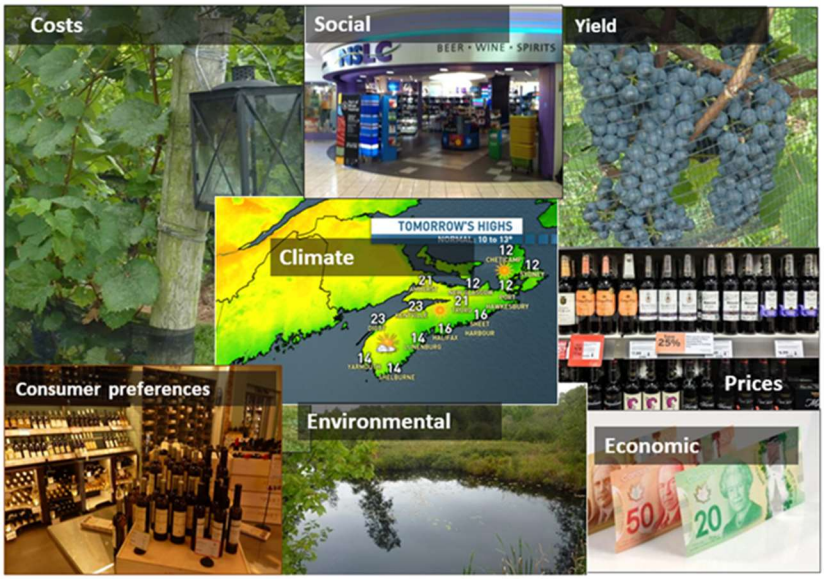
# Risk Proofing Nova Scotia's Agriculture: A Risk Assessment System Pilot (AgriRisk)

## Final Report
## March 2018




***Risk Proofing Nova Scotia Agriculture: A Risk Assessment System Pilot (AgriRisk)***
*Nova Scotia Federation of Agriculture would like to recognize the collaborative relationships that exist among Agriculture and Agri-Food Canada and the Nova Scotia Departments of Agriculture and Environment.*

## Executive summary

The AgriRisk project, funded through Agriculture and Agri-Food Canada's AgriRisk Initiatives, and the Nova Scotia Department of Agriculture, is a pilot project focussed on Nova Scotia's grape and wine industry. The goal of the work was to dynamically integrate and make use of the best available data sets and key variables associated with risks along the grape and wine value chain. Developing statistical models and making those models accessible through interactive, user-friendly risk assessment tools, the project aimed to give stakeholders the opportunity to explore scenarios and risk responses at various points along the value chain.

The project's organizational structures included a governance group, management team, and technical teams. Stakeholder workshops and regular meetings with project and technical team members provided opportunities for meaningful engagement throughout the project during tool and model development and ways of incorporating feedback, addressing weaknesses and gaps, and adjusting outputs so they best reflected stakeholder needs.

Bayesian Network models, which facilitate the examination of complex issues by bringing together linked or conditional variables with full consideration of uncertainties, have been developed to examine grape production, winemaking, economics, and consumption. Other models, represented spatially on the web viewer tool, include agricultural land availability, dyke vulnerability, and wine grape growing suitability mapping. Additional tools for exploring data developed through the project include climate applications and a wine sales application. A number of documents detailing methods for model development and associated tools have been produced to accompany this work.

Early stakeholder feedback suggests some positive outcomes due to involvement in the AgriRisk project including stronger working relationships and collaborations and better knowledge and awareness of types of risk. It is critical to point out, however, that the work is not complete; careful nurturing and support is needed for the risk assessment system to reach its full capacity and therefore to be sustained. Priority next steps include more fully embedding the system within the industry and establishing a reliable mechanism for collecting data to strengthen the tools and reduce the wide range of uncertainty where it exists within the tools. Key lessons learned through the pilot project position the project leads well for exploring new opportunities to develop risk assessment systems using a similar approach for other agricultural commodities.

# Contents

## Acknowledgement

The Nova Scotia Federation of Agriculture would like to gratefully acknowledge the team of people who have contributed to the AgriRisk project, many of whom were part of the various technical teams helping to guide and advise the work. Kevin Bekkers and Mark MacPherson of Nova Scotia Department of Agriculture, Jen Graham with Nova Scotia Environment Climate Change Unit, Joanne Moran with Grape Growers Association of Nova Scotia and Jerry White with Winery Association of Nova Scotia provided solid support and guidance through project governance and management. Significant contributions were made by Perennia's Francisco Diez, Rachael Cheverie and Amy Sangster, thank you. Grape growers and wine makers of Nova Scotia have been extraordinarily generous with their time and knowledge - thank you, it makes all the difference in the world. We are grateful as well for support provided by Heather MacDougall, Stephen Ford and Ritu Gautam of NSLC. We would also like to acknowledge the substantial contributions by team members with GeoNova, Reflecting Society, Dalhousie University's School of Planning, Saint Mary's University's Maritime Provinces Spatial Analysis Research Centre, University of Sherbrooke, Nova Scotia Community College's Applied Geomatics Research Group, Corporate Research Associates, Canmac Economics Ltd, and NS Tourism. A special thank you to Henry Vissers and the team at NSFA - for your guidance and support from the start. Without such an incredible team this work would not have been possible.

## Introduction

The AgriRisk project, funded through Agriculture and Agri-Food Canada's AgriRisk Initiatives and the Nova Scotia Department of Agriculture, is a pilot project focussed on Nova Scotia's grape and wine industry. The goal of the work was to dynamically integrate and make use of the best available data sets and key variables associated with risks along the grape and wine value chain to help contribute to achieving the outcome of a "risk-aware grape and wine industry". By dynamically integrating the best available data and knowledge into statistical models and making those models accessible through interactive, user-friendly risk assessment tools, the project aimed to give stakeholders the opportunity to explore scenarios and risk responses at various points along the value chain.

The project aimed to achieve this outcome through meaningfully engaging and partnering with organizations and individuals with vested interests in Nova Scotia's grape and wine industry. In partnership with them, the project sought to develop risk assessment tools that build awareness while supporting users to explore risk scenarios. The project adopted a value chain approach in recognition that the grape and wine industry is a highly interconnected system where risks or impacts would be felt throughout the value chain. The project also aimed to explore the sustainability of the initiative among partners and stakeholders in order to sustain the relationships and outcomes as well as to maximize the value of the project outcomes.

This report presents an overview of how the project organized itself to achieve its goals as well as a brief overview of the outputs including models, tools, and reports.

## Team and Organizational Structure

Key organizational structures that ensured smooth execution of the project included a governance group, management team, and technical teams. The governance group was established at the project outset and represented key project partners including Nova Scotia Federation of Agriculture, Nova Scotia Department of Agriculture, Nova Scotia Environment Climate Change Unit, Grape Growers Association of Nova Scotia, and Winery Association of Nova Scotia. The purpose of this group was to advise, guide, and approve operations of the project as well as assist in generating partner links and engagement.

A management group, which was a sub-group of the governance group, comprised of members from Nova Scotia Department of Agriculture, Nova Scotia Environment Climate Change Unit, and the Nova Scotia Federation of Agriculture. This group was an action-oriented group tasked with outreach and project management. The group worked closely with Senior Researcher with Reflecting Society, Tim Lynam, to ensure project activities met the needs of and aligned well with the development of the Bayesian Network risk assessment tools.

Technical Teams were established to provide technical oversight on the project and ensure that we had the best possible knowledge feeding into model development. Teams also ensured the quality and utility of the models and analyses. Four technical teams were established following the first set of workshops that focused on: GIS and spatial analysis, grape and wine production, consumer preferences, and economics.

## Key Engagement Opportunities

Hosting three sets of workshops/meetings with Senior Researcher with Reflecting Society and Bayesian Network developer Tim Lynam facilitating, provided opportunities for meaningful engagement by value chain stakeholders, data providers, and other team members from the project's outset. Discussion about models and tools as they were developing ensured opportunities to integrate feedback, address weaknesses and gaps, and adjust outputs so they best reflected stakeholder needs. They also provided opportunities for stakeholders to become more aware of Bayesian Network Technology, its capabilities, and limitations.

### March 2017 Workshops

In March, 2017, 3 start-up workshops were hosted. The goal of the first workshop was to identify how key stakeholders conceive the grape and wine industry of Nova Scotia. The target audience for this workshop was stakeholders involved directly in the industry (e.g., grape growers and wineries). Presentations were given on overviews of the AgriRisk project and Bayesian Network approach, and key activities involved generating an overview of the elements of the grape and wine value chain, and variables that impact it, and essential data sources that can help us understand the risks that each value chain elements pose to industry outcomes. The purpose of the *second workshop* was to identify data relationships and key data gaps in relation to developing a Bayesian Network model of risks faced by the grape and wine industry of Nova Scotia. The focus was to confirm key parameters important for the industry and help define data and model needs for the project. The target audience for this workshop was grape and wine experts and data providers. Discussion and group work focused on identifying data sources, gaps, and synthesis. The third workshop aimed to critically review and refine the preliminary model. The target audience for this workshop was representatives from each segment of the value chain and to include stakeholders and data providers. Discussion focused on identifying gaps in the preliminary model, challenges and opportunities moving forward, and next steps. Please see report 1 listed in the Appendix.

In addition to these larger, more group formal, workshops several small group workshops were held to interact more closely with key knowledge sources or data providers. In particular NSLC, Perennia, researchers at Agriculture and Agri-Food Canada's Kentville Research Station and the AgriRisk management team were participants in separate mini-workshops.

### September 2017 Meeting Workshops

In September, 2017, the project hosted "kitchen-table conversations" with 5 growers/wineries on the risk assessment tools being developed. The purpose of these conversations was to share progress on the tool and invite stakeholder feedback and to ensure it captures risks and concerns in the industry. Similar conversations and meetings were also held with providers, technical teams, and team members in order to ensure model development was progressing.

### February/March 2018 Workshops

In February/March, 2018 workshops were held that targeting grape growers, winemakers and the senior leaders of the wine producing and growers' associations (WANS and GGANS), Perennia extension staff, and researchers at Agriculture and Agri-Food Canada's Kentville Research Station. The workshops aimed to demonstrate results and tools produced through the project, generate feedback, and explore ways that industry might respond to scenarios presented at the workshops (using data and outputs from the

tools). All workshops were designed to be interactive and provide opportunities for participants to engage in a meaningful way. During the first set of workshops participants were led through simulation activity whereby individuals characterized and described how they would respond, based on their role within the grape and wine industry, to scenarios that were presented based on outputs from the draft risk assessment tools (changing climate, flattening trends in wine consumption, and wine supply/demand imbalance). Participants worked through responses related to production practices, marketing practices, relationships, advice, information and knowledge, as well as advocacy and lobbying. Results from these workshops can be found in report 2 listed in the Appendix. In addition, smaller and more focussed workshops were held with Perennia, NSLC, and the AgriRisk management team.

# Products Produced

## Models and Tools

A collection of models and tools have been developed through the AgriRisk project. Models represented through Bayesian Network tools include grape production, winemaking, economics, and consumption. Models represented spatially through the web viewer tool include agricultural land availability, dyke vulnerability, and grape suitability. Other tools for exploring data developed through the project include climate applications and a wine sales application. Bayesian Network models facilitate the examination of complex issues by bringing together linked or conditional variables with full consideration of uncertainties. Bayesian Network models are ideally suited to risk analyses for a number of reasons:

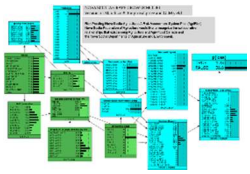
- They facilitate examination of outcomes given uncertainties that exist throughout the network
- They can be used to identify critical uncertainties that would improve assessments
- New data can be added to improve understanding across the whole or key parts of the network
- New elements or modules can be integrated as they become available

As an example of the last point above, at the time of completing the first generation of Bayesian Network models in the current project, there was insufficient data to develop grape yield and climate data relationships and the grape disease models were not available yet. Disease models (for powdery mildew and downy mildew) have now been developed and, given the Bayesian Network flexibility, can be incorporated into the next generation models. The grape and wine industry of Nova Scotia has, through the participation of key stakeholders, recognized the value to the industry of improved data collection of grape and wine production. They have begun discussing mechanisms to build databases of improved data and when these become available the Bayesian Network models can be updated.

Interactive Climate Tools were developed as a way for users to explore current and future climate conditions in the province. An interactive wine sales tool was developed to allow users to explore trends in Nova Scotia wine sales. And finally, a Web Viewer was developed as a way to access and explore the spatial data and models produced for the project as well as view existing relevant spatial information.

Bayesian Network models and tools: Five Bayesian Network tools have been developed for the pilot project. Each is described briefly below. For further details on the Bayesian Network models, including their development, data inputs, uses, interpretation, and limitations please see reports 3, 4, 5, 12, and 13 listed in the Appendix. Links to the tools and reports can be found on the NSFA's AgriRisk webpage. Please note that there is significant underlying uncertainty in the models primarily related to grape yield

on a per hectare basis and revenue for all growers (total industry gross from wine production). Access to more or better data for grape yield, quality, phenology, prices, as well as for grape and wine economics are critical to strengthening the models.



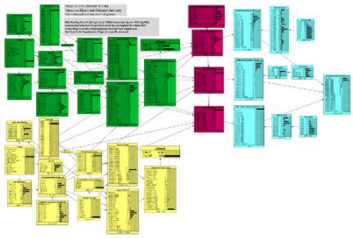
*Grape Grower Model tool*: Components in the grape grower model (right) include variables related to grape growing itself (green) and grape growing economics (blue). Growing variables include grape variety, yield per hectare, vineyard size, proportion of area bearing fruit, total grape harvest, and Brix. Economic variables include grape prices, inflation index, costs per hectare, and annual capital repayments, total costs, and total revenue leading to a profit/loss ratio. The outputs of this model show the probability of a gross profit or loss with the risk of loss being highlights. As with all of the models described here, users can enter values that they know (which will reduce overall uncertainty of model outputs), while also letting other variables vary (i.e., incorporating uncertainty).

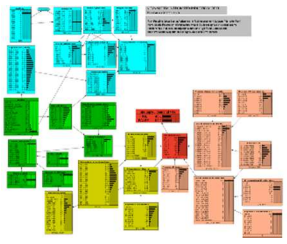
Note that a *Grape Disease Model*, developed by the University of Sherbrooke, which sought to examine the impact of changing climate on the probability of grape disease (downy and powdery mildew), is intended to be integrated into the Bayesian Network. Baseline models were formed using historical Quebec-based disease and climate data and probability estimates were developed using Nova Scotia climate projection data produced for the AgriRisk project. Details from this work, including model development, data, applications, and limitations can be found in report 6 listed in the Appendix.

*Grape Grower Yield (maximizing profit) tool*: This tool is based on the Grape Grower Model described above and includes the same variables. It allows users to explore the grape variety that maximizes possible profit based for a given vineyard size for 14 varieties selected as the basis of the AgriRisk project.

*Grape Grower Yield (minimizing loss) tool*: This tool is based on the Grape Grower Model described above and includes the same variables. It allows users to explore the variety that minimizes possible loss based on a combined variables entered by the user (or left to vary if they are unknown by the user).

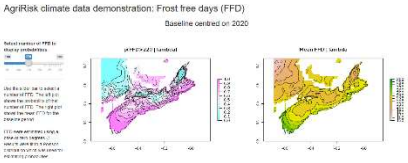
*Winery Model tool*: This model is centered around a winery producing three wine types (Chardonnay, Pinot, and L'Acadie Blanc), whereby grapes are grown by the winery itself as well as purchased from an external grower. Components of the winery model tool (left) include variables related to the winery grape growing (green), an external grower (pale yellow), and winery economics (blue). Wine production yield is represented in pink. Variables represented within both winery (green) and external grower (yellow) components are the same as described in the Grape Grower Model above; the difference lies in the fact that values within the components can be entered (or left to vary/remain uncertain) by users in order to represent the unique situation that they are interested in exploring. Both grower clusters feed into the total wine yield (pink). Winery economics variables (blue) capture – for each wine type - the year for which data is available, price per litre, and total revenue. The output of this model shows the probability of loss for both the external grower and the winery as a grower, as well as providing a total winery revenue variable.



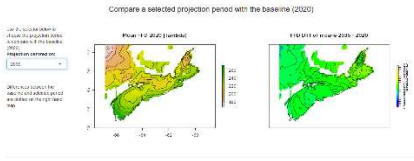


*Integrated supply/demand tool*: This tool allows users to simultaneously explore supply and demand for wine. Major components of the integrated model (right) include variables related to economics (blue), grape growing (green), wine production (yellow), and sales (peach). Economic variables include grape base price, number of grape farms, vineyard size, per acre and total vineyard costs, revenue per hectare, and total grape revenue for the industry. Grape growing variables include grape variety, area under grapes, expansion rate, yield per hectare, and total grape harvest. Wine production variables include wine produced per tonne of grapes, proportion of total inventory of wine with Nova Scotia grape content, and production entering inventory. Sales variables include NSLC wine sales, proportion sold at the farm gate, sales of NS bottled wine, proportion of Nova Scotia grapes going into NS bottled wine and the population of Nova Scotia. As with other models, users can set values or let them vary. The primary outputs of this model (red) shows the ratio of supply to demand, and the probability of supply outweighing demand.

Climate tools: Four climate applications have been developed by Reflecting Society for the AgriRisk project – one each focussing on frost free days (FFD), growing degree days (GGD), days less than -23°C, and days less than -18°C. A link to each application can be found on the NSFA's AgriRisk webpage. Since each application is designed similarly only one (FFD) is described here as an example. Details on methods used to develop baseline and projected data can be found in report 7 in the Appendix

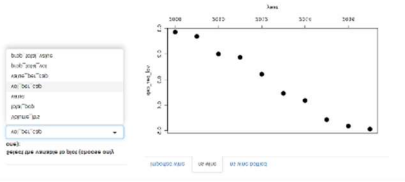



The application consists of 3 sets of maps of Nova Scotia that can be viewed one set at a time by scrolling down the page. The *first set of maps* (right) represent roughly *current conditions* (the baseline year is 2020) and allow users to select a specific number of FFD of interest (for this example we will use 220). The application will take a moment to recalibrate. The right hand map will show the baseline mean number of FFD and the left hand map will show the probability, ranging from 0 to 1, of 220 FFD across the province. The *second set of maps*, which look similar to the first set, allow users to examine a specific number of FFD for a *projection period* (for this example we will use 2035). The right hand map will show the mean number of FFD for the projection period of interest, and the left hand map will show the probability of 220 FFD for the selected projection period. The *third set of maps* (left) offer a *comparison* tool to examine the projected difference in the number of specific FFD between baseline (2020) and the projection period of interest. The left hand map will show the baseline mean number of FFD and the right hand map will show the difference. In other words, the application will subtract the baseline FFD from the projected FFD and it will show the estimated increase in the number of FFD expected.

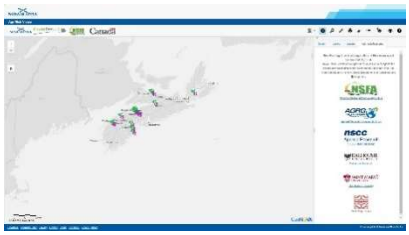



Wine sales tool: Reflecting Society developed an application that uses NSLC wine sales data to show aggregate wine sales in Nova Scotia from the 2007/08 to 2016/17 fiscal years. Data is displayed by year and grouped by wine type: imported wine, Nova Scotia wine (i.e., wine made from at least 85% Nova Scotia grapes), and Nova Scotia bottled wine (i.e., wine that is imported and bottled in Nova Scotia). Users have the option of viewing data by year in either table or graph format. Table format (left) provides the option of viewing multiple variables across years including total NS population, total volume of wine (L), volume of

specific wine type (L), total value of all wine ($), value of specific wine type ($), total value ($), and value per capita. Graph format (right) presents variables one at a time across wine types. Options for display on the graph include annual overall population (independent of wine consumption), overall volume of wine purchased (L), volume per capita, value of wine purchased ($), value per capita, and the proportion of total volume (L) and value ($) across the different wine types.

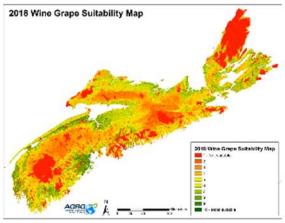


For a brief analysis of wine sales in Nova Scotia, including additional details on the model comparisons (linear vs. non-linear/flattening out of wine sales) which is displayed in the lower portion of the wine sales tool, as well as global trends in wine consumption please see report 8 listed in the Appendix.

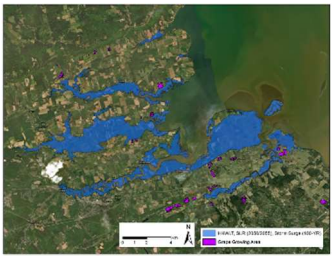


Web Viewer: An interactive Web Viewer was developed by Applied Geomatics Research Group, using a template provided by GeoNOVA, as a tool for bring together and showcase the spatial data sets developed for the AgriRisk project. The web viewer (right) will be navigable using tabs at the right hand side of the screen. The 'Layers' tab will list all layers that can be viewed, many of which will have a transparency setting to allow viewing of multiple layers. The layers will include grape growing areas, current and projected *grape suitability mapping*, current and projected climate, soil characteristics (capability for agriculture, drainage, stoniness, and root restriction), *dyke system vulnerability* (probability of overtopping), and *land availability for agriculture* (probability). The web viewer will have an 'add map' option whereby users can bring in and view external spatial data sets that are not a part of the AgriRisk project. The web viewer will serve as a framework that can be built upon in the future in the event that risk assessment systems are broadened to other commodities. A link to the web viewer will be available on the NSFA's AgriRisk web page.

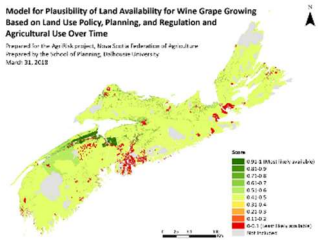
*Grape Suitability Modeling and Mapping*: Applied Geomatics Research Group developed a grape suitability modeling approach, using fuzzy logic analysis, to spatially assess and map where grapes can currently grow in Nova Scotia, and where they could grow in the future (2035 & 2050). For details on the grape suitability modeling and mapping, including data layer preparation, variable weighting, and model validation, please see report 9 listed in the Appendix. All maps can be found in that report and will also be available for users to explore in detail via the Web Viewer described above. A sample map (current grape growing areas) is shown at the left. Variables relevant to grape growing that were included in the modelling for *current* growing areas consisted of baseline climate, topography, soils, and constraint variables (e.g., historic sites, urban centres, federal or provincial parks). Modeling for *future* growing areas included the same variables however climatic suitability was based on projected data (see report 7 listed in the Appendix) and constraint variables included the probability of land availability for wine grape growing (see report 10 listed in the Appendix).



*Dyke System Vulnerability Modeling and Mapping*: Saint Mary's University developed an approach for identifying dyke vulnerability to coastal erosion based on an analysis of foreshore erosion rates and probability of overtopping due to variables including storm surge, sea level rise, and tides. Spatial data outputs of this analysis, which identify areas of greatest vulnerability, will be available on the web viewer, including a static flood layer that shows the 100-year storm surge scenario and its relation to current grape growing areas (left). Details about datasets, methodology including Bayesian Network modeling, and mapped GIS results can be found in report 11 listed in the Appendix.



*Agricultural Land Use Availability Modeling and Mapping:* Dalhousie University's School of Planning developed an approach for assessing the probability of future land availability for crop agriculture. Modeling took into consideration municipal land-use planning, zoning, and by-laws, as well as historical agricultural land conversion. The resulting data layer was incorporated into the grape suitability modeling described above and the map layer showing plausibility of agricultural land availability (right) will be available to explore on the web viewer. Details about data sources and methods, the resulting model and map, as well as validation can be found in report 10 listed in the Appendix.




## Technical Reports and Documents

A number of reports have been produced through the AgriRisk project. These fall into 3 general categories: technical reports, workshop reports, and guides. Technical reports have been produced by each data provider who developed models and data sets for use in one or more project tools, and also by contractors producing tools. Workshop reports were produced following the first and last set of workshops as a way of sharing workshop activities and results. A list of reports, which can be accessed on the NSFA's AgriRisk web page, can be found in the Appendix.

# Project Outcomes

The AgriRisk project has served as a valuable pilot project for understanding the processes, steps, and potential outcomes of a risk assessment system. From engaging industry stakeholders, identifying grape and wine value chain components, and understanding networks of risks along the chain, to compiling data and generating models to help understand links between them, the project team is well positioned for the next steps. Although it is too early to capture long term changes resulting from the project, a March 2018 survey conducted by Corporate Research Associates among grape and wine industry stakeholders and project partners who were involved to some extent in the project show some encouraging preliminary outcomes due to their involvement (n = 35). Although some respondents reported little to no perceived change due to project involvement, a significant portion of respondents reported:

- An increased network, stronger working relationships/collaborations and a better understanding of industry players
- Changes in their knowledge and awareness regarding, for example, different types of risk, changing climate, and Bayesian Networks, and industry trends

- Higher recognition of the need to make changes in the industry relating to, most notably, better and stronger collaboration with industry partners and better data collection
- Changes in future expectations including having more confidence in pursuing opportunities, better collaboration among industry partners, and a better understanding of potential impacts of the changing climate

The risk assessment system developed through the AgriRisk project provides a simple, neutral, and objective set of tools that facilitate bringing the industry stakeholders together to communicate, plan, and build risk resilience within the value chain for the betterment of the grape and wine industry of Nova Scotia. The outcomes of AgriRisk can help to support the grape and wine industry and its stakeholders to make informed decisions in the face of uncertainty. As the industry grows and matures this capacity could prove crucial. But it is critical to point out that the work is not complete. The risk assessment system is fledgling that needs careful nurturing and support to reach its full capacity and therefore to be sustained. Discussions during the final set of workshops and meetings highlighted priority next steps:

- The system needs to be more fully embedded within the industry and relationships among industry stakeholders and academics
- Technical capabilities are needed to sustain what has been developed to date, not least of which includes building a reliable mechanism for collecting and sharing data to strengthen the existing tools now and into the future
- Data inputs over the long term will help to build a better understanding of conditional links between the many drivers of risk and reduce the wide range of uncertainty that currently exists within the tools
- Funds need to be secured to ensure the strengthening and sustainability of project results

In a little more than a year, collaborative working relationships among key stakeholders have been forged and strengthened and greater awareness of risks, approaches to understanding risks (e.g., Bayesian Networks), and a better understanding of industry trends has been generated. Some of the key lessons learned through the project, which position the project leads well for exploring new opportunities to develop risk assessment systems using a similar approach for other agricultural commodities, include:

- The importance of working within realistic timelines in order to broaden uptake and engagement while being sensitive to the heavy workloads and demands that industry stakeholders already face
- Developing clear and accurate framing of project goals and model requirements early on
- Effective engagement with key stakeholders is crucial to having new tools, methods, and results accepted and acted on
- The Bayesian Network modelling approach provides a very flexible and adaptable mechanism for exploring risks and risk mitigation strategies with stakeholders

## Appendix: Reports

| Report Number | Report File Name | Report Title | Report Description |
|---|---|---|---|
| **1** | Start-up Workshops Report | Report on Workshops and Start-up March 2017 | This *workshop report* provides an overview of the first set of workshops as well as the next steps and key milestones for the project. It includes images that map out the project's early understanding of components and key processes within Nova Scotia's grape and wine industry based on input received during workshops and start-up meetings with stakeholders along the grape and wine value chain. |
| **2** | Scenario Workshops Report | AgriRisk: Grape and wine value chain risk scenario workshop report | This *workshop report* was prepared by Reflecting Society and some of the AgriRisk team members as a summary of the processes and outcomes of the final set of workshops for grape and wine value chain stakeholders held in Feb/Mar 2018. The objectives included familiarizing stakeholders with risk assessment tools (e.g., BN, climate apps, and wine sales app), use the tools to explore outputs and respond to scenarios, and generate feedback on data and tools. |
| **3** | Bayesian Network Scenario Modeling Report | AgriRisk: Bayesian Network modeling, scenario modelling and synthesis report | This report, prepared by Reflecting Society, can be used as a *guide* to demonstrate how the BN models can be used to explore a series of risks and response strategies. It also highlights limitations to the uses of the models and future possibilities for strengthening them. |
| **4** | Bayesian Network User Guide | AgriRisk: Bayesian Network modelling for the grape and wine industry of Nova Scotia user guide VO.1 | This *guide*, produced by Reflecting Society, provides users with basic information about how to access and use the Bayesian Network tools developed for the AgriRisk project. The BN tools developed for this project require Netica software in order to be accessed. The guide points users to online Netica tutorials and provides a description of the BN models developed for the AgriRisk project and how to use them, including step-by-step from manipulating the BN models to analyzing scenario outputs, as well as steps for updating the models. The models (as Netica files) can be accessed through the NSFA AgriRisk webpage. |

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| **5** | Bayesian Network Data, Analysis, and Models | AgriRisk: Bayesian Network models. Data, analyses, and models | This is a *technical report* produced by Reflecting Society that provides a description and overview of the development of the BN model components, data sources used, and sensitivity analysis showing how best to focus efforts at reducing uncertainty within the models moving forward. |
| **6** | Probability Estimates of Grape Diseases Infestation and Extent | Development of probability estimates of grape diseases infestation and extent of infestation for each major grape disease | Prepared by Sherbrooks University, this *technical report* details the development of models and risk indexes for downy mildew and powdery mildew. Model outputs considered the relationship between weather and seasonal disease risk to estimate severity (% leaf area diseased) and yield losses (% bunch area diseased). Output from this model is intended for integration into the Bayesian Network model. |
| **7** | Climate Data Methods and Results | AgriRisk Climate and climate projection data: methods and overview of results | This *technical report* was prepared by Reflecting Society and describes the methods used to acquire climate data and derive climate projection data. Projection outputs have been integrated into the grape suitability model and grape disease modeling component, and are available through the online applications for examination of current and projected frost free days, growing degree days, and days below certain critical temperatures for growing grapes (see Climate apps described above). |
| **8** | Consumer Preferences Report | AgriRisk: A brief examination of consumer preferences in relation to Nova Scotia wine | Prepared by Reflecting Society, this *technical report* reviews trends in global wine consumption and production, patterns of wine sales in Nova Scotia, and patterns in recent alcohol consumption experiences and patterns of change in alcohol consumption. Results from analyses of wine sales in Nova Scotia and consumption patterns have been or intend to be integrated into the Bayesian Network. Aggregated Nova Scotia sales data is available online for examination of sales/consumption over the past decade (see Wine sales app described above). |

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| **9** | Mapping and Web-Enabling Nova Scotia's Expanding Wine Grape Industry | Mapping and Web-Enabling Nova Scotia's Expanding Wine Grape Industry Final Report | This *technical report* details the work conducted by Applied Geomatics Research Group for the AgriRisk project. Work included inventory and mapping of all vineyards in Nova Scotia, acquisition and preparation of data layers representing soils, climate and climate projection, topography, regulatory and land-use constraints, and current and future grape suitability modeling and mapping. This report also describes the GIS Web Viewer developed for the project and all layers generated for the AgriRisk project that will be available on the Web Viewer. |
| **10** | Model for Plausibility of Land Availability for Wine Grape Growing | Model for Plausibility of Land Available for Wine Grape Growing based on Land Use, Policy, Planning, and Regulation and Agricultural Land Conversion over Time | This *technical report* was prepared by Dalhousie University's School of Planning. The report details the data, methods, model development, and analysis used to assess future agricultural land availability as well as the resulting analysis map. This work considered land use policy, planning, and regulation as well as agricultural use over time. Mapped output of this work was integrated into the grape suitability modeling by Applied Geomatics Research Group. |
| **11** | Nova Scotia Dyke Vulnerability Assessment | Risk Proofing Nova Scotia Agriculture: Nova Scotia Dyke Vulnerability Assessment | Prepared by Saint Mary's University, this *technical report* details the work that has gone into developing probabilities of dyke overtopping (including a Bayesian Network analysis) and vulnerability to erosion. Map output layers including probability of overtopping, foreshore change rates, and flood layers have been integrated into the Web Viewer produced by Applied Geomatics Research Group. |
| **12** | Grape Operations Model | Grape Operations Model Final Report | This *technical report* details the work conducted by Canmac Economic Ltd. in the development of the grape production model for integration into the Bayesian Network. The model is composed of 4 modules: input price, operations cost, revenue, and owner return. |
| **13** | Labour Supply Growth Projections | Labour Supply Growth Projections Nova Scotia Wine Industry Final Report | This *technical report* details the work conducted by Canmac Economics Ltd. in the development of base case projections of labour supply in the Annapolis Valley economic region. This is derived from outlooks that Canmac Economics provides on regular basis for each of Nova Scotia's 5 economic regions. Output from this work is integrated into the Bayesian Network model. |