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Wind energy versus sustainable agriculture: An Ontario perspective

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Abstract

Wind power is often promoted as an economical and low-carbon alternative to fossil fuels despite ecological concerns about animal mortalities and energy sprawl. Wind-power developments that are becoming commonplace in rural agricultural landscapes reduce the area of arable farmlands, but to date there have been few attempts to quantify their cumulative effects. This paper compiles data on recently completed wind developments in southwestern Ontario, Canada, in order to estimate how much agricultural land is being lost to wind developments, how much of the rural landscape is being modified, and what the implications are to carbon sequestration, sustainable agriculture, and Ontario's food security. Although the direct footprint of wind development is small relative to the total area and productivity of Ontario's farmland, the area of undertaking is many times larger and has already altered 6% of Ontario's total agricultural land base. Wind-power development must thus be considered among the contributors to Ontario's projected food deficit, the ability to sequester carbon in agricultural soils, and must similarly be included in any policies aimed at protecting farmlands from non-agricultural uses.

Keywords: agriculture; energy sprawl; farmland; food security; Ontario; wind power

1.0 Introduction

Sustainable agriculture invokes practices that meet global needs for agricultural products as well as human and ecosystem health. It aims to maximize societal benefits when all costs and benefits are fully accounted for (Tilman, Cassman, Matson, Naylor, & Polasky, 2002). Attaining this lofty goal is challenged by a growing human population expected to reach nine billion by 2050 who will require 70–100% more food than at present (Godfray et al., 2010). Sustainability is further compromised by limited availability of arable land, global climate change, degraded soils (Intergovernmental Technical Panel on Soils of the Food

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and Agriculture Organization of the United Nations, FAO and ITPS, 2015), requirements to preserve biodiversity, and conflicting land uses associated with urbanization, bioenergy (Karp & Richter, 2011) and energy sprawl (Jones & Pejchar, 2013; Jones, Pejchar, & Kiesecker, 2015; Trainor, McDonald, & Fargione, 2016).

Although often viewed positively as a partial solution to global climate change, wind developments now represent a major human caused land-use change on the planet (Zhou, Tian, Baidya Roy, Dai, & Chen, 2013). Wind-generated electrical capacity has increased exponentially over the past decade at both national (Canadian Wind Energy Association, n.d.-a), and global scales (Tabassum-Abbasi, Premalatha, Abbasi, & Abbasi, 2014, Figure 3). Despite its rapid growth, the global industry must expand by 50 times its current size if it is to meet the International Panel on Climate Change's high-side scenario of 20% electricity supply from wind by 2050 (Tabassum-Abbasi et al., 2014). Such rapid expansion would seem to dictate a comprehensive assessment of the relative benefits and costs of wind energy, and particularly so in the agricultural landscapes necessary for food security. Such assessments must include the potential for non-linear negative effects that may emerge at large scales (Gasparatos, Doll, Esteban, Ahmed, & Olang, 2017).

Negative impacts of wind developments on wildlife (Schuster, Bulling, & Köppel, 2015) are widely acknowledged, and accumulating evidence on the effects of wind turbines on surface meteorology (Armstrong, Waldron, Whitaker, & Ostle, 2014) implicate a cause-and-effect relationship between large-scale wind developments and local climate (Zhou et al., 2013; Tabassum-Abbasi et al., 2014). Wind power is nevertheless seen by many in Canada, including leading environmental organizations (e.g., Gadawski & Lynch, 2011; Suzuki, 2014), as a promising route toward a low-carbon future. Even though there is widespread public acknowledgement that wind energy represents part of an acceptable alternative to fossil fuels, wind developments are often opposed at the local level by so-called NIMBYism (Not In My Back Yard) and a variety of inter-dependent socio-economic and political interests (e.g. Wolsink, 2000; Devine-Wright, 2005). NIMBYism and related forms of opposition at the local scale represent one reason why agricultural land, even among environmentalists, is frequently deemed desirable for wind power developments. Other reasons include the ecological perspective that 'disturbed' agricultural lands harbour fewer and less susceptible species than natural areas.

Wind-power developments on productive agricultural lands in North America are nowhere more evident than in rural southern Ontario. Southern Ontario comprises more than 50% of Canada's class 1 farmland[1] (Hoffman, 2001) and the province generates approximately 22% of Canada's total farm cash receipts (Statistics Canada, n.d.-a). In 2015, more than 2,000 turbines (Canadian Wind Energy Association, n.d.-b) churned the wind day and night. By the end of 2016, that number had increased to more than 2,400 (Canadian Wind Energy Association, n.d.-a). Yet, a review in the acclaimed journal *Bioscience* revealed no peer-reviewed studies on the impacts of wind energy in Ontario (Jones et al., 2015). The review found only four in all of Canada.

[1] Land that has no significant limitations on crops.

Studies and media reports in other jurisdictions highlight many of the problems associated with harnessing wind energy. Any search of the predominantly 'grey literature' on the internet will reveal a litany of claims and counter-claims about unreliable and intermittent production, subsidized profits, oil spills, altered property values, restrictions on alternative land use, soil compaction, landscape aesthetics, and social and economic disruption. Other aspects such as bird and bat mortalities (Kunz et al., 2007; Kuvlesky, Brennan, Morrison, Boydston, & Ballard, 2007; Graham & Hudak, 2011; Roscioni et al., 2013) and concerns about annoyance and compromised human and animal health associated with electromagnetic fields, noise, and shadow flicker (Knopper & Ollson, 2011) have received some, but insufficient, attention from scientists. Although research related to human health and wellbeing has increased rather dramatically since Knopper & Ollson's (2011) review (e.g., Knopper et al., 2014; Mroczek, Banaś, Machowska-Szewczyk, & Kurpas, 2015), other impacts have received relatively little scientific scrutiny or international study (Northrup & Wittemyer, 2013).

Many of the concerns and potential mitigations are associated directly with the placement and physical footprints of individual turbines. A less appreciated impact is the potential for rapid, cumulative and unprecedented large-scale effects on rural landscapes and food production. We aimed to find out.

2.0 Methods

We sought the answer with four different methods. First, we measured the length of access roads in four operating wind developments of different sizes and configurations in southwestern Ontario (Chatham Wind Farm—44 turbines, 99.4 MW; Gosfield Wind Farm—22 turbines, 51 MW; Harrow Wind Farm—24 turbines, 39.6 MW; Kent Breeze Wind Farms—8 turbines, 20 MW). Although there are many wind-power developments in southern Ontario farmlands we chose only those for which we could identify each turbine, its access road on Google Earth, and cross-verify each turbine's position against web-based company documents. We assume that the heterogeneity among these developments is representative of wind power elsewhere in rural Ontario.

We used Google's software to measure the length of each road. If one road served multiple sites, then we divided the total length by the number of turbines. We used the mean length to estimate the cumulative length of access roads associated with Ontario's existing wind developments. We then used that value to estimate the total for the province.

Second, we compared the length of access roads to that of established rural roads in order to generate a 'road impact factor'. We joined the peripheral turbines in each development to form a convex polygon such that no interior angle was greater than 180^{o}, and measured the total distance of all rural roads lying within it. We divided the distance of access roads by the total distance of existing concession roads in order to estimate the impact of access roads scaled to the pre-development road network.

Third, we calculated turbine density on the landscape and merged our data with internet documents that were available for three of the four developments to estimate the amount of agricultural land lost from production. We used the companies' estimates of 'study areas', 'project area' and actual footprints and total lot coverage (see Table 1) to estimate the total area of agricultural land impacted and converted by the developments. We verified these estimates with our independent measurements of access roads with Google's maps[2].

Table 1: *Internet sources used to estimate study areas, project areas, actual footprints and the total lot coverage that is associated with three wind developments in rural southern Ontario.*

Development	**Internet Access Date**	**Metric**	**Size Estimate**
Chatham Wind Farm[2]	15 December 2015	Area	About 305 km^2
Gosfield Wind Farm[1]	15 December 2015	Study Area	6300 ha
		Footprint of Infrastructure	15 ha
Kent Breeze[3]	15 December 2015	Total Lot Coverage	12 ha

[1] Retrieved December 15, 2015, from http://www.gosfieldcomberwind.com/_Global/41/documents/relatedlinks/3241.pdf

[2] Retrieved December 15, 2015, from http://energy.kruger.com/en/wind/chatham/ [3] Retrieved December 15, 2015, from http://energy.kruger.com/en/wind/chatham/

Fourth, we wondered whether wind power developments might have longer-term effects on agricultural productivity so we calculated the amount of farmland converted to impervious surfaces or otherwise unproductive land. Although remote imagery revealed access roads clearly, we decided that it was a less reliable indicator of disturbance associated with turbine pads. We therefore limited our direct measures to access roads and calculated disturbance as the product of their mean length times the 6 m width proposed by the South Kent Project Proposed Draft Site Plan (2011). We complemented the direct measure with a conservative estimate of land requirements that we found in publicly available company documents.

We completed our assessment by evaluating the potential effect of wind developments on Ontario's food security (McCallum, 2012). In order to be as objective as possible, we calculated the percent of Ontario farmland impacted by wind developments for two independent assessments of the area of Ontario farmland (McCallum, 2012; Wang & Fox, 2016).

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[2] Use of the maps requires that we properly attribute Google and third party data providers as indicated on the Google images: Chatham Wind Farm = My Maps: © 2015, Google Imagery © 2015, TerraMetrics, Google Earth: © 2015, DigitalGlobe; Gosfield Wind Farm = My Maps: © 2015, Google Imagery © 2015, Cnes/Spot Image, DigitalGlobe, First Base Solutions, Landsat, Sanborn, U.S. Geological Survey, USDA Farm Service Agency; Kent Breeze = My Maps: © 2015, Google Imagery © 2015, Cnes/Spot Image, DigitalGlobe, Landsat, Google Earth: © 2015 DigitalGlobe.

3.0 Results and Discussion

The length of access roads in our sample of 98 turbines averaged 507 m for each turbine compared to 841 m for existing roads (see Table 2). The resulting road impact factor of 0.6 represents, on average, a 60% increase in road density. Traffic flow on access roads during the projected 20-year operational period will be barely perceptible, but there are other reasons for concern. Access roads that fragment agricultural landscapes may impede wildlife movements and serve as potential conduits for invasion of new species, weeds, pests and disease.

Our calculations for land lost from productivity by access roads alone revealed that they consume approximately 1/3 ha per turbine. This estimate is substantially less than the 0.9 ha average land requirement per turbine reported in company documents for the Gosfield (0.68 ha, source in Table 1) and Kent Breeze projects (1.5 ha, source in Table 1), or the 0.42 ha reported for South Kent (124 turbines across 68,000 acres [27,518 ha], South Kent, n.d.) and 0.55 to 0.83 ha for Comber (72 turbines across 6,500 ha, 40–60 ha for infrastructure, Comber Wind Project, n.d.). It thus appears that a conservative estimate of farmland conversion is on the order of 0.5 ha per turbine. Expanded to a provincial scale, this estimate reveals that wind developments in rural Ontario are responsible for the conversion of approximately 1,000 ha of productive agricultural land to impervious or degraded surfaces.

Table 2. *Estimates of the mean length of access and total length of existing concession roads in four wind developments in rural Southern Ontario.*

Development	**Number of Turbines**	**Access Roads (m)**	**Existing roads (m)**
Chatham Wind Farm	44	451	39.7
Gosfield Wind Farm	22	695	19.3
Harrow Wind Farm	24	473	13.9
Kent Breeze	8	403	9.55
Mean per Turbine (m)		507	841

Conversion of agricultural land has local, regional, and global consequences. Most directly, land conversion reduces food production, increases carbon emissions, and eliminates opportunities for carbon sequestration (Jones et al., 2015). In non-forested regions, however, agricultural land can sequester more carbon than similar areas covered by natural vegetation (Jones & Pejchar, 2013).

If we first assess food production, agricultural land converted to wind developments in Ontario, using McCallum's (2012) estimate of 0.29 ha per person, translates to food for approximately 3,500 people. Most readers will consider this trivial in comparison with the province's 2015 population of 13.8 million (Ontario Fact Sheet March 2016, n.d.). But Ontario is precariously close to losing selfsufficiency in food production. Given its current land base, Ontario farmland can feed approximately15.3 million people (McCallum, 2012). Population projections predict reaching that number by 2025 (Ontario Ministry of Finance, n.d.)[3]. The calculations, however, ignore estimates of food waste in Canada of approximately 40% (Gooch, Felfel, & Marenick, 2010). To this we must add ongoing losses of agricultural land[4] (Statistics Canada, n.d.-b) to urbanization, transportation and industrial uses. It is thus likely that Ontario's food security is already compromised by an inability to produce sufficient food for the needs of its citizens. The palpable lesson must be that each ha of agricultural land counts.

Agricultural practices are often interpreted as part of the 'carbon problem' because conventional tillage and cropping practices deplete soil organic carbon. But implementation of best carbon conservation practices on Canadian cropland in 1999 could have sequestered nearly 148 million tonnes of carbon by 2019 (calculated from Table 2 in Bruce et al., 1999). Improved management practices in southwestern Ontario's clay loam soils also have documented potential to improve the sequestration of carbon (Van Eerd, Congreves, Hayes, Verhallen, & Hooker, 2014). Again, on a provincial or national scale, lost ability to sequester carbon through wind power generation is negligible, but nevertheless cumulative. Each ha counts.

Despite its small local footprint, wind-power generation is a major contributor to energy sprawl with potentially far-ranging effects on biodiversity and ecosystem services (Jones et al., 2015). Data from the Gosfield and Chatham wind farms yield a combined development area of approximately 36,000 ha (545 ha per turbine, see Table 1). This estimate is substantially higher than those reported for the Comber—90.3 ha per turbine (Comber Wind Project, n.d.)—and South Kent—221.9 ha per turbine (South Kent, n.d.)—wind developments. So we estimated the total energy sprawl of wind power in Ontario by assuming that the Comber and South Kent weighted average of 173.5 ha per turbine applies to other wind developments on agricultural land. The estimate, unlike the footprint of individual turbines, is monumental in scale. Wind developments in Ontario influence a total agricultural area on the order of 3,500 km^2 (approximately one tenth of the land area of southwestern Ontario and between 6 and 7 % of the province's total agricultural land, see Figures 1 and 2). More revealing perhaps, is that the estimate of non-impacted farmland based on the Wang & Fox (2016) optimistic outlook of stability in the area of Ontario cropland is 12 % lower (64% versus 76%) than is the estimate from McCallum's (2012) more somber perspective that land devoted to food production is in decline.

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[3] The document provides three scenarios so we used the reference scenario—low projections predict 15.3 million Ontarians in 2034; high projections predict that number in 2023.

[4] 1.5% decline in Ontario between 2001 and 2006, Statistics Canada (n.d.-b).

Figure 1. Per cent of Ontario food-producing agricultural land that is impacted by wind developments (With Wind), currently not impacted (Without Wind), and devoted to non-food-production activities (Not Food) (data from McCallum, 2012; original data from Statistics Canada *Census of Agriculture, 2006*).

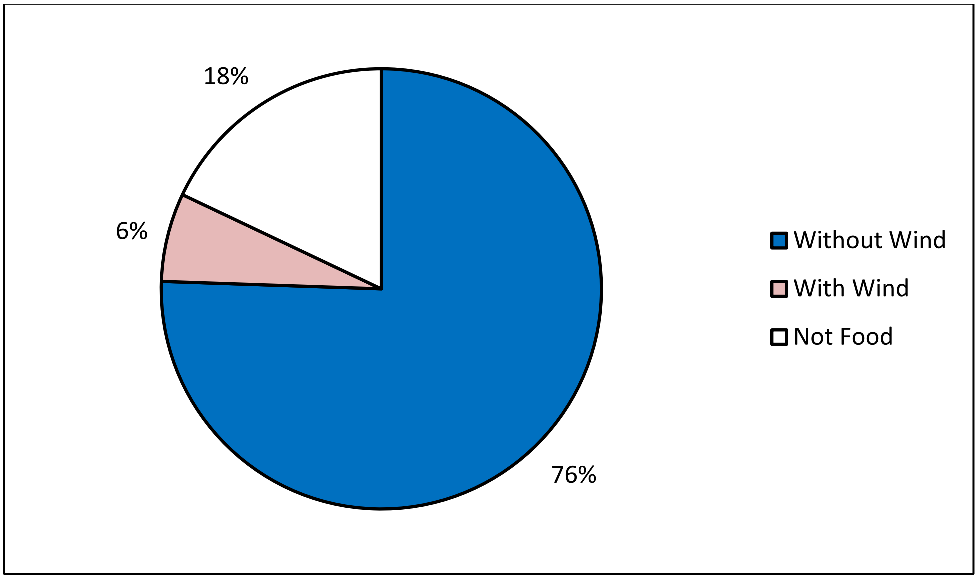
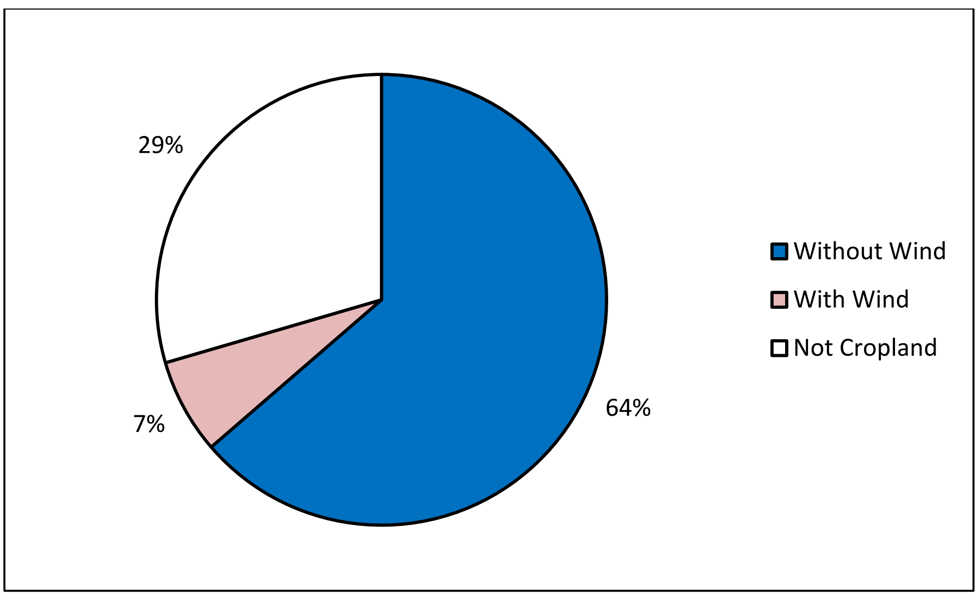


Figure 2. Per cent of Ontario food-producing agricultural land that is impacted by wind developments (With Wind), currently not impacted (Without Wind), and devoted to non-cropland activities (Not Cropland) (data from tables 1 and 2 in Wang and Fox, 2016; original data from Statistics Canada. [1951–2011]. *Census of Agriculture*. Statistics Canada.).



4.0 Conclusion

We agree that wind power has the potential to help move Ontario, Canada, and other nations towards a low-carbon economy. But we caution decision makers and others that no technology is truly ‘green’ and that energy policies must anticipate the cumulative impacts of all forms of energy production. In particular, any plans to expand wind power must recognize the unprecedented rapidity with which it transforms landscapes, and the mostly unknown consequences of its large-scale effects.

Proponents of wind energy are likely to claim that concerns about the conversion of agricultural land to wind energy pale in comparison with the greater risks associated with global warming. They will likely ignore hubris and politically-expedient policies that promote wind power, and downplay the impacts of wind developments that blanket large swaths of rural Ontario. They will argue that onshore wind developments must be part of the solution toward a low carbon future. They will point to studies and statistics on the costs and merits of wind energy relative to its alternatives. They are almost certain to ignore the root problem of too many people consuming resources in short supply. But as they do so, we encourage them to question whether onshore wind developments are prejudicial toward rural residents, and whether profits for multinational corporations are fairly traded off against altered landscapes, ecosystem services, impacts on biodiversity, social disruption of rural communities, and the massive industrialization of agricultural lands. We ask them to explain why intensive agriculture is referred to as ‘factory farming’ while energy factories that consume farmland are called solar and wind ‘farms’. We challenge them to ask how they, and their children, will eat the wind.

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