CONTROL OF HAY-SCENTED AND NEW YORK FERNS WITH OUST XP® HERBICIDE: REVISITING RATE AND TIMING REQUIRED IN MIXED OAK AND NORTHERN HARDWOOD STANDS

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Abstract.—Dense rhizomatous fern layers compete with desirable tree seedlings for light, which suppresses development and even kills seedlings. Sulfometuron methyl (Oust XP®) herbicide can be safely and effectively used to control ferns. Previous research showed that depending on application timing, as little as 2 ounces of Oust XP per acre controlled ferns while hardwood tree seedlings growing beneath them survived. It was recently suggested that some sites may require higher rates because of soil differences. This study uses a wider variety of site conditions than previous studies to reevaluate the rates and timing of Oust application. This study examined the efficacy of 2, 3, and 4 ounces of Oust XP herbicide per acre applied in July, August, and September without a surfactant for controlling *Dennstaedtia punctilobula* and *Thelypteris nove-boracensis* (hay-scented and New York ferns) in mixed oak and northern hardwood forests. Ten-foot by ten-foot plots were treated and monitored for fern control and impacts on nontarget species within 10 stands across north-central and northwestern Pennsylvania. Ferns were controlled with all rates and times of application. More surviving ferns in plots were treated in September. Hardwood seedlings survived even at the highest rate. *Prunus serotina* and *Amelanchier arborea* had some nonsignificant reductions in numbers at all rates and times. Some growth malformations were noticed on individual seedlings with July treatments. Oust XP killed *Rubus* spp. (blackberry) at all rates and times, but grasses and other herbs were unaffected. Oust XP continues to be an effective tool for controlling ferns at a variety of sites and allows seedlings to survive in place.

INTRODUCTION

Overbrowsing by white-tailed deer *(Odocoileus virginianus)* has altered forest understories across the eastern United States (Alverson and Waller 1997, Horsley et al. 2003, Porter et al. 2004). Forest understory plants that interfere with the reestablishment of overstory species following disturbance often become established as a result of long-term herbivory. This can apply selective pressure to an ecosystem, driving species composition toward those that are herbivore resistant (Royo and Carson 2006). Many stands in Pennsylvania have dense herbaceous layers that are dominated by the rhizomatous hay-scented (*Dennstaedtia punctilobula* (Michx) T. Moore) and New York (*Thelypteris noveboracensis* (L.) Nieuwl.) ferns, striped maple (*Acer pensylvanicum* L.), and American beech (*Fagus grandifolia* Ehrh.) (Horsley 1991). These understories are the result of long-term deer browsing followed by increased light, which results from beech bark disease mortality, partial cutting practices, and the shade tolerance of these plants (Horsley et al. 2003, Marquis and Brenneman 1981, Marquis et al. 1992, Tilghman 1989). Since 1991, an herbicide prescription for removing interfering ferns has been used in Pennsylvania (Horsley et al.1992, McCormick et al. 1991). McCormick et al. (1991) showed that hardwood and white pine (*Pinus strobus* L.) seedlings were not affected by Oust XP® application when a surfactant was not included with the product application. Herbicides commonly used to control interfering

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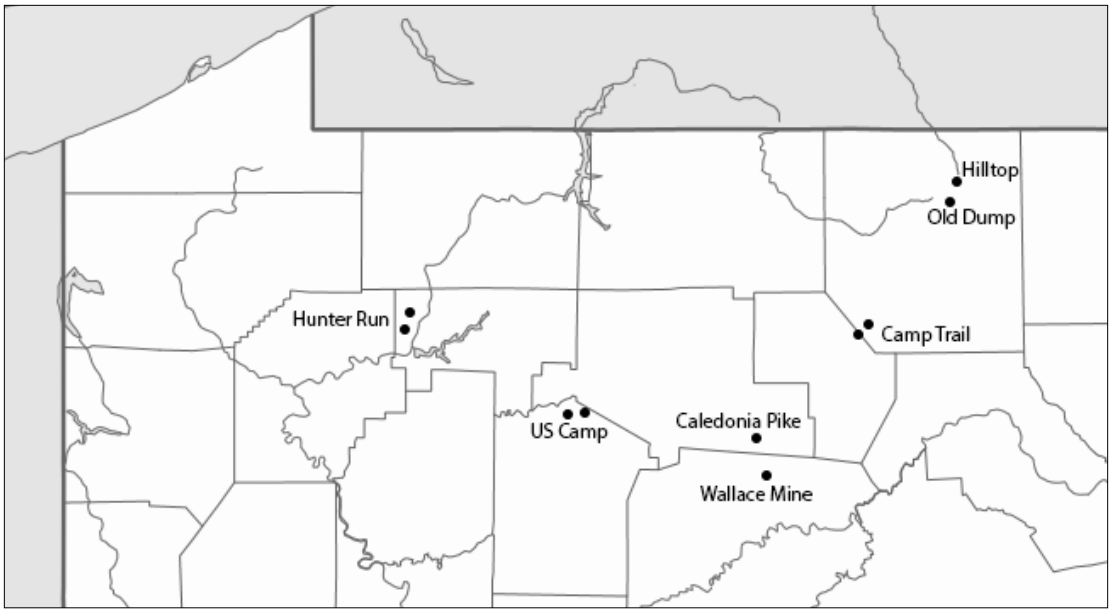

Figure 1.—Study locations throughout north-central Pennsylvania.

plants in Pennsylvania have only short-term impacts on nontarget organisms (Ristau et al. 2011, Stoleson et al. 2011, Trager et al. 2013). Full recovery occurred within 3-5 years. Herbicides are safe and effective for reducing competition and do not harm nontarget organisms.

Public agencies, private companies, and private nonindustrial forest owners currently use herbicides on about 12,000 acres of forest land in Pennsylvania each year. Treating with Oust XP alone does not kill desirable regeneration. Many foresters have expressed concern that fern control is incomplete and unsatisfactory at the recommended 2 ounce per acre rate. They report that higher rates are needed. The Oust XP prescription was developed in Allegheny hardwood stands in northwestern Pennsylvania and in oak stands near State College, PA (Horsley 1988). Differences in soils, genetics, and climate may in turn affect the rate required for adequate fern control. This study expanded the range of sites to include additional oak and northern hardwood stands throughout north-central Pennsylvania to determine if 2 ounces of Oust XP per acre are still effective when applied during July, August, and September.

METHODS

Suitable stands for this study were sought from the Pennsylvania Bureau of Forestry in spring 2012. All stands had 80- to 100-percent summer fern cover and desirable tree seedlings beneath the fern. Overstory density was variable; shelterwood, thinned stands, or stands with mortality provided suitable light conditions for seedlings and interference to develop. Site limitations such as excessively wet or rocky soils were not permitted. Ten sites (see Fig. 1) located in the Clear Creek, Cornplanter, Elk, Moshannon, and Susquehannock districts of the Pennsylvania Bureau of Forestry were selected.

Twelve 100-square-foot (10 foot × 10 foot) treatment plots with a 1/1000th acre (milacre) plot in the center were established in each stand. Application rates used included 0, 2, 3, or 4 ounces of Oust XP per acre (dissolved in 25 gallons of water) applied on or about July 15, August 15, or September 15, 2014 (Fig. 2). Amounts applied to 100-square-foot treatment plots were the proportional equivalents to per-acre amounts (0, 0.13, 0.19, or 0.26 g in 500 mL of water). Surfactant was not included in the applications. Before treatment and full fern expansion (May 15-30, 2014), plant inventories were conducted on milacre plots. These inventories counted

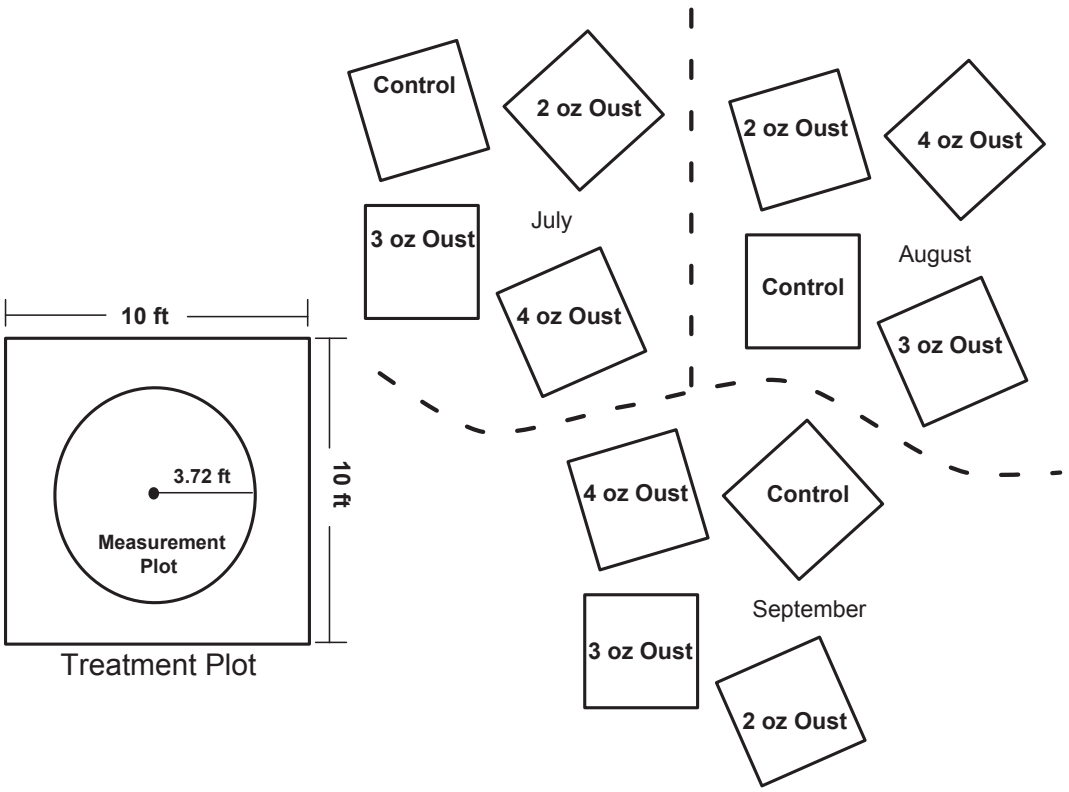

Figure 2.—Stylized plot layout of Oust treatments.

all tree seedlings by species and estimated the percentage of plot covered by broad classes of herbaceous plants, including the targeted fern species. Most fern on the plots was hay-scented fern. Any New York fern encountered was combined with the hay-scented fern cover for analysis because they behave and respond similarly. Inventories were repeated in May 2015 to assess fern control and impacts on nontargeted species. May sampling means that ferns were not fully expressed at the time of the inventory; however, all sample plots had 80- to 100-percent fern cover and were established the year before treatment (2013). Sampling plots with dense fern cover when ferns are fully expressed damages fronds. To avoid that damage, sampling was conducted in May.

The study design was a randomized complete block. Statistical analyses were conducted with SAS PROC MIXED (SAS Institute, Cary, NC 2014). A restricted maximum likelihood technique and the Kenward-Roger correction method for the denominator degrees of freedom were used (Littell et al. 2006). The 10 sites provided replication, and each site contained all rate-by-time combinations. Site was considered as a random effect; year, month of application, and rate applied were treated as fixed effects. Year was considered a repeated measure with a compound symmetry covariance structure (Littell et al. 2006). Treatment effects were evaluated for cover of fern, grass, lycopodium, other herbaceous species combined, and *Rubus* as well as seedling counts of red maple (*A. rubrum* L.), sugar maple (*A. saccharum* Marsh.), serviceberry (*Amelanchier arborea* (Michx.)Fern.), sweet birch (*Betula lenta* L.), American beech (*Fagus grandifolia* Ehrh.), yellow-poplar (*Liriodendron tulipifera* L.), cucumber tree (*Magnolia acuminata* L.), pin cherry (*Prunus pensylvanica* L.), black cherry (*P. serotina* Ehrh.), and northern red oak (*Quercus rubra* L.). Residuals were evaluated graphically using a scatterplot of the residuals, a histogram with normal density, a Q-Q plot, and a box plot of the residuals produced by PROC MIXED. Post-hoc tests to identify differences among experimental treatments were conducted using Tukey-Kramer tests in the LSMEANS option of the MIXED procedure with an alpha probability level of 0.05.

RESULTS AND DISCUSSION

Early summer pretreatment fern cover was 49–60 percent and did not vary between plots of different rates and times of application (Table 1). Following treatment in July or August the percent fern cover was reduced to less than 1 percent for all rates used. All September treatments slightly exceeded 1-percent fern cover for all rates. These results are similar to those reported by Horsley (1988) and Horsley et al. (1992), who indicated no differences in fern control rate across the months tested. Ferns treated in September were often yellowing and the control was expected to be less. Even though the treatments did not differ significantly, there was twice as much fern cover following September treatments as in July and August (Table 1). Other than ferns, the only nontree species that was controlled by Oust XP was *Rubus* spp., which in all treatments except one (2 ounces in August) resulted in substantially lower cover following application. The variability of this species in the 2-ounce treatment was high and there was lower *Rubus* coverage in the plots receiving that rate and timing.

Serviceberry and black cherry were the only hardwood tree seedlings that were affected by Oust XP applications, though these differences were not statistically significant because the sites varied greatly (Table 2). At all rates and times of application, numbers of black cherry seedlings were reduced by 30-50 percent, and serviceberry was reduced by 70–90 percent. Like *Rubus,* which was affected by Oust XP, these species are all in the Rosaceae family, suggesting that members of Rosaceae may be more sensitive to Oust XP herbicide than others in the study. Overall, these results suggest that treatment with Oust XP at any of the rates and times tested does not negatively affect tree seedling numbers. Horsley et al. (1992) cautioned that tree seedling species were affected when a surfactant was added to the herbicide mix.

It is unclear why regional forest managers have observed lack of fern control with the recommended 2 ounce per acre rate (Brose et al. 2008, Marquis et al. 1992). Results of this study show effective control across all study sites, rates, and times. Operational treatments can differ from that of experimental plots, and perhaps the adequacy of coverage is part of the problem. On experimental plots coverage was complete. Mist blower applications may not cover adequately. Greater numbers of fronds were left uncontrolled during the September treatments, suggesting that August treatment with Oust XP may be more effective. July treatment can also work, but these earlier treatments, especially at the higher rates, caused increased malformations on seedlings (data not shown). For an operational recommendation, using 2 ounces Oust XP per acre applied in July or August seems most reasonable, because it reduces the herbicide applied and minimizes damage to desirable hardwood regeneration (Brose et al. 2008, Marquis et al. 1992).

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Table 1.—Percent coverage of herbaceous plants by time and rate of Oust application. Values in parentheses are standard error of the mean. Numbers are from 10 replicates throughout north-central Pennsylvania. Significant ($p < 0.05$) pairwise comparisons between pretreatment and post-treatment are indicated in bold. There were no significant differences among rates and times.

		July (ounce Oust/acre)				August (ounce Oust/acre)				September (ounce Oust/acre)			
	Year	0	2	3	4	0	2	3	4	0	2	3	4
Rhizomatous ferns[a]	2014	56.4 (8.0)	53.6 (5.7)	48.6 (6.5)	55.5 (8.4)	52.7 (6.1)	52.8 (4.7)	54.7 (5.8)	53.0 (6.5)	60.2 (5.0)	56.3 (6.1)	49.7 (6.5)	55.0 (6.4)
	2015	77.0 (4.3)	**0.1 (0.1)**	**0.3 (0.2)**	**0.0 (0.0)**	77.8 (5.6)	**0.6 (0.2)**	**0.4 (0.2)**	**0.5 (0.3)**	76.3 (3.7)	**1.3 (0.5)**	**1.1 (0.2)**	**1.2 (0.4)**
Lycopodium spp.	2014	0.2 (0.2)	0.1 (0.1)	1.5 (1.5)	0.0 (0.0)	2.0 (2.0)	8.5 (8.5)	3.5 (2.5)	0.0 (0.0)	8.4 (8.0)	2.5 (1.7)	1.1 (1.0)	4.5 (4.5)
	2015	2.6 (2.5)	2.0 (2.0)	2.5 (2.5)	0.2 (0.2)	0.1 (0.1)	8.0 (8.0)	9.5 (6.6)	0.1 (0.1)	8.5 (7.0)	7.5 (6.0)	2.5 (2.5)	6.1 (6.0)
Graminoids	2014	0.9 (0.5)	1.8 (1.5)	1.7 (1.0)	0.8 (0.5)	0.2 (0.1)	2.4 (1.0)	1.9 (1.0)	6.2 (4.9)	1.8 (1.0)	1.3 (0.7)	2.1 (1.5)	1.7 (0.6)
	2015	2.0 (1.0)	2.5 (1.5)	1.0 (0.5)	0.7 (0.2)	1.4 (1.0)	4.8 (2.2)	1.9 (1.0)	3.3 (1.6)	1.3 (0.5)	2.0 (1.5)	2.5 (2.0)	1.5 (1.0)
Rubus spp.	2014	2.4 (2.0)	2.4 (1.5)	0.7 (0.2)	1.0 (0.5)	3.8 (1.9)	1.3 (0.7)	5.2 (2.3)	4.0 (2.0)	1.5 (0.6)	7.8 (5.9)	4.3 (2.6)	0.5 (0.2)
	2015	5.0 (3.0)	0.2 (0.1)	0.1 (0.1)	0.1 (0.1)	6.0 (2.4)	0.6 (0.5)	**0.8 (0.3)**	0.9 (0.3)	3.8 (2.0)	**0.9 (0.5)**	0.1 (0.1)	0.2 (0.1)
Other herbaceous	2014	5.7 (1.6)	3.8 (1.9)	4.8 (1.9)	4.1 (1.7)	3.4 (1.2)	2.3 (1.0)	3.9 (1.1)	4.7 (2.0)	4.9 (1.6)	3.0 (1.3)	5.8 (2.3)	5.8 (2.1)
	2015	8.1 (3.8)	3.1 (1.0)	6.6 (2.4)	2.0 (1.5)	4.0 (1.9)	6.4 (2.0)	5.0 (2.0)	5.2 (2.6)	13.2 (4.2)	2.3 (1.1)	8.1 (4.0)	2.4 (0.7)

[a] Combined cover of *Dennstaedtia punctilobula* and *Thelypteris nove-boracensis* (mostly *Dennstaedtia punctilobula*).

Table 2.—Thousands of stems per acre by time and rate of Oust application. Values in parentheses are standard error of the mean. Numbers are from 10 replicates throughout north-central Pennsylvania. There were no significant differences among treatments.

		July (ounce Oust/acre)				August (ounce Oust/acre)				September (ounce Oust/acre)			
Species	Year	0	2	3	4	2	2	3	4	0	2	3	4
		Thousands per acre											
Acer rubrum	2014	14.7 (4.1)	20.0 (6.5)	27.0 (6.0)	18.6 (4.8)	12.7 (4.0)	12.4 (4.9)	11.5 (5.3)	27.9 (10.7)	25.4 (11.2)	21.1 (8.3)	15.0 (4.4)	14.1 (3.9)
	2015	16.9 (3.5)	27.4 (8.6)	31.5 (8.4)	23.6 (8.5)	17.5 (6.6)	14.0 (4.3)	20.0 (12.8)	24.7 (6.5)	25.5 (12.6)	25.8 (10.4)	21.0 (6.1)	18.0 (4.1)
Acer saccharum	2014	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.3 (0.3)	0.6 (0.6)	0.1 (0.1)	0.1 (0.1)	0.0 (0.0)	0.3 (0.2)	0.4 (0.3)	0.1 (0.1)	0.0 (0.0)
	2015	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.3 (0.3)	0.5 (0.5)	0.1 (0.1)	0.1 (0.1)	0.2 (0.2)	0.2 (0.1)	0.0 (0.0)	0.4 (0.3)	0.0 (0.0)
Amelanchier arborea	2014	4.9 (3.1)	1.4 (0.9)	3.0 (1.5)	0.9 (0.5)	10.1 (5.6)	3.8 (1.8)	2.1 (0.9)	3.0 (1.2)	4.4 (3.0)	6.6 (4.1)	2.6 (1.6)	4.5 (2.7)
	2015	2.9 (1.5)	0.8 (0.7)	0.4 (0.2)	0.2 (0.2)	4.9 (2.2)	0.6 (0.5)	0.1 (0.1)	0.9 (0.4)	5.1 (2.9)	0.2 (0.2)	0.0 (0.0)	1.1 (1.1)
Betula lenta	2014	0.6 (0.3)	0.9 (0.7)	0.2 (0.2)	0.7 (0.4)	0.0 (0.0)	0.0 (0.0)	0.1 (0.1)	0.9 (0.6)	0.0 (0.0)	0.1 (0.1)	0.0 (0.0)	0.0 (0.0)
	2015	0.3 (0.2)	0.5 (0.4)	0.1 (0.1)	0.2 (0.1)	0.0 (0.0)	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)	0.0 (0.0)	0.0 (0.0)
Fagus grandifolia	2014	0.3 (0.3)	0.5 (0.5)	0.1 (0.1)	0.0 (0.0)	0.1 (0.1)	0.0 (0.0)	0.0 (0.0)	0.2 (0.2)	0.0 (0.0)	0.3 (0.2)	0.2 (0.2)	0.1 (0.1)
	2015	0.4 (0.4)	0.2 (0.2)	0.1 (0.1)	0.2 (0.2)	0.1 (0.1)	0.0 (0.0)	0.0 (0.0)	0.3 (0.3)	0.0 (0.0)	0.4 (0.3)	0.2 (0.2)	0.0 (0.0)
Liriodendron tulipifera	2014	0.5 (0.4)	1.4 (1.4)	0.7 (0.5)	0.7 (0.5)	0.3 (0.3)	0.7 (0.6)	1.2 (0.9)	1.4 (0.9)	1.8 (1.8)	0.5 (0.5)	0.1 (0.1)	1.7 (1.7)
	2015	0.9 (0.6)	0.7 (0.7)	1.0 (0.7)	0.8 (0.7)	0.3 (0.3)	0.6 (0.6)	1.4 (1.0)	1.2 (0.9)	1.2 (1.2)	0.9 (0.6)	0.1 (0.1)	1.3 (1.3)
Magnolia acuminata	2014	0.4 (0.3)	0.7 (0.5)	0.3 (0.2)	0.9 (0.5)	0.3 (0.2)	0.4 (0.3)	0.4 (0.3)	0.0 (0.0)	0.7 (0.3)	0.9 (0.5)	0.5 (0.3)	0.4 (0.3)
	2015	0.4 (0.2)	0.6 (0.5)	0.3 (0.2)	0.3 (0.2)	0.4 (0.2)	0.7 (0.6)	0.3 (0.2)	0.0 (0.0)	0.7 (0.3)	0.8 (0.4)	0.3 (0.2)	0.2 (0.2)
Prunus pensylvanica	2014	0.3 (0.3)	0.5 (0.3)	0.2 (0.2)	0.5 (0.4)	0.1 (0.1)	0.0 (0.0)	0.1 (0.1)	0.3 (0.3)	0.0 (0.0)	0.0 (0.0)	0.1 (0.1)	0.0 (0.0)
	2015	0.1 (0.1)	0.0 (0.0)	0.0 (0.0)	0.1 (0.1)	0.1 (0.1)	0.0 (0.0)	0.0 (0.0)	0.3 (0.2)	0.1 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Prunus serotina	2014	4.0 (1.9)	3.1 (1.5)	7.8 (5.4)	2.7 (1.4)	6.7 (4.9)	4.5 (2.0)	9.6 (6.6)	10.3 (8.3)	4.0 (1.4)	15.4 (9.2)	8.8 (5.7)	2.7 (1.1)
	2015	3.5 (1.4)	1.4 (0.9)	3.7 (2.1)	1.7 (1.0)	4.7 (3.4)	3.4 (1.8)	3.1 (1.6)	4.7 (3.5)	3.8 (1.5)	8.8 (4.9)	8.9 (5.5)	0.7 (0.3)
Quercus rubra	2014	5.0 (2.0)	5.0 (2.7)	6.5 (3.6)	8.8 (3.5)	7.2 (3.4)	5.4 (1.7)	3.3 (1.8)	6.9 (3.2)	5.7 (2.8)	3.7 (1.7)	7.5 (3.9)	11.8 (9.7)
	2015	5.5 (1.7)	6.6 (3.3)	5.2 (2.7)	5.1 (2.5)	3.9 (1.4)	3.3 (1.4)	7.3 (3.7)	3.5 (1.8)	7.3 (3.1)	6.2 (2.6)	5.6 (2.3)	8.0 (6.2)

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