

DETERMINING ADAPTIVE CAPACITY TO CLIMATE CHANGE IN THE GRAPE AND WINE INDUSTRY

Kerrie PICKERING¹, Ryan PLUMMER^{1,2}, Gary PICKERING^{1,3,4}

¹Environmental Sustainability Research Centre, Brock University, 500 Glenridge Ave, St. Catharines, ON L2S 3A1, Canada, Phone: 1-905-688-5550

²Stockholm Resilience Centre, University of Stockholm, Kräftriket 2B, SE-106 91 Stockholm, Phone: 46-8-674-7070 Fax: 46-8-674-7020

³Cool Climate Oenology and Viticulture Institute, Brock University,

⁴Dept. of Biological Sciences, Brock University, kpickering@brocku.ca, rplummer@brocku.ca, gpickering@brocku.ca

Corresponding author email: kpickering@brocku.ca

Abstract

The agricultural sector is sensitive to climate change (CC) and associated extreme weather events, but suffers in Canada from little strategic research and policy on CC adaptation. The wine industry is often considered the 'canary in the coal mine' for CC due to the narrow geographic and climatic range required by many grape varieties. Adapting to current and projected CC challenges requires industry stakeholders to determine the risks and benefits of CC and develop a level of adaptive capacity. The objectives of this study were to develop a metric for assessing the adaptive capacity of a grape/wine industry, and apply that tool to the Ontario case. A framework was developed and represented as a three-tiered, hierarchical structure, which included eight operational and strategic determinants (financial, institutional, technological, political, knowledge, perception, social capital, and diversity), and 28 specific indicators. A comprehensive questionnaire was created from this framework consisting of 26 statements to which participants indicated their level of agreement. 42 Ontario wine industry members completed the questionnaire via an on-line survey. Results show that the Ontario wine industry has some adaptive capacity in all the key resources assessed. Perception, diversity and knowledge are the determinants with the greatest capacity, while political and technological are the most limited. Overall, industry stakeholders do not perceive they are at a coping threshold and are interested in learning how to better adapt to the impacts of CC. Results are discussed in the context of opportunities to enhance adaptive capacity in the grape/wine community.

Keywords: adaptation, adaptive capacity, wine industry.

INTRODUCTION

The agricultural sector, including grape and wine, is sensitive to climate change and the associated extreme weather. The global wine industry is already experiencing impacts, including earlier growing seasons, changes in precipitation patterns, and increased frequency and intensity of extreme weather events, all of which are affecting wine quality (Jones, 2010, Mira de Orduña, 2010). To adapt to the challenges and opportunities created by climate change industry stakeholders must develop and sustain a level of adaptive capacity.

Development of the Assessment Framework

Vulnerability and social-ecological resilience are dominant approaches to climate change

adaptation. Vulnerability is rooted in hazard management and focuses on identifying the sensitivity of a system when exposed to an extreme event such as a flood. The vulnerability of a system fluctuates with the degree of exposure and type of extreme event (Brooks, 2003). Vulnerability is reduced through adaptive capacity, which can reduce both exposure and sensitivity (Smit and Wandel, 2006). Social-ecological resilience emphasizes linkages between humans and nature and the dynamic properties of adaptive cycles (Berkes et al., 2003). An adaptive cycle is a four-stage process (exploitation, conservation, release, reorganization). With adequate adaptive capacity these systems are capable of self-reorganization, sustaining and developing with the ability to build and

increase capacity for learning and adaptation (Folke, 2006; Gunderson, 2003). Many resources affect the adaptive capacity of a system in adapting to climate change. Consistently listed among these are: financial resources, social capital, education, technology, infrastructure, institutions, political power, culture, governance, leadership, and human capital (Yohe and Tol, 2002; Brooks et al., 2005; Eakin and Lemos, 2006; Adger et al., 2007). Gupta et al., 2010 focuses on the role of institutions as the most dominant force affecting adaptive capacity under which access and availability to all other resources is controlled. Marshall and Marshall (2007) instead focus on the impact perception can have on the adaptive capacity of primary resource users such as fishers. Armitage (2005), taking a broader view, categorises resources as operational (exogenous) coming from outside the system and over which the system has limited control. Strategic (endogenous) occur within the system and the system has greater control of over these.

While these determinants have become more clearly defined there is still a need to develop measurement and assessment criteria (Engle, 2011; Holland & Smit, 2010). Adaptive capacity research has generally focused on either the macro national scale, which is too broad for contextualization (Brooks, 2005), or micro scale case studies making generalizations difficult (Armitage, 2005). Given the many institutional and social processes that influence and shape adaptive capacity it remains heavily context-specific and cannot be generalized between contexts or across scale (Engle, 2011). The international wine industry must adapt to the present and future impacts of climate change if it is to sustain present production. Adaptive capacity plays a critical role in the adaptation process but to date no integrated framework exists to assess the adaptive capacity of the wine industry so one was developed. This consideration formed the basis of our current study.

The Ontario Wine Industry: a case study

The Canadian wine industry has a current economic value of CAD \$6.8 billion, with the majority of her wines produced in Ontario, along Lake Erie and Lake Ontario. The Ontario

industry is comprised of approximately 17,000 acres of vineyards located in 3 major appellations: Lake Erie North Shore, Prince Edward County, and Niagara Peninsula (Figure 1).



Figure 1. Map of the major wine appellations in Ontario (Sourced from <http://www.vqaontario.com/Appellations>)

Niagara is the main producer, and consists of 10 sub-appellations and 2 regional appellations. The main *Vitis vinifera* cultivars grown are Chardonnay, Riesling, Gewürztraminer, Pinot gris, Sauvignon blanc, Pinot noir, Cabernet franc, Cabernet sauvignon, Merlot and Gamay noir. A smaller portion of table wines are produced from French-American hybrid grape varieties, particularly Baco noir, Vidal and Maréchal Foch. In 2013, 21.9 million litres (2.4 million cases) of wine were produced for the local and international market (Wine Council of Ontario, 2013). The industry is internationally recognized for its excellent icewines, which contribute 50% of the \$40 million revenue from wine exports. The Ontario wine industry has four main supporting bodies: the Grape Growers of Ontario, Wine Council of Ontario, Winery and Growers Alliance of Ontario and the Vintners Quality Alliance.

Climate change challenges for the Ontario wine industry are numerous, and include warmer winter temperatures increasing the susceptibility of grapevines to freeze injury, delayed and shortened icewine harvest windows, and increasing pest pressures (Cyr and Shaw, 2010). The 2012 growing season had one of the earliest springs on record, with many growers relying on wind machines to reduce the risk of frost damage. Warmer average summer temperatures are also affecting production, with vines suffering increased

drought stress, and cooler-climate varieties such as Pinot noir showing reduced wine quality. While the Ontario wine industry is actively researching new technologies and practices to adapt to these and other impacts, a comprehensive assessment of its adaptive capacity to climate change is identified as an important component of positioning the industry for success in the future (Pickering et al., 2012).

MATERIALS AND METHODS

The conceptual framework serving as a foundation to this research is illustrated in Fig. 2. Based on this framework, we develop a questionnaire template for the industry consisting of 28 statements related to each determinant (e.g. I have access to income stabilization plans).

All except two statements were positively phrased, with agreement indicating the presence of adaptive capacity.

Responses to the two negatively phrased statements were reversed for analysis.

Two additional questions were asked of growers related to their use of crop insurance and credit in ‘bad’ years.

Participants rated their level of agreement on a five point Likert scale.

An on-line link to the questionnaire was sent out to all members of the Ontario Grape Growers, Wine Council of Ontario and Winery and Growers Alliance of Ontario.

Forty-two Ontario wine industry members completed the questionnaire.

RESULTS AND DISCUSSIONS

The results from this research are divided into two sections:

- 1) the development of the adaptive capacity assessment framework, and
- 2) the adaptive capacity responses.

Assessment Framework

Frameworks are useful for analysing systems and issues so that a fuller understanding of components and their relationship can be attained. Several models have already been developed to explore the relationship of the determinants of adaptive capacity, although none specifically for agriculture or the

grape/wine industry. We considered those proposed by Armitage (2005), Gupta et al., (2010) and Marshall (2010) as relevant, and synthesised key elements of their approach into the framework for our study (Figure 2).

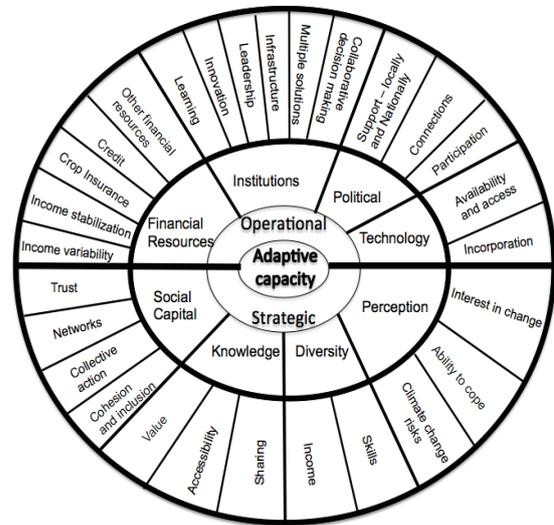


Figure 2. Adaptive Capacity assessment framework for the wine industry (Pickering, 2013)

This framework has some similarity to the institutional adaptive capacity wheel of Gupta et al., (2010). However the determinants selected in this framework are tailored to the interests and concerns of the wine industry. The framework also has an additional layer categorizing determinants as operational (exogenous) or strategic (endogenous).

The indicators in the outer tier identify the presence of each determinant. Each indicator has been developed from a review of the climate change concerns within the wine industry literature. For example, having access to crop insurance is an important financial resource for a wine industry.

The framework is derived from diverse theoretical bases found in the adaptive capacity literature (Crimp, 2000; Belliveau et al., 2006; Engle and Lemos, 2007; Plummer and Fitzgibbon, 2007; Battaglini et al., 2009; Wesche and Armitage, 2010; Bohensky et al., 2010; Marshall, 2010; Engle 2011).

Further, the questionnaire derived from the framework represents a conceptually sound, comprehensive yet practical tool that may be applied to understanding the adaptive capacity of the Ontario grape and wine industry.

Adaptive Capacity Responses

The following results correspond to the eight determinants of the framework. Responses were reduced to a 3-point likert scale (agree, neither agree nor disagree, disagree) to show direction of adaptive capacity; this removed the intensity of responses only (strongly).

Figure 3 shows the result for financial resources. There is access to crop insurance and credit, which are being used during ‘bad’ years. More participants experience income variability than use stabilization plans.

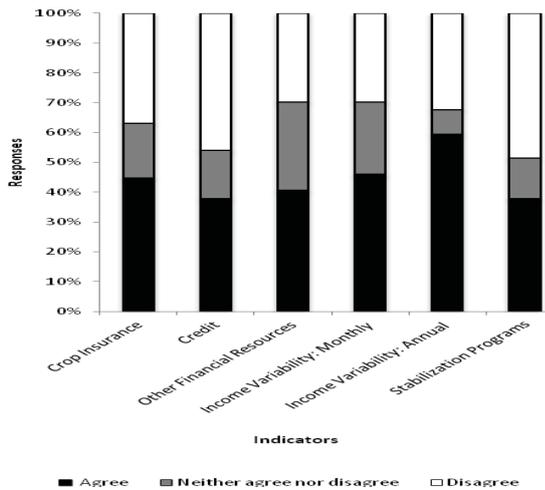


Figure 3. Financial Resources (adapted from Pickering et al., 2014)

Institutional results are shown in Figure 4. The majority of participants indicated there was support for new and improved practices within the industry, along with various types of leadership. Access to water infrastructure and climate change policy options were more limited.

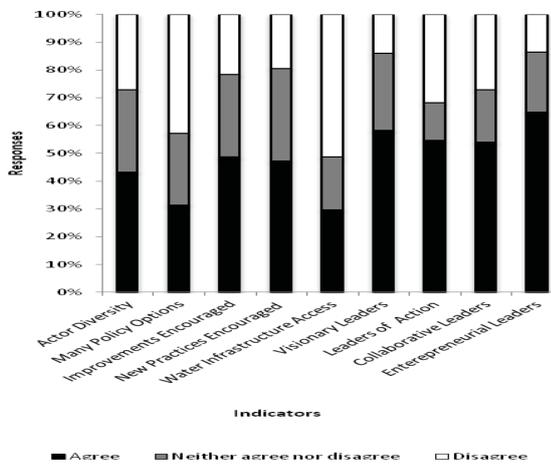


Figure 4. Institutional (adapted from Pickering et al., 2014)

The results for the political determinant are shown in Figure 5. Overall the majority of participants indicate they are politically active and believe there is greater political support for the industry provincially than federally.

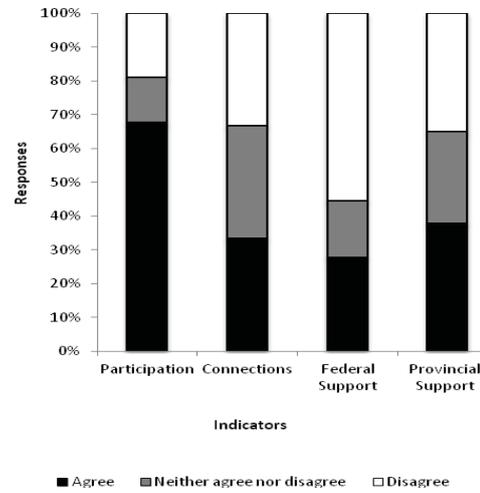


Figure 5. Political (adapted from Pickering et al., 2014)

Results for the technology determinant, Figure 6, show there is greater incorporation of new technologies than participants believed they had access to.

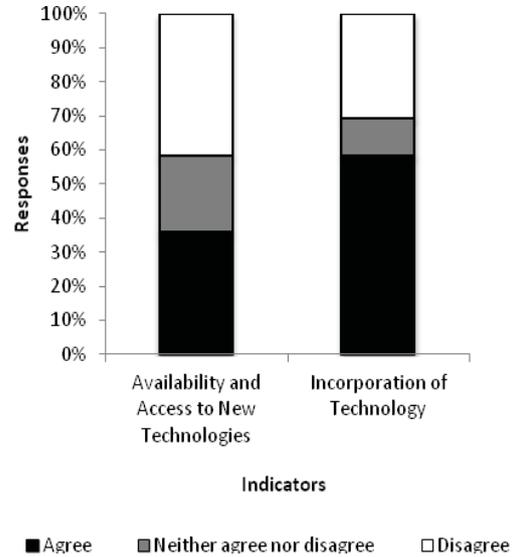


Figure 6. Technological (adapted from Pickering et al., 2014)

Figure 7 shows the results for perception. Less than 20% of participants disagreed that climate change would impact the Ontario wine industry. Over 90% wanted to learn how to better adapt to extreme weather events and climate change.

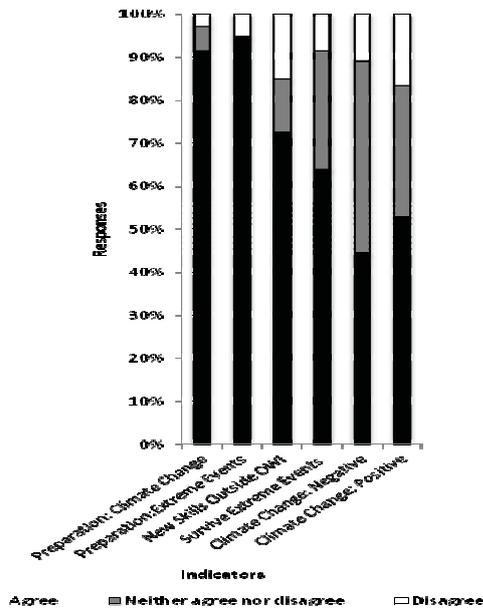


Figure 7. Perception (adapted from Pickering et al., 2014)

The results for the diversity determinant are shown in Figure 8. The majority of participants indicated they have income source other than grape and wine, and 42% indicated they had income source outside of the Ontario wine industry. The majority indicated they had career options outside of the Ontario wine industry.

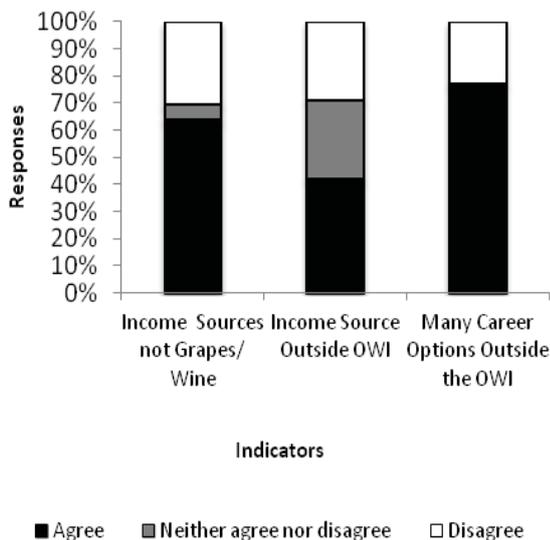


Figure 8. Diversity (adapted from Pickering et al., 2014)

Figure 9 illustrates the results for the knowledge determinant. The majority of participants indicate they have access to both local and scientific knowledge. Both of these knowledge types are also valued and shared by most participants.

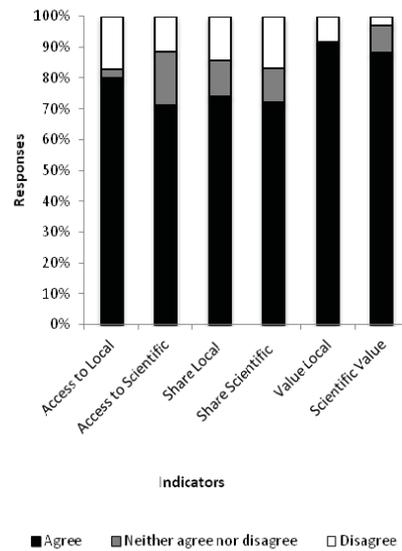


Figure 9. Knowledge (adapted from Pickering et al., 2014)

Results for social capital are shown in Figure 10. Solidarity, social networks and trust are well established. Inclusion and closeness are also believed to be present by the majority of participants.

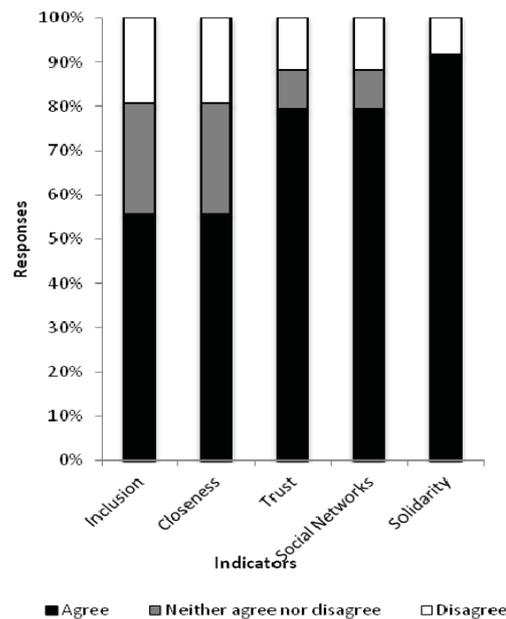


Figure 10. Social Capital (adapted from Pickering et al., 2014)

Overall, these results show that the Ontario wine industry has some adaptive capacity in all of the determinants assessed. The strategic determinants of perception, diversity and knowledge show the greatest capacity. Ontario wine industry members have greater control over their adaptive capacity in these areas, and

can further enhance the present state by continuing to support and facilitate skill development, education, and communication, which will further build social capital and diversity. The most limited determinants were operational, specifically; political and technological. The Ontario wine industry has less influence over these areas, but can strengthen adaptive capacity in them by continuing to strengthen political resources. Examples include the creation of more policy options for managing climate change impacts, continuing subsidized access to crop insurance and income stabilization programs, and supporting development of and access to new technologies. Increasing dialogue on the future need for water infrastructure to established and new viticultural areas will also help build capacity.

CONCLUSIONS

From the existing climate change and wine industry literature a framework was developed that captures the most important dimensions of adaptive capacity for the wine industry. From this framework a questionnaire was developed and used to assess the adaptive capacity of the Ontario wine industry. The results show the Ontario wine industry has some adaptive capacity in all of the key areas assessed, while the political and technological resources require more attention. These results are important because they give the Ontario wine industry an initial baseline assessment. With knowledge of the key areas of strength and limitation, it can begin to strategically plan how to build and enhance present and future capacity.

ACKNOWLEDGEMENTS

Funding for this research was provided by the Ontario Research Fund: Research Excellence Funding (Round 5). The authors would like to acknowledge The Ontario Grape and Wine Research Network, for their support with this research. In particular the Wine Council of Ontario, Grape Growers of Ontario, Winery and Growers Alliance of Ontario.

REFERENCES

- Adger N., Agrawala S., Mirza M., Conde C., O'Brien K., Pulhin J., Pulwarty R., Smit B., Takahashi K., 2007. Assessment of adaptation practices, options, constraints and capacity. In: L. Parry, M., Canziani, O., Palutikof, J., van der Linden P., Hanson, C., (Eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate*. Cambridge University Press, Cambridge, UK, p. 717-743.
- Armitage D., 2005. Adaptive capacity and community-based natural resource management. *Environmental Management*, 35, 6, p. 703-715.
- Battaglini A., Barbeau G., Bindi M., Badeck F.W., 2009. European winegrowers' perceptions of climate change impact and options for adaptation. *Regional Environmental Change*, 9, 2, p. 61-73.
- Belliveau S., Smit B., Bradshaw B., 2006. Multiple exposures and dynamic vulnerability: evidence from the grape industry in the Okanagan Valley, Canada. *Global Environmental Change*, 16, p. 364-378.
- Berkes F., Colding F., Folke C., 2003. Synthesis: building resilience and adaptive capacity in social-ecological systems. In: Berkes, F., Colding, J., Folke, C., (Eds.), *Navigating social-ecological systems: building resilience for complexity and change*. Cambridge, New York, University Press, p. 25-57.
- Bohensky E., Stone-Jovicich S., Larson S., Marshall N., 2010. Adaptive capacity in theory and reality: implications for governance in the Great Barrier Reef region. In: Armitage, D., Plummer R., (Eds.), *Adaptive Capacity and Environmental Governance*, Springer Heidelberg Germany, p. 23-42.
- Brooks N., 2003. Vulnerability, risk and adaptation: A conceptual framework. Tyndall Centre for Climate Change Research. Working Paper 38. Retrieved from <http://www.tyndall.ac.uk/sites/default/files/wp38.pdf>
- Brooks N., Adger W.N., Kelly P.M., 2005. The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change*, 15, p. 151-163.
- Crimp S., 2000. A capital concept of adaptive capacity. *Climate: Ground Cover*. Retrieved from <http://www.grdc.com.au/Media-Centre/Ground-CoverSupplements/~media/7DFFD3C49C034C5F90611A95826D5432.pdf> November 8, 2013.
- Cyr D., Shaw T., 2010. The impact of global warming on Ontario's icewine industry. VIII International Terroir Congress, Proceedings Session 3, p. 9-16. <http://terroir2010.entecra.it/atti/index.html>.
- Engle N., 2011. Adaptive capacity and its assessment. *Global Environmental Change*, 21, p. 647-656.
- Engle N., Lemos M., 2007. Unpacking governance: Building adaptive capacity to climate change of river basins in Brazil. *Global Environmental Change*, 20, p. 4-13.
- Folke C., 2006. Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change*, 16, p. 253-267.

- Gunderson L., 2003. Adaptive dancing: interactions between social resilience and ecological crises. In: Berkes F., Colding J., Folke C., (Eds.), *Navigating social-ecological systems: building resilience for complexity and change*. Cambridge, New York, University Press, p. 57-76.
- Gupta J., Termeer C., Klostermann J., Meijerink S., van der Brink M., Jong P., Nooteboom S., Bergsma E., 2010. The adaptive capacity wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. *Environmental Science and Policy*, 13, p. 459-471.
- Holland T., Smit B., 2010. Climate change and the wine industry: Current research themes and new directions. *Journal of Wine Research*, 21, 2-3, p. 125-136.
- Jones G., 2010. Climate change and the global wine industry. In: Williams, P., Pretorius, I., Blair, R., (Eds), *Proceedings of the Thirteenth Australian Wine Industry Technical Conference*, p. 1-8.
- Marshall N., Marshall P., 2007. Conceptualizing and operationalizing social resilience within commercial fisheries in Northern Australia. *Ecology and Science*, 12.
- Marshall N., 2010. Understanding social resilience to climate variability in primary enterprises and industries. *Global Environmental Change*, 20, p. 36-43.
- Mira de Orduña R., 2010. Climate change associated effects on grape and wine quality and production. *Food Research International*, 43, p. 1844-1855.
- Pickering K., Pickering G., Inglis D., Shaw T., Plummer R., 2012. Innovation and adaptation in the Ontario grape and wine industry: An integrated, transdisciplinary response to climate change. Environmental Sustainability Research Centre. Working Paper series. 2012 URI: <http://hdl.handle.net/10464/4149>.
- Pickering K., 2013. Assessing the adaptive capacity of the Ontario wine industry to climate change: a case study. MA Thesis, Brock University. <http://hdl.handle.net/10464/4607>.
- Pickering K., Plummer R., Shaw T., Pickering G., 2014. Assessing the adaptive capacity of the Ontario wine industry for climate change adaptation. In review.
- Plummer R., FitzGibbon J., 2007. Connecting adaptive co-management, social learning, and social capital through theory and practice. In: Armitage, D., Berkes, F., Doubleday N., (Eds), *Adaptive Co-Management: Collaboration, Learning and Multilevel Governance*. UBC Press: Vancouver, BC, p. 38-61.
- Smit B., Wandel J., 2006. Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, 16, p. 282-292.
- Vintners Quality Assurance, 2014. Map of wine growing appellations in Ontario. Retrieved from <http://www.vqaontario.com/Appellations>.
- Wesche S., Armitage D., 2010. From the inside out: A multi-scale analysis of adaptive capacity in a northern community and the governance implications. In: Armitage D., Plummer, R., (Eds.), *Adaptive Capacity and Environmental Governance*. Springer, Heidelberg Germany.
- Wine Council of Ontario, 2014. Industry facts. Retrieved from <http://www.winecouncilofontario.ca/Resources-Media/Industry-Facts> January 24, 2014.
- Yohe G., Tol R., 2002. Indicators for social and economic coping capacity - moving toward a working definition of adaptive capacity. *Global Environmental Change-Human and Policy Dimensions*, 12, 1, p. 25-40.