The evolving landscape of plant varietal rights in the United States, 1930–2008

Philip Pardey, Bonwoo Koo, Jennifer Drew, Jeffrey Horwich & Carol Nottenburg

The types of plants being protected, by whom and by what form of varietal right, has changed markedly since the United States first enabled intellectual property protection for plant varieties in 1930.

Intellectual property (IP) protection for plant varieties seems perpetually embroiled in policy controversy and professional debate. The United States, a hub of plant innovation with multiple types of plant IP protections, has long been at the center of the storm. As early as 1869, the objections of a writer in the *Rural New Yorker* captured the essential argument against such protections that persists to this day:

"As a horticulturalist I protest this movement and hope that Congress will pay no attention to it. The originators of valuable varieties of fruits, grains or vegetables have it in their power now to secure ample compensation: and it is their own fault if they do not. ...In my opinion, the influence of a patent law of this kind would be to retard the dissemination of new things and in this way be a positive damage to the country. ...For these and many other reasons I am in favor of letting this matter regulate itself, as it does at present...".

His wish, of course, was ultimately denied: Congress saw fit to extend the protections of patent law to plants and other living organisms and has been refining and expanding the purview of those protections ever since. The flames are now being fanned again as the Leahy-Smith America Invents Act of 2011 has begun to reshape elements of US patent law.

**A brief legal history**

Though the debate over IP protections for plants took off with the work of Darwin and Mendel in the late 1800s, it was not until 1930 that President Herbert Hoover signed the Plant Patent Act into law. Plant patents, granted by the US Patent and Trademark Office, cover asexually reproduced plants, a category that largely encompasses ornamental plants and fruits. Unlike the utility patents that cover most inventions in the United States, plant patents require no yearly maintenance fee to remain in effect. Under a 1998 update to the law, patentees are able to exclude others from importing any part of a protected plant.

Sexually reproduced crops, a category that includes grains, oilseed crops and grasses, gained IP protection in 1970 under the Plant Variety Protection Act. Plant variety protection (PVP) certificates are administered by the US Department of Agriculture, and they are weaker than plant or utility patents in two important ways. A “breeders’ exemption” allows others to use protected varieties for breeding but not for commercialization. And a “farmers’ exemption” allows farmers to save seed for reproductive purposes and even to resell it to other farmers whose primary occupation is growing crops for consumption or feed.

A third form of protection became possible in 1980 with *Diamond v. Chakrabarty*, in which the US Supreme Court narrowly found that “anything under the sun that is made by man” is patentable subject matter. In practice, this case and subsequent legal rulings clarified that plant varieties, parts of plants, genetically engineered organisms and gene products themselves were eligible for the same US utility patents that cover most other inventions. In 2001, the Supreme Court further clarified that plants covered by a plant patent or PVP certificate could obtain utility patent protection as well (see Supplementary Table 1 for a chronology of key legislative and legal events related to IP protection of plant varieties in the United States). Notably, in the United States it is possible to get dual protection for plant varieties through a utility patent and a plant patent, or a PVP certificate and a utility patent, but not a PVP certificate and a plant patent. This issue was legally resolved in 2001 by a ruling that affirmed the legality of dual protection for plants. Protecting plant varieties by utility patents is rare worldwide: the United States, Australia and South Korea are among the few countries that explicitly allow it. Although Canada does not explicitly allow utility patents on plant varieties, the Canadian Supreme Court upheld in 2004 a finding of infringement of a plant containing a patent-protected DNA sequence.

The legal landscape will continue to be shaped by court rulings and the increasingly common contractual licensing arrangements between patent holders and customers, which in many cases impose additional restrictions beyond IP protections. Trade negotiations over IP continue to shift the international landscape, and new legislation is creating changes in the United States. The Leahy-Smith America Invents Act, passed late in 2011, makes it easier to challenge patents, expands the categories of prior art and changes the US patent regime to a 'first-to-file' system for all patents, including plant patents and all utility patents applying to plants.

**Varietal rights since 1930**

The policy and practical concerns that arise from enabling property rights to plant varieties are myriad. Some analysts and commentators suggest that varietal rights...
restrain access to germplasm, which in turn slows the pace of crop varietal innovation\textsuperscript{7}. Corollaries include the assertions that varietal rights decrease R&D spillovers; that they shift the balance of innovation from freely accessible, public sources to private, profit-making ones; and that these processes undercut the welfare of developing countries and subsistence farmers\textsuperscript{8–10}. Others find little evidence that plant varietal protection works as intended, by whom and by what instrument, and how these rights have evolved over time.

The number of varietal rights has generally increased over time (Fig. 1); 42% of all these rights were lodged between 2000 and 2008 (an average of 1,600 a year in this recent period, compared to just 41 applications in the first decade of our time series; see Supplementary Methods). Plant patents are applied for most often among the three. Their growth did not slow—in fact, it accelerated—after utility patents began to be granted during the 1980s for plants. Although utility patents initially grew slowly, in recent years the rate of utility patenting has generally outpaced the rate of PVP applications. Annual utility patent volumes have been greater than that of PVP applications in most years since 2006.

As one might expect given the subject-matter restrictions of each type of varietal right, none of the (sexually reproduced) cereal or oilseed varieties is protected by a plant patent. A much more diverse set of crop classes is subject to PVP, including cereals (29%), oilseeds (20%), vegetables (20%), grasses (12%) and fiber crops (6%) (see Supplementary Table 2 for a more detailed breakdown of the rights by category of plant). Although all plant types are eligible for utility patents, two specific cereal crops have dominated this type of protection: corn varieties constituted 46% of the 3,719 utility patents granted from 1982 to 2008, and soybeans accounted for 38%. Vegetables made up a smaller but notable share (5%), and fewer than 2% of the utility patents protected ornamental, fruit and tree crops.

The structure of rights has changed considerably over time. During the 1950s, before PVPs and utility patents were granted, ornamentals and fruits accounted for 95% of the rights issued, with ornamentals alone accounting for 76% of the total (Fig. 2a). Fifty years later, specialty horticultural crops were still the predominant plant type being protected, but they constituted a much reduced share of the rights granted (63% of the total, with ornamentals accounting for about half the specialty horticultural crop rights). Looking at the distribution of crop types across the three types of protection, ornamentals and fruits account for 96% of plant patents and cereals and oilseeds account for 87% of utility patents.

Diving more deeply into specific plant types, rose varieties account for the largest share of all varietal rights issued over 1930–2008. But roses have lost some ground, slipping to third place during the last five years of our sample. Notwithstanding the continued dominance of horticultural crops as a category, corn and soybean varieties are now the two highest-ranked crops overall. They accounted for around one-third of all PVP applications lodged and for more than 80% of the pool of utility patents granted in 2004–2008. Cotton ranked third for utility patents and fifth for PVP applications.

Crop concentration varies markedly among the types of rights. Whereas corn and soybeans accounted for far more than half of the utility patents granted during 2004–2008, it took four crops (soybean, corn, wheat and turf grasses) to reach a 50% market share for PVPs, and ten crops to account for half the plant patents during this period.

The pool of applicants seeking varietal protection has also changed substantially over the years (Fig. 3). The share of grants and applications from individuals has dwindled, and the share from the corporate sector (foreign and domestic companies) has risen dramatically. During the 1930s and 1940s, private companies accounted for about 55% of the rights; during the last five years of our time series, private companies accounted for 82% of the total rights. Although the rate of growth in grants and applications from US individuals has inched up over the years (from an average of 20 rights a year in the 1930s to 91 rights a year in the 2000s), these applicants now

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig1.png}
\caption{US varietal rights, 1930–2008. Number of applications filed for PVP certificates (PVPs) and number of utility and plant patents granted (reported according to year of application). Source: see Supplementary Methods.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig2.png}
\caption{Changing distribution of varietal rights by crop. (a) Proportion of varietal rights by crop category, 1950–2008. (b) Crop composition by type of right, 2000–2008. Source: see Supplementary Methods.}
\end{figure}
constitute just 4% of all varietal rights. This change in the structure of IP activity probably reflects more fundamental changes in the structure and cost of research and, equally if not more importantly, the structure and cost of marketing new seed and crop varieties\textsuperscript{10,13}. Notably, utility patents have always been dominated by companies—US companies in particular (Fig. 3b). PVP applications were also sought mainly by companies.

The share of foreign entities (the vast majority of which are companies) has risen dramatically and consistently in recent decades (largely accounting for the share lost by US individuals). In contrast, although the patent volume accounted for by US companies has been somewhat volatile, its long-run share has oscillated around 60% from 1930–2000, ceding more of its share to foreign applicants thereafter. Before 1982, foreign companies accounted for about 10% of varietal rights in the United States; since 2001, their share has been consistently in the 30–40% range. Much of the gain in foreign volume has come in the form of plant patents (Fig. 3b). The inflation-adjusted value of floriculture and nursery imports (including cut flowers, nursery stock and bulbs) increased six-fold from 1976 to 2006 (ref. 14), so it should be no surprise that foreign entities accounted for 64% of all the plant patent rights in the United States in 2008 (compared to 21% in 1984). We estimate (in data not shown here) that 62% of the foreign plant patent rights in 2008 came from just four countries: the Netherlands, Germany, the United Kingdom and Japan.

Another notable trend, evident in Figure 3, might be more accurately described as a lack of one: despite the high volume of US agricultural research performed worldwide at universities, research foundations and government agencies, such public entities still account for only a small share of varietal rights. Nonetheless, US universities accounted for the lion’s share of all publicly sourced PVP applications and patent grants in recent years (Fig. 3). In 2008, US universities accounted for just 5.6% of the year’s 1,882 applications and grants—even fewer than the number lodged by individuals.

Has concentration increased, in any general sense? The data suggest that it has (Fig. 4), although a certain degree of concentration has been present from the start. Figure 4 shows the cumulative share of varietal rights applications for each of the three types of rights on offer, plotted against the cumulative number of applicants arrayed from left (largest) to right (smallest) in terms of the total number of applications lodged per applicant (other than individuals) during the 1930–2008 period. The curves ‘bowed’ more strongly toward the upper left-hand corner of the graph, indicating a more concentrated holding of rights; flatter curves indicate a more even distribution of rights among applicants. Plant patents have been, and remain, quite dispersed, with half the total pool of applications spread among 79 entities from 1930–2008. In contrast, just two applicants (Pioneer Hi-Bred of Johnston, Iowa, and Monsanto of St. Louis, Missouri) account for nearly half the utility patents, and 22 applicants were needed to account for half the PVP applications during the same period\textsuperscript{10}. These data represent the entities applying for or granted the rights; subsequent changes in the status (merged, divested or otherwise) of entities over time are not accounted for. All three types have seen an increase in concentration. As companies
within the plant innovation markets in general—and the US seed sector in particular—have consolidated, so too has the pool of applicants for varietal rights.

A granular look at the dominant entities for each type of protection over the most recent years of our time series, 2000–2008, underscores the changing institutional complexity of these evolving IP markets (Table 1). Table 1 lists the top ten applicants for each form of varietal rights on offer, irrespective of type, plus aggregate counts and shares of the top 10, top 20, and all applicants. These details reveal a major institutional dichotomy between the agencies most active in the utility patent and PVP market segments and those with major stakes in the plant patent segment. Only one company (Syngenta) that shows up in the top-ten list for plant patents also appears in the top-ten lists for the other forms of protection. In contrast, four companies are cross-listed among the top ten for PVPs and utility patents. This suggests that the technical (for example, breeding and multiplication) and marketing requirements for the vegetatively propagated (mainly ornamental) crops are distinct from the sexually reproduced crops that constitute most of the utility and all of the PVP claims. Apparently, there are fewer compelling scientific or commercial rationales for integrating operations among sexually and asexually reproduced crops (at least up to 2008). The relative extent of concentration reflected in Figure 4 is quantified in Table 1.

## Conclusion

When plant varietal rights were first offered in the United States in 1930, the agriculture sector, including horticulture, produced $10.2 billion in output; there were 6.5 million farms in the United States, averaging 151 acres per farm. Almost 80 years later, the US agricultural economy has grown 24-fold, yet the

### Table 1  Top ten applicants by varietal rights, 2004–2008

| Plant patents | PVPs | Utility patents | All IP |
|---------------|------|----------------|-------|
| Applicant name | Holdings (number) | Share (%) | Applicant name | Holdings (number) | Share (%) | Applicant name | Holdings (number) | Share (%) |
| Yoder Brothers | 239 | 4.5 | Pioneer Hi-Bred International | 360 | 19.3 | Monsanto | 558 | 31.2 | Pioneer Hi-Bred International | 876 | 9.8 |
| Syngenta | 228 | 4.3 | Monsanto | 196 | 10.5 | Pioneer Hi-Bred International | 516 | 28.8 | Monsanto | 754 | 8.4 |
| Goldsmith Seeds | 182 | 3.4 | Seminis Vegetable Seeds | 108 | 5.8 | Stine Seed Farm | 172 | 9.6 | Syngenta | 466 | 5.2 |
| Ball Horticultural Co. | 164 | 3.1 | Syngenta | 104 | 5.6 | Syngenta | 134 | 7.5 | Yoder Brothers | 239 | 2.7 |
| SunTory | 157 | 2.9 | Delta and Pine Land Co. | 50 | 2.7 | Mertec | 73 | 4.1 | Goldsmith Seeds | 182 | 2.0 |
| Klemm & Sohn | 128 | 2.4 | Pure Seed Testing | 49 | 2.6 | Delta and Pine Land Co. | 59 | 3.3 | Ball Horticultural Co. | 176 | 2.0 |
| Terra Nova Nurseries | 115 | 2.2 | Bayer CropScience | 43 | 2.3 | Shamrock Seed Co. | 25 | 1.4 | Stine Seed Farm | 172 | 1.9 |
| Poulsen Roser | 103 | 1.9 | Rutgers University | 43 | 2.3 | Seminis Vegetable Seeds | 23 | 1.3 | SunTory | 157 | 1.7 |
| Danziger “Dan” Flower Farm | 72 | 1.4 | WestBred | 42 | 2.3 | Bayer CropScience | 16 | 0.9 | Seminis Vegetable Seeds | 131 | 1.5 |
| CP Delaware | 71 | 1.3 | North Dakota State University | 34 | 1.8 | Dow AgroSciences | 15 | 0.8 | Klemm & Sohn | 128 | 1.4 |
| Top 10 applicants | 1,459 | 27.4 | 1,029 | 55.2 | 1,591 | 88.9 | 3,281 | 36.5 |
| Top 20 applicants | 2,026 | 38.1 | 1,228 | 65.9 | 1,668 | 93.2 | 4,103 | 45.7 |
| All applicants | 5,324 | 100.0 | 1,864 | 100.0 | 1,789 | 100.0 | 8,977 | 100.0 |

Data represent count and share of each type of right held by granted applicant. Consolidation of holdings due to subsequent merger and acquisition activity (for example, Monsanto’s acquisition of Seminis in 2005 and Delta and Pine Land Co. in 2007) or divestitures are not reflected in this compilation. Source: see Supplementary Methods.
farm sector has massively consolidated, down to 2.1 million farms, averaging 446 acres in size. Moreover, 70% of the agricultural production (by value) came from just 7% of all commercial farms in the United States in 2003 (ref. 16).

Across the board, US farms are less reliant on farm-produced inputs. Farm-produced power (mainly horses and mules for traction) has given way to off-farm traction and energy sources. A substantial share of animal feed is now grown off the farms on which it is used, and purchased chemicals (herbicides, pesticides and fertilizer) have grown as a share of the total cost of farm production. Notably, and of particular relevance for this paper, substantial amounts of seed are now purchased annually rather than saved and reused.

Accordingly, seed and other input markets servicing US agriculture have evolved and adjusted. The scientific basis for manipulating cultivated crops has also changed radically over the past 80 years, again changing the incentives and structures of the crop-breeding, multiplication and marketing sectors. Along with these broader market changes have come changes in US markets for IP in general, and for IP pertaining to plant varieties in particular. Here we describe the changing legislative and legal structures that directly affect plant varieties, as well as the marked changes in the crops being protected, the types of varietal rights sought and the applicants seeking them since 1930.

Benchmarking these evolving IP rights provides a basis for beginning to understand the complex interplay between the legal, scientific and market forces that have shaped these varietal rights in the United States. A better understanding of these IP markets can guide the policy and practice of varietal rights in the United States. It can also inform the international dimensions of these markets, which are increasingly intertwined by way of international treaties and global trade.

Note: Supplementary information is available at http://www.nature.com/doifinder/10.1038/nbt.2467.

ACKNOWLEDGMENTS
The authors are especially appreciative of research assistance from C. Pratt, S. Pardey, M. Hallaway and C. Chan-Kang, and for the excellent assistance with data queries from personnel at the US Patent and Trademark Office and USDA’s Plant Variety Protection Office. The research for this paper was supported by the International Science and Technology Policy (InSTePP) center at the University of Minnesota, the University of Waterloo, the US National Institutes of Health and the Bill and Melinda Gates Foundation, by way of the HarvestChoice project.

COMPETING FINANCIAL INTERESTS
The authors declare no competing financial interests.

1. Newman, M.R. USDA Agr. Lib. Notes 6, 35–42 (1931).
2. (7 U.S.C. 2543 (d–e)).
3. (7 U.S.C. 2541).
4. Diamond v. Chakrabarty, 447 U.S. 303, 309 (1980).
5. J.E.M. Ag Supply v. Pioneer Hi-Bred Int’l., 534 U.S. 124 (2001).
6. Monsanto Canada Inc. v. Schmeiser [2004] 1 S.C.R. 902, 2004 SCC 34.
7. Louwaars, N.P. et al. Impacts of strengthened intellectual property rights regimes on the plant breeding industry in developing countries: a synthesis of five case studies (Wageningen, UR, 2005).
8. Kimbrell, A. Fatal Harvest: The Tragedy of Industrial Agriculture (Island Press, 2002).
9. t ansey, G. Food security, biotechnology and intellectual property: unpacking some issues around TRIPS (Quaker United Nations Office, 2002).
10. Alston, J.M. & Venner, R.J. Res. Pol. 31, 527–542 (2002).
11. Heald, P.J. & Chapman, S. Veggie tales: Pernicious myths about patents, innovation, and crop diversity in the twentieth century. Illinois Program in Law, Behavior and Social Science Paper No. LB511-34; Illinois Public Law Research Paper No. 11-03. (2011). http://ssrn.com/abstract=1928920
12. Marco, A.C. & Rauser, G.C. Amer. J. Agr. Econ. 90, 133–151 (2008).
13. Jerardo, A. Floriculture and nursery crops yearbook (USDA, ERS, 2007).
14. Fernandez-Cornejo, J. Bulletin 786 (USDA, ERS, 2006).