAT in cotton and soybeans (DPL-DuPont 2006). The GAT trait is being developed in cotton by a DPL-DuPont joint venture known as DeltaMax Cotton LLC. The GAT trait provides tolerance to two herbicides rather than one, as with all previous HT traits. GAT crops, if successfully developed, will be tolerant to both glyphosate and ALS inhibitors, a popular class of herbicides used on cotton, soybeans and corn. GAT is being advertised by DuPont as a means for farmers to continue using the popular herbicide glyphosate, while at the same time permitting application of a second herbicide to deal with the growing problem of glyphosate-resistant weeds (DuPont-Pioneer 2006a).

The merger would present Monsanto with an interesting dilemma – whether to allow its new subsidiary to market DPL cotton varieties with a competitor's glyphosate-tolerance trait. Monsanto's glyphosate-tolerance traits (Roundup Ready & RR Flex) are the pillar of the company's biotech crop empire. Not only is Roundup Ready by far the dominant trait in cotton, it represents the only trait deployed in biotech soybeans (and 89% of US soybeans were transgenic in 2006 (USDA ERS 2006b)), and the dominant HT trait in both corn and canola. Monsanto might well be reluctant to allow DPL to market cotton varieties with a competitor's glyphosate-tolerance trait. This reluctance can only be increased by the plans of DuPont and Syngenta to jointly incorporate GAT in soybeans, corn and perhaps other crops, further challenging Monsanto's dominance in HT technology (Greenleaf Genetics 2006; StLPD 2006).

Growers in the Southeast, where DPL's market share exceeds 86% (USDA AMS 2006), are concerned that the proposed merger would reinforce DPL's "inordinate control" of their seed market and deny them needed new varieties. According to University of Georgia cotton agronomist Steve Brown:

> "The collective technology pool of the merged company would conceivably include not only Monsanto's Bollgard, Bollgard II, Roundup Ready, and Roundup Ready Flex traits but also the Verdia GAT gene, the DuPont ALS-tolerant gene, and Syngenta's VIP system. These latter technologies could be developed … or shelved. The fact that they are not in another company's laboratory or greenhouse prevents the introduction of products that could effectively compete with Monsanto's current portfolio. Shelving such technology – or even

[24] While most genetically engineered crops require only USDA approval for commercial introduction, those like VipCot that produce pesticides require additional approval of the pesticide by the EPA. Companies normally seek time-limited approvals for GM crop pesticidal proteins from EPA while the pertinent crop is undergoing field trials.

> physically eliminating existing transgenic lines in which these new genes have successfully been introduced – establishes serious, lengthy hurdles for other would-be competitors.
>
> Growers in Georgia are already frustrated with the inordinate control exercised by one company. Unless issues of traits are adequately addressed in the proposed merger, things could get worse. The real answer to the overwhelming control of varieties and technology by a single provider is legitimate competition" (Brown 2006b).

3.4.3 Other biotech cotton trait R&D

Companies wishing to conduct outdoor field trials of experimental biotech crops (i.e. environmental releases) must submit "notifications" to USDA's Animal and Plant Health Inspection Service (APHIS). Notifications give basic information about the proposed field trials, such as the type of crop and genetic modification, containment measures, and overall acreage. APHIS normally responds by issuing "acknowledgements," allowing the trials to proceed. APHIS makes some of the notification information available to the public in a searchable database. The following analysis is based on these data for biotech cotton field trials from the year 2000 through the end of 2006.

Monsanto has received over half (53%) of the 449 USDA permits for transgenic cotton field trials since the year 2000, three times more than its closest competitor, Bayer, at 17%. These two companies, plus Syngenta and Dow, received 91% of all permits, with the remainder divided among DPL and six other institutions. While these data show Monsanto's clear dominance in cotton trait R&D, they greatly ***overestimate*** the degree of competition in transgenic cotton trait research and development. Aggregate field trial acreage is a better measure of R&D efforts than number of permits.

This is because new biotech crops require extensive field testing that can take 5-10 years, and the majority fail early on. Stage of development correlates roughly with size of field trials. Permits for small trials from fractions to dozens of acres indicate early-phase development, and high likelihood of failure. Permits for larger field trials in the hundreds to thousands of acres, especially if conducted in multiple locations over consecutive years, indicate a greater likelihood of eventual USDA clearance. The significance of field trial acreage as a measure of R&D progress is indicated by the fact that companies sometimes claim permit acreage as confidential business information (CBI) so as to prevent competitors from learning the R&D status of a given experimental crop (personal communication, James White, APHIS).[25]

When one compares acreage figures (see Appendix 5), Monsanto's dominant position as measured by number of permits becomes overwhelming. Monsanto was responsible for nearly 94% of experimental biotech cotton acreage (80,956 acres) over the past seven years – 26 times more than Bayer (3.6% or 3073 acres) and 47 times more than Syngenta (2.3% or 1943 acres), its closest competitors. By the more accurate measure of acreage, then, Monsanto has roughly the same predominant position in R&D for future cotton traits as it does for currently marketed cotton traits.

In the event of a merger, Monsanto would have a natural incentive to exclude competitors' traits from DPL seeds. Its overwhelming dominance in cotton trait R&D demonstrates that it would have no need to license traits from Syngenta, Bayer or other firms.

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[25] Alternately or additionally, the company will claim the trait or gene being field tested as confidential business information.

3.5 Production Costs and Productivity of Cotton Cropland

Glyphosate-resistant weeds are on the rise, and they are already increasing growers' production costs, in some cases dramatically. Continued increases in the use of glyphosate promise an accelerated development of glyphosate-resistant weeds, with concomitant rise in production costs to control them and adverse agronomic impacts, such as increased erosion from reduction in conservation tillage and a return to the use of more toxic herbicides (Section 2.7). The negative effects of rising Roundup use on soil microorganisms and plant nutrition may pose an increased long-term risk of plant disease and yield losses, both in cotton and other crops, and potential threats to amphibian populations (Section 2.8). Finally, the sometimes erratic performance of Monsanto's cotton – problems such as deformed bolls and dramatic yield losses first noted in the 1990s, but still occurring today (Section 2.6) – makes near-total dependence on cotton with Monsanto technology unwise.

All of these adverse impacts are direct consequences of the growing dominance of Monsanto's traits, particularly its Roundup Ready (Flex) traits, in cotton. The merger would exacerbate these problems by enhancing Monsanto's ability to incorporate its traits in a large portion of U.S. cotton seeds well into the future.

3.6 Impacts on Growers of Other Crops

While the cotton industry is the most relevant context for assessment of the proposed combination, the merger would likely contribute to further increasing Monsanto's seed and trait dominance in other crops as well. This is because Monsanto has extensive germplasm holdings and/or trait penetration in corn, soybeans, canola, vegetables, fruits and other major crops, while DPL is a major presence in soybeans as well as cotton; and essentially the same traits are often deployed, or deployable, in multiple crops. One effect of this increased dominance in seeds and traits is that growers of other crops will experience an exacerbation of the adverse agronomic and environmental impacts discussed above with respect to Monsanto's technology, particularly Roundup Ready (Flex), in cotton. Indeed, in many cases cotton growers are also growers of other crops, such as soybeans and corn.

3.6.1 Concentration in seeds and traits other than cotton

In 2005, Monsanto became the largest seed firm in the world, with seed sales of $2.8 billion, to surpass the traditional leader, DuPont Pioneer (ETC 2005). Appendix 6 illustrates the company's dramatic rise to dominance. Monsanto undertook two major "shopping sprees"[26] in the mid-90s and the middle of this decade. Here, we will treat only the North American acquisitions (see Section 3.9 for international deals).

From 1996-1998, Monsanto's aggregate multi-billion dollar acquisitions of DeKalb Genetics, Asgrow, Agracetus, Holden's Foundation Seeds, Calgene and smaller firms catapulted it to number one in U.S. soybean and number two in U.S. corn seed sales (Fernandez-Cornejo 2004, Tables 16 & 19). In 2005, Monsanto reportedly had 41% and 25% market shares in global corn and soybean seed sales, respectively (ETC 2005). The second, and ongoing, wave of acquisitions in this decade has focused on regional U.S. seed firms, which Monsanto is purchasing through its holding company, American Seeds, Inc. (ASI). In the two years from ASI's formation in November 2004 to December 2006, Monsanto spent $350 million to acquire 15 firms, giving it an additional share in

[26] See http://www.americanseedsinc.com/news/2005-03-01.htm

U.S. corn and soybean seed sales of more than 6.5% and 2.0%, respectively (Table 3).[27] Monsanto's $1.4 billion acquisition of the world's largest fruit and vegetable seed firm, Seminis (Monsanto 2005a), in 2005 reportedly gave the company from 23% to 38% shares of the global seed markets for tomatoes, onions, peppers, cucumbers and beans (ETC 2005). The $300 million buyout of Emergent Genetics, also in 2005, included 12% of U.S. cotton seed sales represented by the Stoneville and NexGen brands (Monsanto 2005b). Monsanto also acquired significant canola germplasm with buyouts of Limagrain Canada (Monsanto 2001) and the Advanta and Interstate canola brands (Monsanto 2004a). In addition, Delta and Pine Land is fast becoming a major player in soybeans as well as cotton (DPL 2004).

Table 3
Monsanto's Acquisitions Through American Seeds, Inc.: 2004 to 2006*

Company / Brands	State	Amount ($)	% of U.S. Market	Date acquired
Channel Bio Corp: * Crow's Hybrid Corn Co. * Midwest Seed Genetics * Wilson Seeds	Indiana	120 million	2% of corn	Nov. 2004 (American Seeds, Inc. formed)
NC+ Hybrids	Nebraska	40 million	1% of corn	March 2005
Fontanelle Hybrids	Nebraska	52 million	1% of corn	Sept. 2005
Stewart Seeds	Indiana			
Trelay Seeds	Wisconsin			
Stone Seeds	Illinois			
Specialty Hybrids	Eastern Corn Belt			
Gold Country Seed, Inc.	Minnesota	8.7 million	0.4% of corn and soy	March 2006
Heritage Seeds	Indiana			
Diener Seeds	Indiana	77 million	1.4% corn 2.0% soy	July 2006
Sieben Hybrids	Illinois			
Kruger Seed Company	Iowa			
Trisler Seed Farms	Illinois			
Campbell Seed	Indiana			
Landec Corp.: * Fielder's Choice * Heartland Hybrids	Indiana	50-55 million	Slightly more than 1% of corn	Dec. 2006
15 companies	**6 states**	**$348 - $353 Million**	**> 6.5% corn > 2.0% soy**	

* Source: Compiled from information in news releases at http://www.americanseedsinc.com/news.htm.

3.6.2 Cross-crop trait deployment

A given trait, or slightly differing versions thereof, is deployable in multiple crops. The pre-eminent example of cross-crop trait deployment and dominance is Monsanto's Roundup Ready. According

[27] Compiled from information in news releases at http://www.americanseedsinc.com/news.htm

to Monsanto's figures, 102.6 million acres of Roundup Ready soybeans (66.4), corn (24.8), cotton (10.8) and canola (0.6) were planted in 2005. Monsanto's corresponding estimate for 2006 is 113-117 million acres (Monsanto 2006c). Monsanto has also received commercial clearance for Roundup Ready versions of beets and alfalfa, though neither of these are grown to a significant extent due to rejection by consumers and the food industry. Monsanto dropped efforts to gain USDA approval for Roundup Ready wheat in 2004 for similar reasons, though it could re-apply in the future. USDA is currently considering de-regulation of Roundup Ready turfgrass for lawns and golf courses. Monsanto is field-testing a number of other Roundup Ready crops, including onions, peas and Kentucky bluegrass (Cerdeira & Duke 2006).

The majority of commercialized Roundup Ready crops utilize the same mechanism, a modified version of a bacterial enzyme that is immune to glyphosate, CP4 EPSPS, from soil bacteria of the genus Agrobacterium (Cerdeira & Duke 2006).[28]

The only other significant transgenic HT trait is Bayer's LibertyLink (glufosinate tolerance). LibertyLink (LL) versions of canola, corn, cotton, soybeans, beets and rice have received USDA approval,[29] though only LL canola, cotton and corn are being grown commercially.[30] Though we have not found precise figures, commercial acreage of LL crops in the U.S. is estimated at roughly 1 million acres,[31] or about one percent of Roundup Ready crop acreage. LibertyLink crops utilize the glufosinate-inactivating enzyme phosphinothricin acetyl transferase (PAT) generated from either one of two closely related genes (*bar* and *pat*) derived from soil bacteria of the genus Streptomyces (USDA APHIS 2006, p. 29).

One finds similar cross-crop deployment in the smaller market for IR traits, although only in corn and cotton. Monsanto's Bollgard and Bollgard II IR traits are found in 99% of IR cotton acreage. While we have not found figures for IR trait market shares in corn, Monsanto is likely dominant here as well, though Syngenta, Dow, and Dow-Pioneer all have competing traits. IR traits in corn include a handful of slightly differing versions of insecticidal proteins that kill differing insect pests; the most notable difference is found in corn, where differing IR traits kill pests of grains and leaves (e.g. corn-borers) and root pests (corn rootworm).

3.6.3 Fewer trait choices and adverse impacts on other crops

With DPL's additional germplasm in cotton and soybeans, a post-merger Monsanto-DPL would have secure access to more seed varieties in which to incorporate its traits. Since essentially the same trait can be deployed in multiple crops, an investment in development of a single trait brings returns roughly commensurate with the number of trait-bearing seeds, of whatever crop, that are

28 Roundup Ready canola contains 2 mechanisms of glyphosate resistance: EPSPS and glyphosate oxidase (GOX), an enzyme that degrades glyphosate.

29 See "phosphinothricin-tolerant" listings for Bayer CropScience and two companies it has since acquired, AgrEvo and Aventis, at http://www.aphis.usda.gov/brs/not_reg.html. Phosphinothricin is another name for glufosinate, the active ingredient in Bayer's Liberty-brand herbicides.

30 LL soybeans received USDA approval in 1996, but were never marketed due to concerns over export market rejection (Illinois Extension 1999), though Bayer reportedly plans to introduce them in 2008 (Gullickson 2006). Three LL rice varieties have also received USDA approval, but have not been marketed for similar reasons (Weiss 2006).

31 USDA AMS data for 2006 show that 3.64% of 14.95 million acres of upland cotton, or 550,000 acres, were planted to LL cotton; Monsanto's estimate that 3% of transgenic HT corn was LibertyLink in 2003 suggests roughly 350,000 acres of LL corn in that year (Monsanto 2004b); since 75% of the 1.08 million acres of canola in 2003 were Roundup Ready (Cerdeira & Duke 2006, p. 1635), LL canola represents some fraction of the remaining 270,000 acres.

sold.[32] For instance, Monsanto's recent acquisition of Seminis gives it broad new opportunities for introduction of its current and future traits in a number of new vegetable crops. Conversely, a trait provider with lesser germplasm has fewer opportunities to recoup its investment in the development of a given trait, and is thus at a competitive disadvantage in all crops. This vertical integration effect is clearly at play in the proposed combination with respect to Monsanto's industry-leading Roundup Ready (Flex) traits. Thus, the merger would consolidate Monsanto's current overwhelming dominance in traits and seeds for all major crops, and help extend its trait dominance to minor crops such as vegetables in the future. Vertical integration efficiencies are generally adduced in support of mergers. Yet in this case, the additional vertical integration of traits and germplasm in a combined Monsanto-DPL will only increase market power and discourage competition. Monsanto-DPL's near monopoly in traits and predominance in (cotton) seeds means that vertical integration would not bring lower seed prices for farmers.

Less competition in traits will mean fewer choices for growers of other crops. In addition, the adverse agronomic and environmental impacts discussed above for cotton will be exacerbated in other crops, particularly for cotton growers who also grow other crops.

Government research would seem to support this assessment of fewer seed choices. Researchers with the USDA's Economic Research Service have found that "consolidation in the private seed industry over the past decade may have dampened the intensity of private research undertaken on crop biotechnology relative to what would have occurred without consolidation, at least for corn, cotton and soybeans." They add: "Also, fewer companies developing crops and marketing seeds may translate into fewer varieties offered" (Fernandez-Cornejo & Schimmelpfennig 2004).

3.7 Organic Cotton

Organic cotton production by definition excludes use of genetically engineered seeds, chemical fertilizers and pesticides under USDA organic standards (OCA 2004). Though it still represents a very small market, organically grown cotton has enjoyed tremendous growth recently at the retail, manufacturing and farm levels. Global retail sales of organic cotton products increased from $245 million in 2001 to $583 million in 2005, an annual average growth rate of 35%. Global organic cotton fiber sales increased nearly six-fold, from 5,720 metric tonnes in 2000 to 32,326 metric tonnes in 2005 (Organic Exchange 2006).

Major retailers are largely responsible for this booming market. For instance, Patagonia converted its entire line of sportswear to 100% organic cotton in the 1990s, and 2.5% of Nike's total cotton use in 2003 was organic,[33] making it the largest user of organic cotton in that year (Organic Exchange undated). In 2004, Wal-Mart and Sam's Club began marketing an organic cotton line of yoga outfits, and since then have introduced organic cotton baby clothes, bed sheets, towels, and ladies apparel. The popularity of these products spurred Wal-Mart to become the largest single purchaser of organic cotton in 2006. Other retailers with organic cotton lines include Eileen Fisher and Timberland (Gunther 2006). This strong growth is expected to accelerate in the coming years (Organic Exchange 2006).

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[32] This applies to early-stage research and development of the trait. Incorporation of the trait requires later-stage development expenditures specific to the individual crop.

[33] The common practice of blending organic and conventional cotton accounts for the greater increase in global organic cotton fiber sales vs. retail sales, since products must contain over 95% organic cotton to be labeled "organic cotton."

Conventional and biotech cotton production is extremely chemical-intensive, accounting for approximately 25% of global insecticide use, and 10% of overall pesticide use (Organic Exchange undated). Thus, organic cotton production means significantly less chemical pollution of the environment, avoidance of chemical-related threats to the health of growers,[34] and no contribution to the rapidly growing problem of herbicide-resistant weeds. Equally important is the increased revenue from organic cotton, which offers smaller growers an opportunity to survive in a ruthless cotton industry marked by fewer and ever-bigger farms (see Figure 3). By one estimate, organic cotton producers can increase their income by 50%: they receive a 20% premium over the price paid for conventional/biotech cotton, and spend less on inputs (which includes seeds and fertilizers as well as pesticides) (Fashion United).

Organic cotton is grown in the U.S. (primarily Texas, but also Arizona, Missouri and New Mexico),[35] but increasingly in a number of African nations as well as India, China, Turkey, Peru and Paraguay.[36] An in-depth, two-year study in India showed that organic cotton producers spent 40% less on inputs, and had slightly higher yields, than conventional cotton producers (Ramakrishnan 2006). Low input costs are particularly important for resource-poor farmers in developing countries, who frequently incur debt at high interest rates to purchase seeds and chemicals. The high price of biotech cotton seed has been a major complaint of developing country farmers induced to buy it in expectation of better performance (see Section 3.9.1).

Biotech cotton poses a number of potential threats to organic producers. First, biotech cotton could contaminate organic cotton and render in unsaleable. Contamination can occur when pollen from transgenic plants blows or is carried by insect pollinators to fertilize neighboring conventional/organic fields, through admixture of transgenic seeds in conventional/organic seeds, by the sprouting of transgenic "volunteer" plants from unharvested seeds in a subsequently grown field of conventional/organic crops, and by other means (UCS 2004). There are numerous examples of inadvertent transgenic contamination ruining markets for conventional/organic producers in other crops. For example, as reported in *Nature Biotechnology,* "[t]he introduction of transgenic, herbicide-tolerant canola in western Canada destroyed the growing, albeit limited, market for organic canola," which commands a 100% premium over conventional canola (Smyth et al 2002). The extremely widespread contamination of grain supplies and food products with transgenic StarLink corn in 2000/2001 resulted in extremely costly recalls of over 300 corn products, sharp drops in exports as contaminated corn shipments were rejected, and lower prices for corn farmers (Freese 2001). Both canola and corn are considered "outcrossing" crops, while cotton is generally "self-pollinated."[37] But even self-pollinating transgenic crops like rice can pose a threat, as seen in the recent episode in which an unapproved variety of transgenic rice (LLRICE601) widely contaminated commercial rice supplies, wreaking havoc with rice markets and causing losses to rice farmers projected at up to $150 million (Weiss 2006). CFS (2006) gives additional examples of transgenic contamination.

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[34] See http://www.organicexchange.org/Farm/cotton_facts_intro.htm

[35] See http://www.aboutorganiccotton.org/stewards.html.

[36] See http://www.organicexchange.org/Map/oce.html

[37] "Self-pollinated" means that a particular plant's (male) pollen fertilizes primarily its own (female) ova, while the pollen of "outcrossing" plants normally fertilizers other plants of the same species. But the terms are relative. For instance, insect pollinators like honeybees can carry cotton pollen for hundreds of feet to fertilize other cotton plants, see: http://www.aphis.usda.gov/brs/cotton.html.

Contamination episodes are seldom adequately explained, but are generally blamed on slipshod management practices on the part of the biotech company or farmers growing the crop, or on deficient regulatory oversight by governmental authorities. For instance, the USDA's Inspector General recently issued a scathing audit lambasting the USDA's Animal and Plant Health Inspection Service for numerous fundamental flaws in its oversight of genetically engineered crop field trials (USDA IG 2005). A less charitable interpretation was suggested by Don Westfall, of the biotech consultancy firm Promar International, who reportedly stated in connection with the StarLink corn episode noted above: "The hope of the industry is that over time the market is so flooded [with GMOs] that there's nothing you can do about it. You just sort of surrender" (Laidlaw 2001).

The production practices associated with biotech cotton may also reduce yields of nearby organic cotton producers through spray drift damage. Herbicides are sprayed liberally to kill weeds in virtually all non-organic cotton production. Sprayed herbicides can drift several miles, especially when applied via airplane, as is common with cotton, and damage other farmers' crops (Bennett 2007, see also Section 2.4). The potential for spray drift damage has increased with the introduction of Roundup Ready cotton, since it permits application of glyphosate over a wider time window than conventional cotton. Roundup Ready Flex cotton widens the application window still further, since it withstands glyphosate throughout the growing season, and moreover survives higher application rates than original RR cotton (see Section 2.7).

A third potential risk to organic cotton producers is the rapidly declining availability of high-quality conventional seeds, since organic standards prohibit use of transgenic seeds.

Acquisition of DPL would give Monsanto the world's largest cotton seed holdings, with substantial presence in both U.S. and many foreign markets (see Section 3.9). Monsanto has explicitly stated that important goals of its acquisition of DPL are "to create a new ***global*** platform in cotton" and "to accelerate biotech trait penetration" (Monsanto 2006b, emphasis added). Therefore, the merger would likely lead to increased acreage of Monsanto biotech cotton planted overseas, posing the significant threats outlined above to organic cotton producers in African and other developing country nations, where governmental oversight of biotech crops is often even weaker than in the U.S. Since organic cotton products sold in the United States increasingly come from organic fiber grown overseas, the merger could have the effect of restricting the choice of organic cotton products for American consumers.

3.8 Seed Sterility Technology (Terminator)

DPL and USDA jointly hold at least three major patents on a transgenic method for genetic sterilization of seeds (ETC 2003). Known as the Technology Protection System, or Terminator, it involves genetically manipulating seeds such that, upon application of a chemical trigger, mature plants arising from the treated seeds themselves produce seeds that are sterile (UCS 1998). The purpose of Terminator technology is to prevent farmers from saving seeds from their harvest for the purpose of replanting. The USDA and DPL regard Terminator as a way to provide U.S. seed and trait firms with a biological means to prevent "unauthorized" reproduction of seeds bearing their patented biotech or other traits (USDA ARS 2001). This is regarded as particularly important in developing countries, home to most of the world's 1.4 billion people who depend on farm-saved seed and seeds exchanged with their neighbors as their primary seed source (Shand 1999).[38]

[38] Seed saving is also practiced in developed countries, however. As recently as 1997 in the U.S., it is estimated that 63% of wheat, 22% of cotton, and 19% of soybeans came from saved seeds (Fernandez-Cornejo 2004, Table 5). However,

Terminator proponents often argue that poor farmers would continue to be free to save and replant their own varieties. Yet if a farmer's neighbor plants a Terminator crop, cross-pollination could render a portion of the first farmer's seed sterile (CGIAR 1998). And if shipments of Terminator seed-containing grain are sent to developing countries, the common practice of planting seed from grain ostensibly meant for consumption (e.g. food aid) could also lead to farmers unknowingly planting their fields with sterile seeds, resulting in significant drops in yield (FAO 2002, p. 5; ETC 2003, pp. 3-4). The growing number of often unexplained episodes in which biotech crops inadvertently contaminate conventional crops demonstrates that these are real possibilities (CFS 2006).

Proponents also argue that resource-poor farmers would continue to have access to non-Terminator seeds developed by the public sector. Yet this is by no means assured. After all, it is a public agency (the USDA) that helped develop sterile seed technology in the first place, and stands to earn an estimated 5% royalties on net sales (RAFI 1998). And public sector plant breeding has declined dramatically in the past two decades, both in the U.S. and around the world, increasingly supplanted by private sector seed (Fernandez-Cornejo 2004; Shand 1999). We have already discussed how university-bred cotton varieties virtually disappeared in the U.S. in the early 1990s (Section 2.1.1, Appendix 1), and how farmers' choice of both conventional and biotech cotton seeds is being restricted due to oligopolistic market power (Sections 2.4 and 2.5).

These developments help explain the international outcry against Monsanto's proposed acquisition of DPL in 1998. Critics feared that Monsanto would deploy seed sterility technology in its growing stocks of the world's germplasm (see Sections 3.6 & 3.9 and Appendix 6). Criticism of Terminator came from many sources, including Jacques Diouf, Director General of the United Nations' Food and Agriculture Organization; the Consultative Group on International Agricultural Research (CGIAR), the world's largest international agricultural research network (RAFI 2000); and Gordon Conway, former President of the pro-biotech Rockefeller Foundation, a major funder of the Green Revolution (Rockefeller 1999). Opposition to Terminator is strong in developed countries and near universal in the developing world (RAFI 2000).[39] World Food Prize winner M.S. Swaminathan of India warned that deployment of Terminator technology would erode the right of farmers to save and breed seed varieties appropriate to their areas, as well as foster genetic uniformity, increasing the vulnerability of crops to pests and disease (Swaminathan 1998).

Such criticism impelled Monsanto, before the merger fell through, to make "a public commitment not to commercialize sterile seed technologies" (Shapiro 1999). In its 2005 Pledge Report, however, Monsanto initially restricted its pledge to read "not to commercialize sterile seed technologies ***in food crops.***" When challenged over this apparent change of policy, Monsanto apologized and eventually restored the original language (ETC 2006). Nevertheless, the company left the door open to future deployment of Terminator in food or non-food crops with the proviso: "…but Monsanto people constantly reevaluate this stance as technology develops" (Monsanto 2005c, p. 29).

Should the proposed combination take place, there are several reasons to be concerned about an imminent "reevaluation" leading to possible deployment of Terminator technology in cotton.

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the dramatic rise of patented biotech cotton and soybeans varieties that cannot be legally saved has almost certainly reduced these figures.

[39] See also http://www.banterminator.org/news_updates/news_updates

1) DPL has always been a zealous proponent of Terminator. In 2000, DPL's Harry Collins declared: "We've continued right on with work on the Technology Protection System. We never really slowed down. We're on target, moving ahead to commercialize it. We never really backed off" (as quoted in RAFI 2000). DPL and USDA have reportedly tested Terminator cotton and tobacco in greenhouses (ETC 2003).
2) Despite its pledge, at least one Monsanto officer has reportedly been promoting genetic use restriction technologies (a category that includes Terminator) at numerous international meetings (Dr. Roger Krueger, see ETC 2006).
3) Monsanto's restriction of its "no-Terminator" pledge to "food crops" (altered only after a public challenge), coming just one year before its renewed attempt to acquire DPL, holder of Terminator patents and the dominant player in non-food cotton, is at the very least suspicious.
4) Since objections to Terminator have focused heavily on its threat to the food security of developing countries, initial deployment in a fiber crop like cotton may be regarded as less likely to provoke the same level of opposition.
5) In 2001, USDA confirmed that commercial introduction of Terminator would likely be in cotton: "Delta and Pine Land Co. researchers are further developing the technology to ready it for commercial use. However, even the most optimistic predictions estimate that commercial cotton with built-in TPS technology may not be available until 2004" (USDA ARS 2001).
6) Monsanto's aggressive investigations and/or prosecution of thousands of U.S. farmers for (allegedly) saving the company's patented Roundup Ready soybeans demonstrate the lengths to which the company will go to discourage the practice of seed-saving (CFS 2005).[40] Terminator would provide it with a more effective, biological means to the same end. As former DPL president Murray Robinson put it: "We expect [the new technology] to have global implications, especially in markets or countries where patent laws are weak or non-existent" (as quoted in Shand 1999).
7) Monsanto could profit substantially from deployment of Terminator. In 1998, DPL projected that Terminator could generate revenues in excess of $1 billion (Shand 1999).

Should Monsanto choose to "reevaluate" its current "pledge" not to deploy Terminator, its acquisition of DPL would give it a much expanded germplasm base in which to roll out sterile seed technology in a fiber crop less likely to arouse public opposition, thereby threatening the millennia-old tradition of farmer-led seed-saving and breeding.

3.9 International Perspective

The potential international impacts of the merger also deserve consideration, for at least two reasons. First, a combined Monsanto-DPL would have large market shares of cotton and other crops in a number of countries, raising anti-competitive concerns. Second, Monsanto is known for questionable and in some cases illegal business practices in foreign countries, practices that may raise red flags with government regulators outside of the U.S.

DPL is the eleventh largest seed company in the world, with 2004 seed sales of $315 million (ETC 2005). An unknown portion of these sales occur overseas. According to a 2004 presentation to investors, DPL controls 86% of the Mexican cotton seed market, and has an 85% share in South

[40] Monsanto budgets $10 million annually for a department of 75 employees to investigate and prosecute farmers. Through 2004, Monsanto had won over $15 million in damages from U.S. farmers in cases that went to court, and likely much more in confidential out-of-court settlements (CFS 2005, pp. 23, 33-34).

Africa, 70% (estimated) in Colombia, 30% (estimated) in Brazil, 30% in Greece, 27% in Spain, 25% (estimated) in Australia, 14% in Argentina, and 5% in Turkey and China (DPL 2004). In May 2006, DPL announced acquisition of Syngenta's global cotton seed business, comprised of operations and assets in India, Brazil, Europe, and certain cotton germplasm in the United States. The Indian acquisitions included a research facility and "cotton seed germplasm and distribution assets in each of the three primary growing regions of India" (DPL-Syngenta 2006).

In addition to its international cotton operations in India (see next section), Monsanto has also gained a substantial international presence in other crops (Appendix 6). For instance, its purchase of at least four Brazilian seed firms in the 1990s gave it a 63% market share in Brazilian corn seed in 1998-99 (Pardey et al 2004, p. 19) and a substantial stake in Brazil's soybean market as well. Other notable international deals in the 1990s include acquisition of Cargill's international seed division ($1.4 billion), and two major South African seed firms (mainly corn).

The large international market presence of a combined Monsanto-DPL in cotton seed and other major crop markets would be of great concern, particularly in light of Monsanto's history of questionable and illegal business practices overseas.

3.9.1 Monsanto in India

Monsanto has undertaken a major effort to introduce GM cotton internationally, notably in India and Indonesia (for the following discussion, see FoEI 2007, pp. 42-55). For instance, Monsanto acquired a 26% share of India's largest seed firm, Maharashtra Hybrid Seed Company (Mahyco), in the 1990s, and established a 50:50 joint venture with Mahyco known as Mahyco Monsanto Biotech to market Bt cotton there (Cyber India 2004). India plants more cotton (over 20 million acres) than any country in the world, making it a lucrative market. Controversy over the commercial introduction of Mahyco-Monsanto Bt cotton in India from 2002 to 2005 has centered on allegedly deceptive advertising campaigns portraying the Bt cotton as endowed with magical qualities, the more than three-fold higher price of biotech cotton seed,[41] and numerous crop failures. Many Indian farmers went into debt to purchase the high-priced seed, based on promises of greatly increased yields and reduced insecticide expenditures. However, reports from Indian state government officials and farm organizations document that the Bt cotton often yielded less than conventional cotton, and did not resist pests as promised by Mahyco-Monsanto. In consequence, Indian government officials in various states, most recently in Tamil Nadu (Sharma 2007), have demanded compensation for farmers who have suffered Bt cotton failures.

As reported in *Nature Biotechnology*, a study by the Nagpur-based Central Institute of Cotton Research revealed a constellation of problems with Mahyco-Monsanto's Bt cotton varieties, which were developed for U.S. farmers but often proved unsuitable to Indian conditions (for the following discussion, see Jayaraman 2005). First, the built-in insecticide was not produced at sufficient levels in cotton bolls to adequately control the cotton bollworm, India's chief cotton pest, especially late in the growing season, which is longer than in the U.S. This meant both greater-than-expected insect damage for some farmers, and in the longer term, increased probability of development of pests resistant to the Bt insecticide. Second, an estimated one-quarter of the hybrid Bt cotton seeds didn't

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[41] Acting on a complaint from the government of Andhra Pradesh, India's Monopolies and Restrictive Trade Practices Commission issued notices to Monsanto and its Indian affiliates for taking undue advantage of its monopoly in Bt cotton seed by charging a royalty of 1,250 rupees on a 450 gm packet of seed, raising its price to 1,800 rupees (Mitta 2006).

produce any insecticide at all, a problem not seen in the U.S., where true-breeding varieties are planted. Suman Sahai, president of the Indian civil society group, Gene Campaign, reportedly charged Monsanto with promoting the use of hybrids in India to force farmers to buy fresh seeds every year even though it is aware that true-breeding varieties (whose seeds can be saved for subsequent crops) perform better. The deficient insect-resistance of Bt cotton in India has meant that Indian cotton growers purchase and spray more chemical insecticides than Bt cotton growers in other parts of the world. Due to such agronomic problems, the Indian government refused to renew the licenses for three Bt cotton varieties in many states. The recent spate of farmer suicides in Indian cotton-growing regions has many causes, including drought-related crop failures and low cotton prices, but indebtedness arising from purchase of high-priced biotech cotton seeds that sometimes failed to perform was by many accounts a significant factor (FoEI 2007, p. 50).

3.9.2 Monsanto's bribery in Indonesia

Monsanto's abortive bid to introduce biotech cotton to the Indonesian market involved bribery of and illicit payments to Indonesian government officials. According to a U.S. Securities and Exchange Commission (SEC) complaint (SEC 2005a), in 2002 a senior Monsanto manager based in the U.S. authorized payment of a $50,000 bribe to a senior Indonesian Ministry of Environment official to repeal a decree requiring environmental impact assessments of biotech crops prior to their introduction, a decree applying to Monsanto's Bt cotton (the decree was never repealed). In addition, Monsanto's Indonesian affiliates made at least $700,000 in illicit payments to 140 Indonesian government officials and their family members from 1997 to 2002. Monsanto was fined $1 million by the U.S. Department of Justice for violation of the U.S. Foreign Corrupt Practices Act and an additional $500,000 by the SEC (SEC 2005b). As in India, many Indonesian farmers were extremely disappointed with the performance of Monsanto's cotton, which was sold at a substantial premium to conventional seed but in many cases failed to deliver the promised added value (FoEI 2007, pp. 52-53).

3.9.3 Monsanto's questionable soya lawsuits in Europe

A third example of questionable business practices involves Monsanto's lawsuits against eight European importers of Argentine soy meal, which is largely derived from Roundup Ready soybeans. Monsanto is demanding that the importers pay royalties on these imports based on the company's European patents on Roundup Ready (RR) soybeans (MarketWatch 2006).

Monsanto's attempts to collect royalties from Argentine soybean farmers have failed, chiefly because the company does not have a patent on RR soy in Argentina (FoEI 2007, p. 24), and the country's 1973 seed law allows farmers to legally save and replant RR soy from their harvests (Valente 2004). Monsanto chose to introduce RR soy in Argentina despite the lack of patent protection (Benbrook 2005, p. 14). Measures ostensibly introduced to penalize the illegal practice of ***selling*** saved RR seed also affect farmers who legally save their own seed for replanting. For instance, an "extended royalty" scheme introduced in 1999 requires farmers to sign a contract obligating them, upon purchase of RR soybean seeds, to pay a surcharge of $2 for each 50 kg of saved seed, and is associated with lengthy interrogations of farmers and intrusive inspections of farmers' field by seed dealers (Nellen-Stucky & Meienberg 2006; Valente 2006). Argentine farmers are generally opposed to such schemes, which recall Monsanto's practices in the U.S. Monsanto's U.S. patents on RR soybeans have allowed the company to aggressively investigate and/or prosecute thousands of American farmers for (allegedly) replanting saved RR soy, resulting in decisions awarding the company over $15 million through 2004 (CFS 2005).

Monsanto's lawsuits against European importers of Argentine soy meal are widely regarded as having little chance of success, because they illegitimately assert a right to collect royalties on a processed derivative (soy meal) of the patented RR soy based on the mere presence of the RR gene, whereas the European patents at issue confer protection only to seeds in which the RR gene performs its function of conferring resistance to glyphosate, which is only true of planted seeds, not seeds or seed derivatives meant for (animal) consumption (Nellen-Stucky & Meienberg 2006). Argentina has reportedly obtained a legal opinion to this effect from the European Commission's Internal Market and Services Directorate-General (MarketWatch 2006). Some regard Monsanto's lawsuits as a stratagem to impose costly delays on Argentine soy meal exports to Europe, and thereby pressure the Argentine government to change its seed laws to suit the company (Nellen-Stucky & Meienberg 2006).

3.10 Monsanto-DPL a Virtually Unchallengeable Competitor

DPL's cotton seeds are generally considered the highest-quality germplasm in the industry, as suggested by its 51% share of the cotton seed market and the fact that it has the two top-selling cotton varieties sold by any company (USDA AMS 2006). Monsanto is the undisputed leader in cotton traits, with an over 95% market share, and has a similarly dominant position in R&D, with 94% of experimental transgenic cotton acreage since the year 2000 (Appendix 5). On this basis alone, a merger of these two giants can only exacerbate concentration in an already highly concentrated industry.

But the merger's impacts look still more dire when one considers the strong linkage between quality germplasm and trait dominance. Access to limited high-quality germplasm – regarded as the "delivery mechanism" for traits – is absolutely crucial to effectively marketing biotech cotton.

> "Seed proved to be the delivery mechanism of choice for agrobiotechnology, and, because high quality proprietary germplasm was in short supply, the strategic value of certain seed companies rose quickly" (Kalaitzandonakes 1998).

At present, in the U.S., Monsanto has sure access only to its Stoneville subsidiary's germplasm, representing 12% of US cotton. While its traits are currently offered widely in other firms' seeds via licensing agreements, these agreements are limited in duration and subject to expiration or cancellation. Acquisition of DPL would give Monsanto control of the highest-quality seeds, planted on more than four times as much acreage as Stoneville's, in which to incorporate its traits. The acquisition could also lead to cancellation of DPL's plans to diversify its trait offerings, as described in Section 3.4.

If Monsanto's competitors are prevented from deploying their traits in DPL's germplasm, they will be forced to seek access to a much smaller pool of mostly lower-quality germplasm in which to incorporate their traits via licensing agreements or acquisition. They would thus face two, likely insurmountable, obstacles: first, marketing new and unfamiliar traits to farmers committed from long experience and habit to Monsanto's industry-leading traits; and doing so in germplasm whose quality in terms of yield and other desirable (non-biotech) attributes is unlikely to match Monsanto-DPL's. The extremely high concentration in seeds post-merger would make acquisition of quality germplasm by Monsanto's competitors effectively impossible. High-quality cotton germplasm is a naturally limited form of capital that accrues slowly over many years of patient breeding efforts. Unlike brick and mortar factories or other capital equipment, it cannot be fabricated, given only sufficient funds. This limitation makes entry considerably more difficult for a would-be innovative competitor than would be the case in a nuts-and-bolts or information technology industry.

Perhaps the single, most important factor to consider in assessing the merger is Monsanto's extraordinary success in deploying its traits in the seeds of its competitors, ***even competitors that are also trait providers themselves***, via licensing agreements. In other words, Monsanto has come to overwhelmingly dominate traits in cotton (and other crops) ***even without*** the substantial additional vertical integration represented by acquisition of DPL. Since at present there is little room left for Monsanto traits in cotton, the proposed acquisition could only act to extend Monsanto's already unacceptably high level of trait dominance into the indefinite future.

Despite the undeniable attractiveness of the Roundup Ready system, however, there are also clear signs that transgenic trait "adoption" is a push as well as a pull affair, a product of oligopolistic market power as well as farmer demand. As demonstrated above, even popular conventional seed varieties are being eliminated or restricted in supply, while conventional versions of leading transgenic lines popular mainly for their yield (or other non-biotech attributes) are simply not available (Section 2.4). Thus, an accelerated decline in the availability of high-quality conventional seed is another likely outcome of the merger.

3.11 Conduct-Based Solutions in Light of the High Failure Rate in Agricultural Biotechnology

One might imagine that the anticompetitive effects of the merger could be adequately addressed by requiring Monsanto-DPL to incorporate competitors' traits – for instance, Syngenta's VipCot IR and DuPont's Optimum GAT HT traits (Section 3.4). However, this sort of solution runs a high risk of failure due to the high failure rate associated with this relatively new technology, a factor easily overlooked by those inexperienced in the world of biotech crops.

In brief, the overwhelming majority of biotech traits developed in the laboratory are never effectively commercialized. Failure occurs at several stages in the research, development, regulatory review and commercialization process. A trait developed in the laboratory may well not reach the stage of outdoor field trials due to unexpected technical difficulties. The great majority of biotech plant varieties that do undergo outdoor field testing never receive government clearance for commercial cultivation, most often because the company drops development because of trait instability, poor agronomic performance in certain environments, and/or unforeseen health or environmental risks. And even the majority of those few biotech crops that do receive government clearance fail in the marketplace.

This high failure rate is often obscured by overly optimistic public relations material from biotech companies, which are understandably optimistic about future prospects for their traits and loathe to air their failures.

An approximate measure of the failure rate is provided by USDA data, which show that 976 genes,[42] and thus nearly as many biotech traits,[43] have been tested in roughly 50,000 outdoor field trials

[42] See http://www.isb.vt.edu/cfdocs/isblists2.cfm?opt=16, last accessed Feb. 12, 2007.

[43] In the great majority of cases, a biotech trait is conferred by a single gene. A limited number of the 976 genes noted above are marker genes employed to facilitate the crop development process and do not themselves express a trait. USDA also lists alternative designations for some genes separately. On the other hand, an unknown but substantial

(Caplan 2005) involving more than 100 different plant species[44] since the late 1980s. Yet only 71 biotech "events," or particular crop-trait combinations, have received commercial clearance.[45] Of these 71, only four crops with HT and/or IR traits have succeeded commercially, representing virtually 100% of the world's biotech acreage (see Appendix 7 and ISAAA 2006).[46]

While Syngenta's VipCot cotton has received USDA clearance, the EPA has not given final approval to VipCot's VIP3A insecticidal protein, perhaps due to concerns that it will kill non-target organisms as well as insect pests by virtue of its broad-spectrum activity. As noted in Section 3.4.1, DPL has already pushed back the introduction date of VipCot from 2006 to 2008-09, and there is no guarantee it will be released then, even assuming that a compulsory licensing agreement is imposed on Monsanto as a condition of the merger.

DuPont's Optimum GAT trait is even less certain to succeed. DuPont optimistically projects commercial introduction of GAT in soybeans in 2009 (StLPD 2006), to be followed by introduction in corn and cotton some years later, by one account 2012 (Polaris 2005). DuPont's website indicates that GAT cotton is at the early phase 1 (proof of concept) of 4 phases of development (DuPont-Pioneer 2006b). USDA field trial data show that to date, DeltaMax Cotton LLC has received only two permits to conduct small field trials of GAT cotton, on 5 and 10 acres, both in 2006.[47] The small scale of these field trials confirms that GAT cotton is at an early stage of development.

Interestingly, DuPont received commercial clearance for a transgenic cotton resistant to ALS-inhibitor herbicides in 1996, but either did not try or was unable to market it.[48] (We find no record that this HT trait was ever incorporated into a commercial cotton cultivar.) Tolerance to ALS-inhibitors is the trait paired with glyphosate-tolerance in Optimum GAT. One limitation of ALS-inhibitor tolerance is the prevalence of weeds already resistant to this class of herbicides.[49] This, combined with rapidly increasing glyphosate-resistance in weeds, may limit the usefulness and marketability of Optimum GAT.

History clearly demonstrates that any given experimental biotech crop is very unlikely to become commercialized. Conduct-based solutions to correct the anticompetitive effects of a merger naturally rely on "picking a winner." Given the high failure rate in agricultural biotechnology, this is a risky strategy that is very likely to fail.

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number of genes claimed as "confidential business information" (CBI) of the biotech crop developer do not appear in this list (see Caplan 2005 on the growing number of CBI claims for genes), so the true number of biotech traits tested in field trials surely exceeds 1,000.

44 http://www.isb.vt.edu/cfdocs/isblists2.cfm?opt=3, last accessed Feb. 12, 2007.

45 http://www.aphis.usda.gov/brs/not_reg.html, last accessed Feb. 12, 2007.

46 Approved biotech crops other than HT and/or IR soybeans, corn, cotton and canola account for well under 1% of global biotech crop acreage.

47 At http://www.isb.vt.edu/cfdocs/fieldtests1.cfm, search on "Institution," then "DeltaMax Cotton LLC."

48 Go to USDA's list of GM crops cleared for commercial use (i.e. petitions for non-regulated status granted) at http://www.aphis.usda.gov/brs/not_reg.html. Petition 95-256-01, for sulfonylurea tolerant cotton, line 19-51a, was cleared on Feb. 21, 1996. Sulfonylurea is an ALS-inhibitor type herbicide.

49 The Weed Science Society of America lists 95 weeds resistant to ALS inhibitors worldwide. http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=3&FmHRACGroup=Go

4. CONCLUSION

Based on our analysis, the Center for Food Safety and International Center for Technology Assessment believe that the proposed merger would have a number of anticompetitive effects, including increased cotton seed prices; restricted choice of cotton seed varieties with no traits (i.e. conventional seed) or one trait; and increased obstacles to entry of and/or greater market penetration by Monsanto's cotton trait competitors. Other possible effects include an accelerated exit of smaller cotton seed firms from the market; acquisition of a uncompetitive, divested Stoneville, leading to a duopoly in seeds; harm to organic cotton growers, particularly overseas, and potentially reduced choice of organic cotton products for U.S. consumers.

However, agriculture is not software. Production of food and fiber to meet basic needs is a far more serious affair than computer operating systems. Agriculture requires competition in seeds and traits for all the reasons that apply to other industries, but also to ensure the diversity that is essential to sustain the health and productivity of American agriculture. As discussed in Sections 2.6 to 2.8, the near-monopoly in biotech traits promises a future of unprecedented reliance on a single herbicide, glyphosate. Excessive use of glyphosate leads to increasingly stubborn weeds, a threat to the cotton industry compared by one expert to the boll weevil; disease-prone, mineral deficient crops; and heightened risks of widespread yield reductions and failures. Increased use of Roundup may also endanger amphibian populations.

From an international perspective, the merger will give Monsanto, a company known for questionable and illegal activities overseas, increased access to foreign markets, particularly in cotton. Monsanto's acquisition of DPL's seed sterility technology increases the potential for eventual introduction of Terminator cotton and other crops, with adverse equity impacts on resource-poor farmers.

5. RECOMMENDATIONS

I. We call on the Department of Justice to unconditionally oppose the acquisition of Delta and Pine Land Company by Monsanto to protect farmers from higher seed prices, reduced seed choices and other adverse impacts as outlined in this report.

II. We call on the Department of Justice to oppose future acquisitions of cotton seed firms by the oligopolists – Delta and Pine Land, Bayer and Monsanto – to avert the negative effects of increased concentration in the cotton seed industry.

III. We urge the U.S. Department of Agriculture to resume its historical role of promoting the interests of American farmers, through:

   A. Increased funding of public sector breeding efforts to supply American farmers with affordable, high-quality seed varieties in cotton and other crops, in particular conventional seed varieties neglected by the private seed industry;

   B. Denial of any and all permits to entities applying to field test any crop incorporating Delta and Pine Land's Technology Protection System, or any other other genetic use restriction technologies that render the seeds of harvested plants sterile (popularly known as "Terminator" technology); and

   C. Otherwise following the recommendations of eleven members of the USDA's Advisory Committee on Agricultural Biotechnology (ACAB) with respect to Terminator technology, as set out in a joint letter to ACAB's chair of August 25, 2000 (USDA ACAB 2000).

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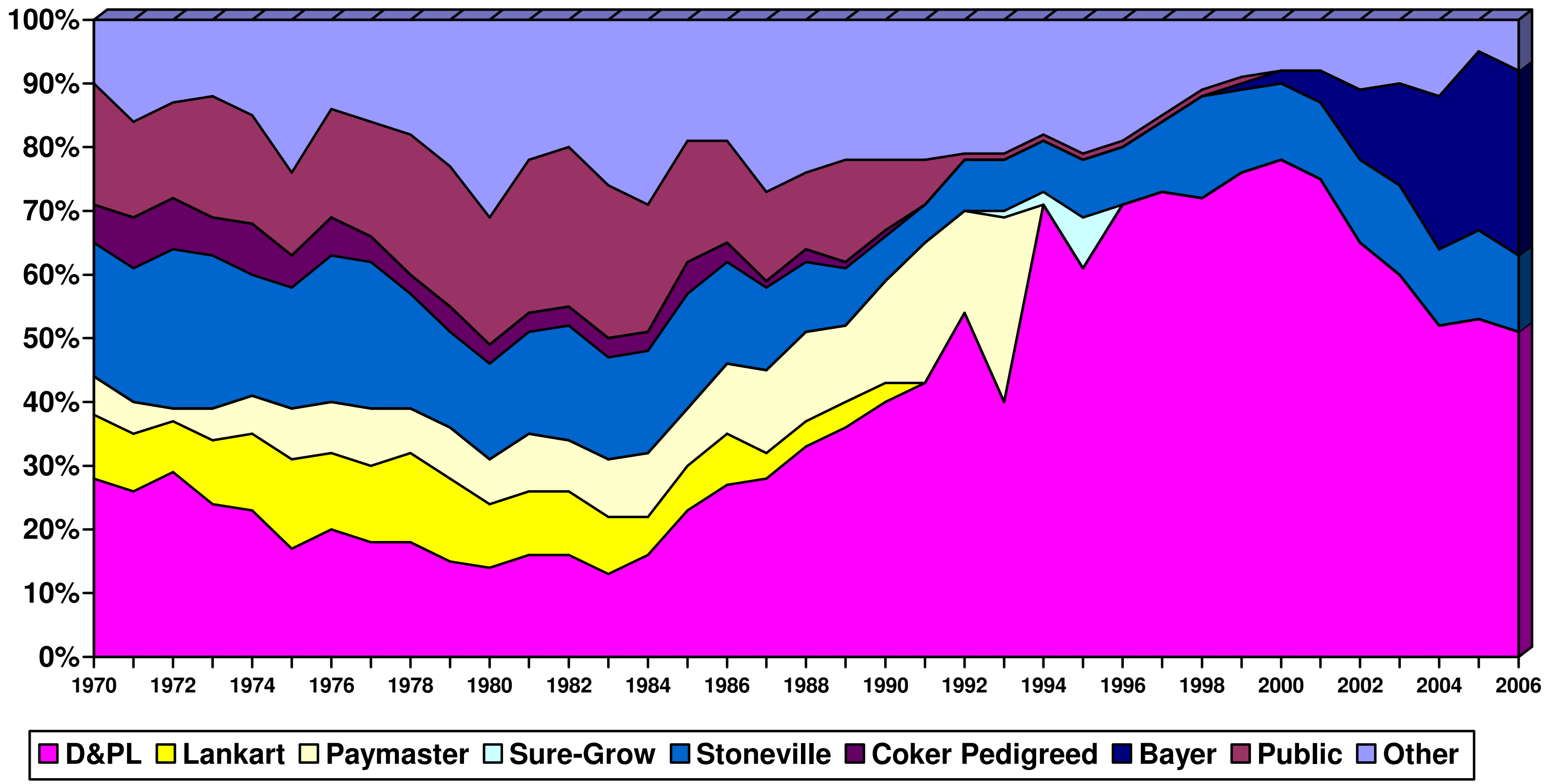
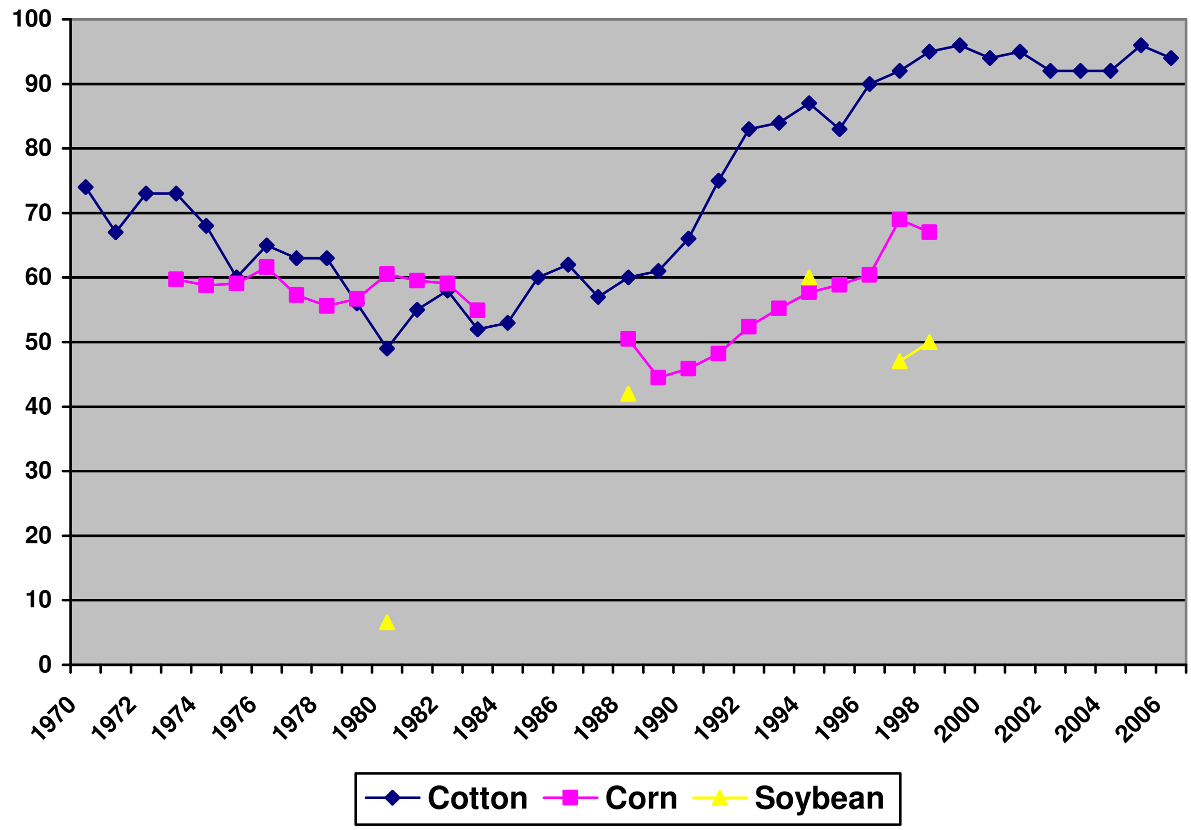
Appendix 1: Cotton Seed Market Share of Selected Companies in U.S.: 1970 to 2006



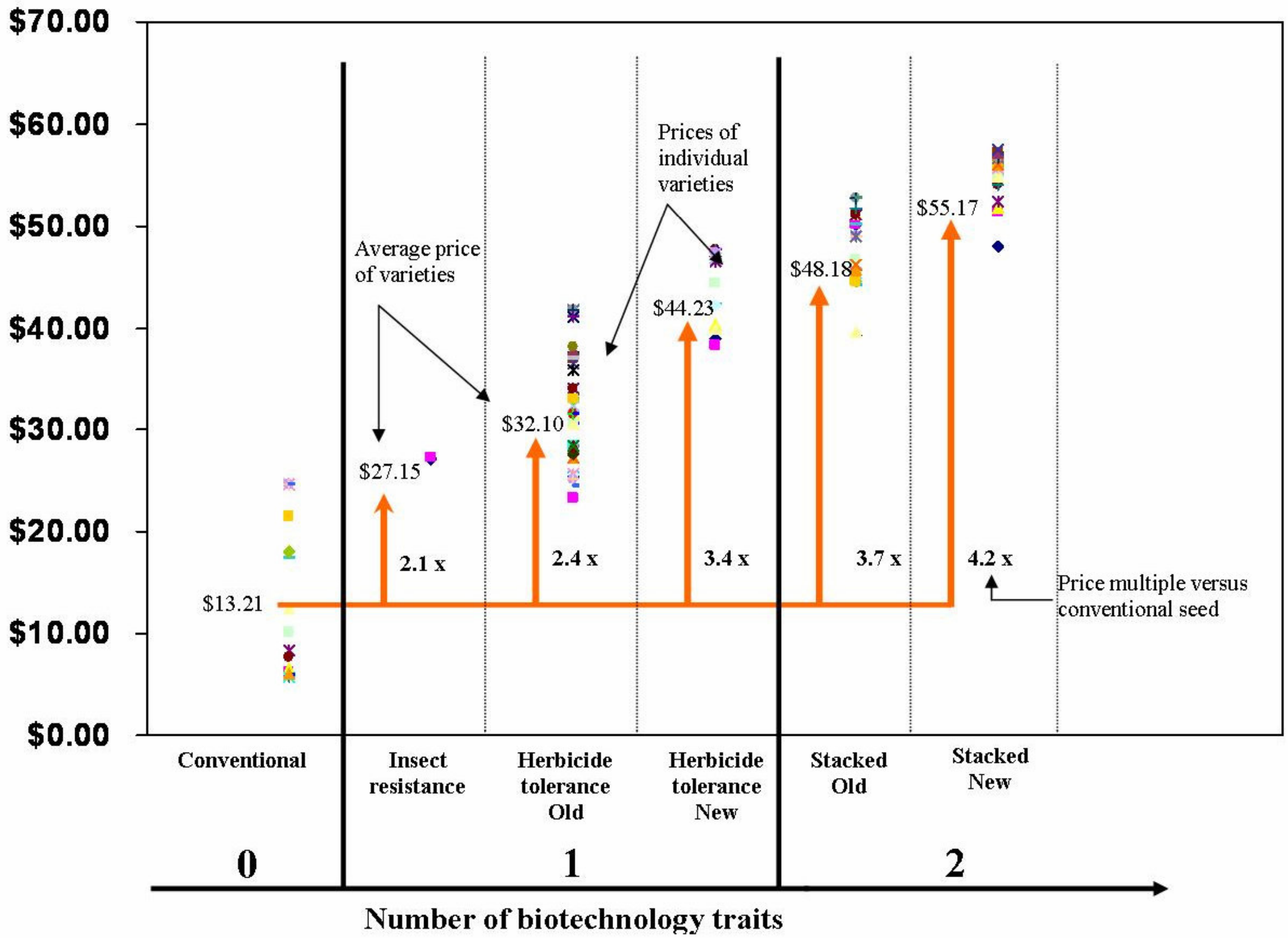
Notes: DPL acquired Lankart & Paymaster (1994) and Sure-Grow (1996). DPL's Summit counted under DPL 1987-1990. Stoneville acquired Coker (1990). Monsanto acquired Stoneville in 1997, sold it in 1999, then re-acquired it as part of Emergent Genetics in 2005. Bayer acquired the Fibermax brand through purchase of Aventis CropScience in 2002, then acquired AFD Seed in 2005. "Public" comprises 5 universities in Arkansas, Mississippi, Oklahoma, Texas and New Mexico. Sources: 1970-1999, see: Fernandez-Cornejo (2004), Table 20. For 2000-2002, estimated from: Monsanto (2006b). For 2003-2006, see USDA AMS (2003-2006).

Appendix 2
Market Share of Four Largest Private Seed Firms: Cotton, Corn and Soybeans



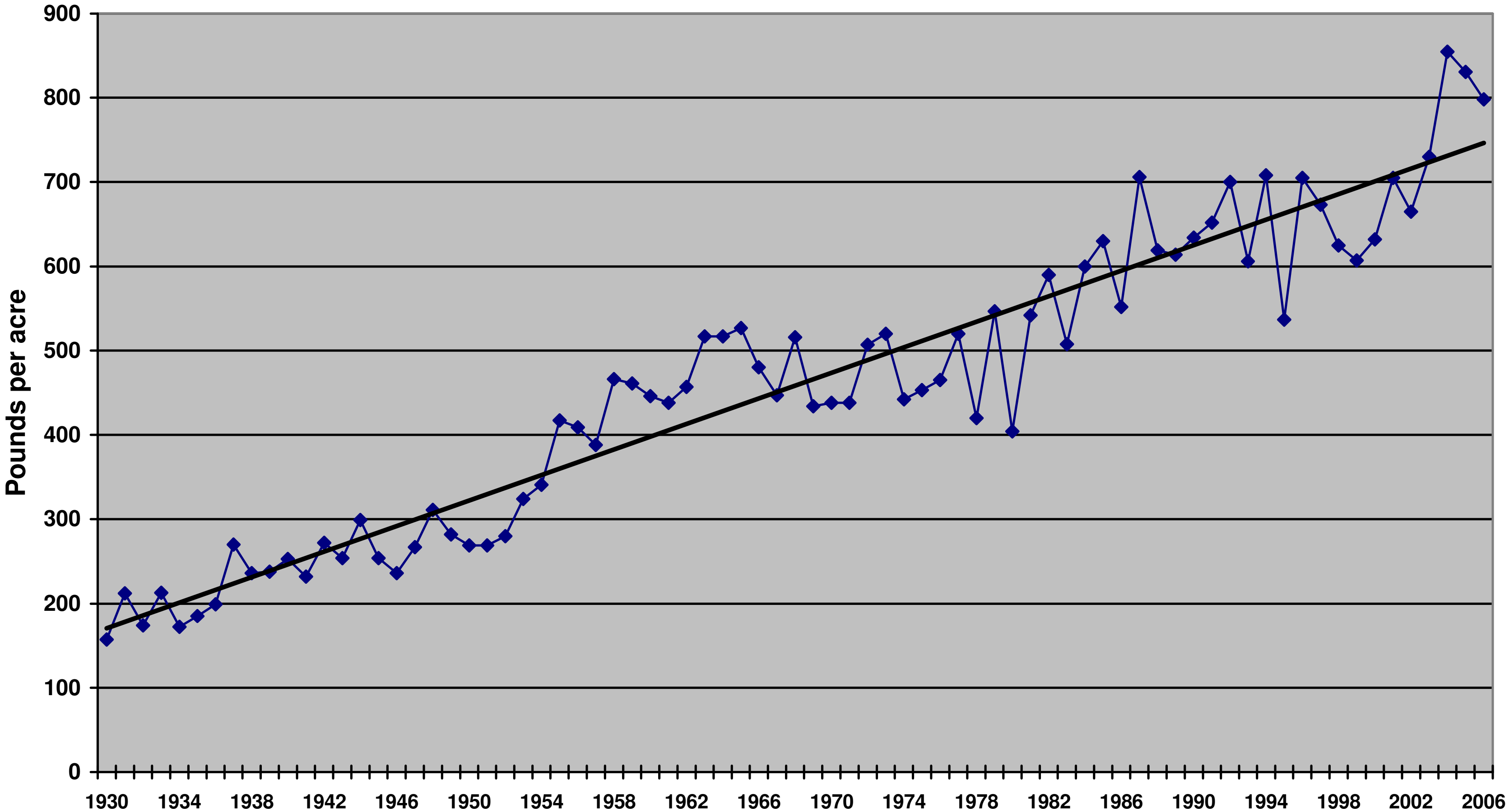
Sources: For corn seed from 1973-83 and 1988-98, cotton seed from 1970-1999, and soybean seed for 1980, 1988, 1994 and 1997-98, see: Fernandez-Cornejo, J. (2004), Tables 15, 16, 18, 19 and 20. For cotton seed, 2000-2002, estimated from Monsanto (2006b). For cotton seed, 2003-2006, see USDA AMS (2003-2006). Note that public-sector breeders, which were among the top four cotton and soybean seed providers for most of the 1970s and 1980s, are excluded here. Data on corn and soybean seed firms not available for all years.

Appendix 3
Cost of Cotton Seed: Conventional vs. Biotech



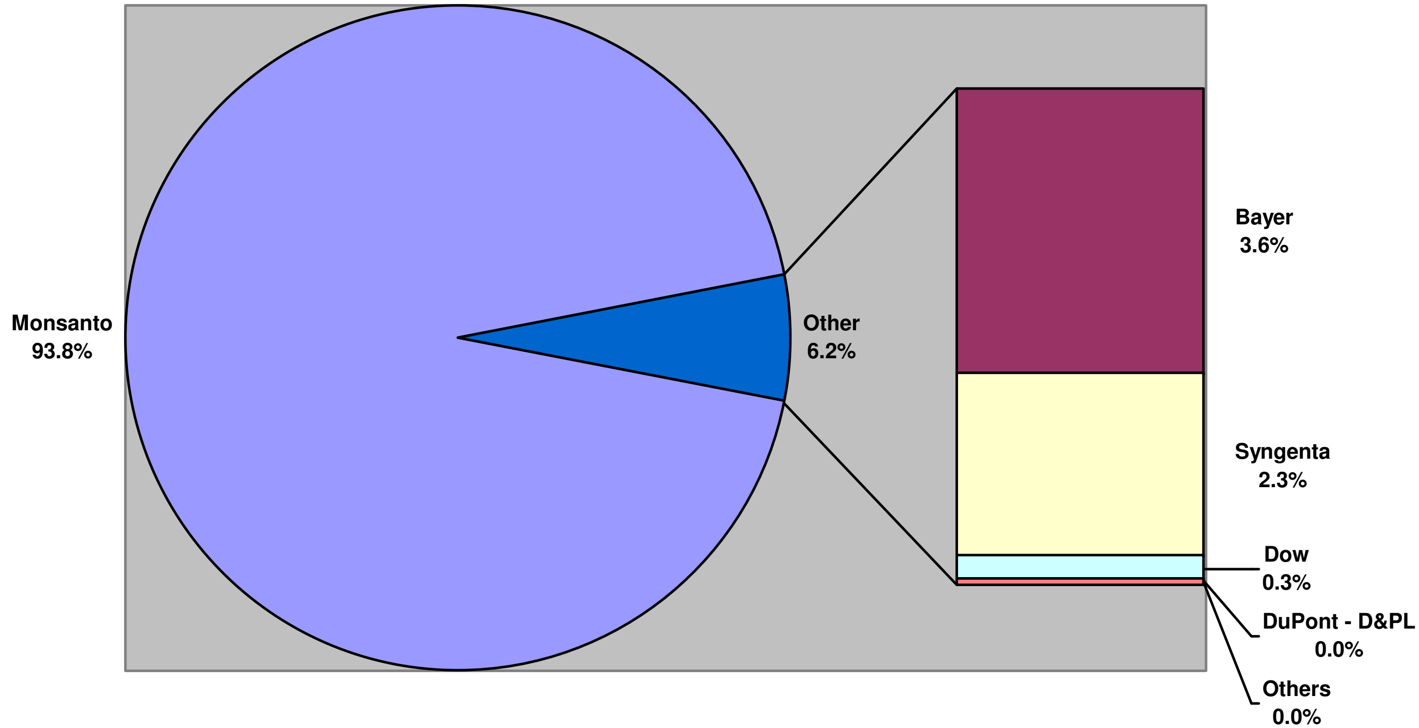
Based on Plains Cotton Growers (2006). Prices of 140 cottonseed varieties are plotted—conventional (21), IR (2), HT Old (45), HT New (15), Stacked Old (26), Stacked New (31) — together with the average price of the varieties in each category and the increased cost versus the conventional average. Per acre price based on 40 inch crop rows and 4.0 seed/feet. See www.plainscotton.org/seed/seedindex.html.

Appendix 4
Average Cotton Yields in the U.S.: 1930 to 2006



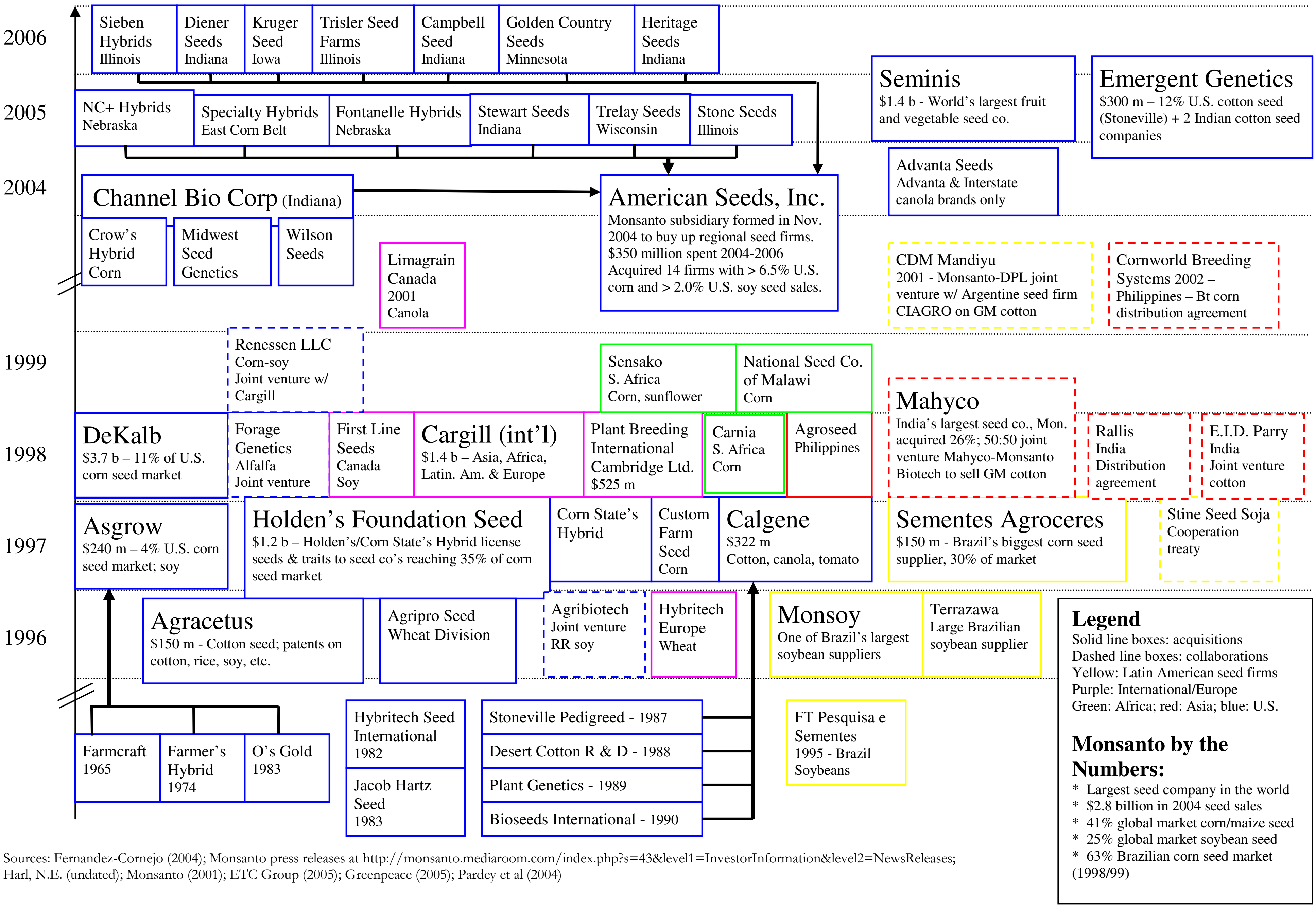
Pounds per harvested acre. Source: USDA's National Agricultural Statistics Service at: http://www.nass.usda.gov/QuickStats/. Last accessed 12/26/06.

Appendix 5
Acreage of Biotech Cotton Field Trials in the U.S.: 2000 to 2006



Source: Data downloaded January 2, 2007 from USDA's searchable database of transgenic crop field trials at http://www.isb.vt.edu/cfdocs/fieldtests1.cfm. Data covers biotech cotton field trial acreage authorized by USDA's APHIS for the given firm between 1/1/00 to 1/2/07. Permits listed as "denied" and "withdrawn" not counted; "pending" permits counted. Acreage figures not available for some permits.

Appendix 6 - Monsanto Acquisitions and Collaborations



Sources: Fernandez-Cornejo (2004); Monsanto press releases at http://monsanto.mediaroom.com/index.php?s=43&level1=InvestorInformation&level2=NewsReleases; Harl, N.E. (undated); Monsanto (2001); ETC Group (2005); Greenpeace (2005); Pardey et al (2004)

Appendix 7
Approved versus Commercially Grown Genetically Engineered Crops

This table portrays the universe of genetically engineered (GE) crops that have been de-regulated (i.e. approved for commercial cultivation and sale) by the U.S. Dept. of Agriculture as of Nov. 17, 2006, and the subset of these approved GE crops that are actually being grown to any significant extent for commercial use in food products. GE crops are broken down by trait or trait combination (see Legend below). Tinted boxes represent the GE crop types that comprise virtually 100% of those that are commercially grown and in the food/feed supply. Numbers represent the number of distinct GE 'events' – differing versions of the same basic crop-trait combination – approved in each category. An empty box signifies that there are no approved versions of the pertinent crop-trait combination.

	HT	IR	HT/IR	Sterile pollen	HT/Sterile pollen	VR	IR/VR	Delayed ripening	Altered composition	Low nicotine	TOTAL
Alfalfa	1										1
Beet	3										3
Canola	**4**				2				1		7
Chicory				1							1
Corn	**4**	**8**	**4**	1	2				1		20
Cotton	**5**	**5**	**1**								11
Flax	1										1
Papaya						1					1
Potato		2					3				5
Rice	2										2
Soybean	**4**								1		5
Squash						2					2
Tobacco										1	1
Tomato		1						10			11
TOTAL	24	16	5	2	4	3	3	10	3	1	71

Legend: HT = herbicide-tolerant; IR = insect-resistant; VR = virus-resistant; HT/IR, HT/Sterile pollen & IR/VR = 'stacked' crops with both of the indicated traits. Sterile pollen corn is used for breeding purposes. Altered composition indicates altered oil composition (soybeans and canola) or altered protein composition (corn). Based on USDA data, current as of November 17, 2006, from http://www.aphis.usda.gov/brs/not_reg.html. For 4 crops with two traits = 100% of biotech crop acreage, see ISAAA (2006)