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Weed Risk Assessments Can Be Useful, But Have Limitations

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Gordon et al. (2016) claim that our study (Smith et al. 2015) "misrepresents the utility of WRA tools" and outline four key issues. We affirm that our study was conducted in accordance with Weed Risk Assessment (WRA) guidelines (Koop et al. 2012; Pheloung et al. 1999) and is equally robust as or more robust than other evaluations of bioenergy crop invasiveness using WRAs; moreover, we detail cherry-picked quotes and misrepresentation of our conclusions by Gordon et al. (2016).

First, Gordon et al. (2016) criticize our application of WRAs at the species level. To start, all other WRA assessments of bioenergy crops have been done at the species level (even for species that have clear subspecific taxa), including several by our critics (Buddenhagen et al. 2009; Davis et al. 2010; Gordon et al. 2011). In rare circumstances WRAs have been run for clear and unambiguous existing [e.g., fertile vs. sterile *Miscanthus* × *giganteus* M. Greef & Deuter ex Hodkinson & Renvoize (giant miscanthus)] or hypothetical [e.g., sterile switchgrass, *Panicum virgatum* (L.)] sub-specific taxa (Barney and DiTomaso 2008; Barney et al. 2015). In particular, Gordon et al. (2016) criticize our decision to combine data for crop sorghum and its invasive variety, shattercane—both *Sorghum bicolor* (L.) Moench. However, we already discuss the consequences of this decision, and our rationale for making it, in our paper (Smith et al. 2015; see also Barney et al. 2015). Gordon et al. (2016) also ignore the example in which we evaluated the two major "cultivars" of *M.* × *giganteus,* which get very different WRA outcomes (Smith et al. 2015), as well as sorghum and shattercane (Barney et al. 2015). Ironically, in describing the challenge of running the WRA for *S. bicolor*, Gordon et al. (2011) state that "the taxa whose traits are described are not always clearly identified in the literature." As we state (Smith et al. 2015), subtle differences in traits among subspecific taxa are unlikely to be well captured with current WRAs, or, more likely, there exists too little information for specific subspecies to conduct a WRA, or, as Gordon et al. (2011) found, the literature does not make clear distinctions among subspecific taxa. In other words, evaluating WRAs at the cultivar level is often impossible and rarely done. Because the vast majority of WRAs are instead assessed at the species level—for example, there are >100 named cultivars of *Miscanthus sinensis* Anderss. (eulaliagrass), but all WRAs have been run at the species level (Crosti et al. 2010; Gordon et al. 2008; Nishida et al. 2009)—it was crucial that our study also be conducted at the species level. As we discuss (Smith et al. 2015), we agree that when sufficient information exists, WRAs can be conducted at the subspecies level (e.g., Barney et al. 2015), but argue this becomes especially complicated in the case of crops (agronomic or horticultural) with their myriad cultivars and domesticated traits. Despite running the WRAs using the same criteria as our critics (e.g., Buddenhagen et al. 2009; Gordon et al. 2011), Gordon et al. (2016) claim we are afoul of standards.

Second, Gordon et al. (2016), stating that "not all agronomic weeds become invasive," claim that we do not clearly define invasive and argue that this has influenced our results. Gordon et al. (2016) do not outline how or where in the WRAs the distinction of the term "weed" would contrast "invasive," nor how that would affect WRA outcomes, but they claim that "if evidence of crops as agronomic weeds were interpreted as invasiveness outside of cultivation," results would be confounded. Not to debate semantics, but these tools are called "weed" risk assessments because they are intended to "help prevent the entry of weeds and invasive plants into new areas" (Koop et al. 2012). More so, WRAs explicitly allow operators to assess invasiveness in agricultural and natural habitats, and both of these scores are used to complete the assessment. The assessments were conducted as designed and concluded that most crop species posed a high invasion risk. Whether they accurately predict invasiveness in both habitats is important but not germane to this study. Without specific examples of how this issue matters, despite making our raw data available, their criticism is speculative. Even if examples had been provided, "expert users may still disagree on important scoring traits" in WRAs (Lewis and Porter 2014) that may yield different results (Cousens 2008; Pheloung et al. 1999).

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Third, Gordon et al. (2016) claim that our statement "WRAs should not be the singular element in risk management" (Smith et al. 2015), "misinterprets how WRAs are used in practice." To begin, the quote of our statement is actually a paraphrase of Cousens (2008), not just our opinion—although we strongly agree, and our results support it. Additionally, WRAs are in fact used in practice as singular tools in several countries and states that use WRAs to advise listing species as noxious weeds (Lewis and Porter 2014). Our argument is that "we should be cautious of the role of WRAs in setting policy" and argue repeatedly that WRAs be one element of a multitiered system (Barney 2014; Barney et al. 2015). Importantly, our study and conclusions are limited to the application of WRAs to cultivated species, and bioenergy crops in particular, which Koop et al. (2012) specifically quote as likely requiring "more detailed assessments."

Additionally, despite the argument of Gordon et al. (2016) for WRAs to be used in a multitiered system, which we agree with, they have done the opposite. Quinn et al. (2015) published a "white list" of 49 species that have low invasive potential based solely on WRAs, which they propose as a "proactive policy solution." Ironically, their list of "safe" species includes 28 species listed as weedy or invasive globally (Randall 2002), some of which are known to be noxious or invasive in the United States. We strongly disagree with using WRAs as a sole "policy solution" and advocate for adoption of additional risk tools.

Lastly, Gordon et al. (2016) levy a series of claims regarding execution and transparency of the WRAs in our study. As stated, we followed the guidelines for both WRAs (Koop et al. 2012; Pheloung et al. 1999) and used "all available data." Despite the Gordon et al. (2016) claim that we did not present the "WRA numerical scores," in fact Figure 1 has all of the U.S. WRA scores. The Australian WRA (AWRA) scores were not included, although all results were, which is what is used to make regulatory decisions, not the numerical scores. We concede that the AWRA scores should have been included, and add them here (Supplemental Table S1; http://dx.doi.org/10.1614/IPSM-D-16-00001.S1).

In summary, we find the claims of Gordon et al. (2016) to be unsupported, assert that our study was conducted in accordance with WRA guidelines, and continue to advocate for WRA use in a multitier risk approach. To be clear, our conclusions were limited to the application of WRAs as the sole policy device for application to *crops*—bioenergy crops specifically. In the conclusion we state, "our aim … was to evaluate candidate bioenergy crops … to determine the rigor of WRAs in their evaluation of new crops." We affirm that WRAs are important biosecurity tools, particularly as the first tier of a multitiered risk assessment. However, the evaluation of crops, which was the focus and extent of our study, presents challenges that WRAs were not designed to handle. Thus, additional risk elements must be considered when assessing bioenergy crop risk in particular.

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