

Convolutional Neural Network Web Application for Aiding Field Management in Wild Blueberry

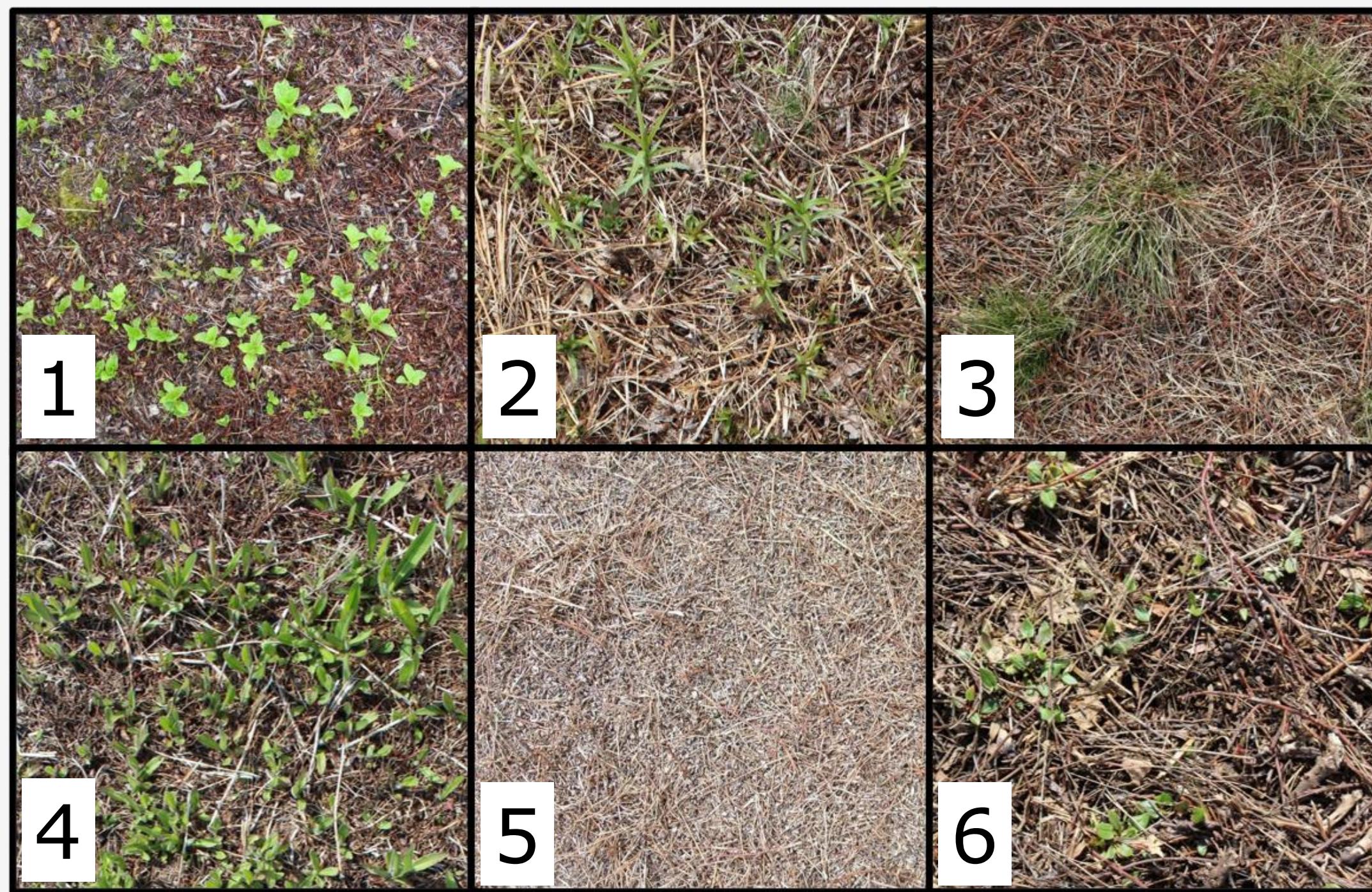
Patrick J. Hennessy¹, Travis J. Esau¹, Arnold W. Schumann², Qamar U. Zaman¹, Scott N. White¹, Aitzaz A. Farooque³
¹Dalhousie University, ²University of Florida, ³University of Prince Edward Island



Mitacs

Introduction

- The wild blueberry (*Vaccinium angustifolium* Ait.) is a perennial crop native to northeastern North America.
- Weeds, including bunchberry (*Cornus canadensis* L.), goldenrod (*Solidago* spp.), hair fescue (*Festuca filiformis* Pourr.), hawkweed (*Hieracium* spp.), and sheep sorrel (*Rumex acetosella* L.) limit wild blueberry yield.



1) bunchberry, 2) goldenrod, 3) hair fescue, 4) hawkweed, 5) bare field (no weeds), 6) sheep sorrel.

- Herbicides needed for effective management of weeds varies by species.
- Updates for best management practices are traditionally communicated to growers through biannual meetings, email dispatches, and a telephone hotline.
- Convolutional Neural Networks (CNNs) provide accurate, real-time image identification.
- A web-based application which provides field-specific information using CNNs will improve accessibility to updates in management practices.

Objectives

- Train and evaluate the MobileNet and EfficientNet-B0 CNNs for correctly classifying five weed species and bare field.
- Develop a web application which uses a CNN to classify pictures uploaded by users.

Materials & Methods

- More than 15000 images were collected in April, May, and June 2019 and 2020 in northern and central Nova Scotia.
- Images were sorted by the most prevalent weed shown in the frame if more than one species was present.
- 800 images of each target weed and 800 images of bare field with no weeds were selected for use with the CNNs.
- 70% of the images (4080) were used for training the CNNs, while 30% (720) were reserved for validating them.
- Google Colab was used to train MobileNet and EfficientNet-B0 using TensorFlow and Keras.
- Both networks were trained twice. First with all layers unfrozen, and second with only the first half of the layers unfrozen.
- A web application was written in JavaScript using the ReactJS framework for users to upload their images for classification.
- MobileNet was converted from Keras to TensorFlow.JS for processing in the users' web browser.

Results & Discussion

- EfficientNet-B0 (93.5%) produced a greater overall accuracy on the validation dataset than MobileNet (77.2%) after two training cycles.

		EfficientNet-B0 Confusion Matrix					
		Bunchberry	Goldenrod	Hair Fescue	Hawkweed	No Weeds	Sheep Sorrel
True Label	Bunchberry	98.3	0.0	0.0	0.8	0.0	0.8
	Goldenrod	0.0	99.2	0.0	0.8	0.0	0.0
	Hair Fescue	0.0	0.0	93.5	2.2	1.4	2.9
	Hawkweed	0.9	0.9	0.9	90.8	0.0	6.4
	No Weeds	2.5	0.0	0.0	0.8	95.8	0.8
	Sheep Sorrel	0.0	0.9	3.6	6.3	0.0	89.2
		Bunchberry	Goldenrod	Hair Fescue	Hawkweed	No Weeds	Sheep Sorrel
		Predicted Label					

		MobileNet Confusion Matrix					
		Bunchberry	Goldenrod	Hair Fescue	Hawkweed	No Weeds	Sheep Sorrel
True Label	Bunchberry	78.3	1.7	4.2	3.3	10.8	1.7
	Goldenrod	0.0	81.8	1.7	5.0	1.7	9.9
	Hair Fescue	8.6	4.3	63.3	13.7	6.5	3.6
	Hawkweed	1.8	5.5	5.5	74.3	0.0	12.8
	No Weeds	3.3	0.8	5.8	0.0	89.2	0.8
	Sheep Sorrel	2.7	4.5	3.6	9.9	0.9	78.4
		Bunchberry	Goldenrod	Hair Fescue	Hawkweed	No Weeds	Sheep Sorrel
		Predicted Label					

Confusion matrices for classification of validation images using EfficientNet-B0 (left) and MobileNet (right).

Correspondence: Patrick.Hennessy@Dal.ca

The application can be accessed by scanning this QR code, or by visiting https://patrickhennessy-dal.github.io/weed_class_asabe21/



- Accuracy may be improved by using images that contain only one species of weed.
- The rescaling layers used in EfficientNet-B0 are not available in Tensorflow.JS as of the current version (3.6.0).
- Processing images on a backend sever instead of in the users' browser would allow for different CNNs such as EfficientNet-B0 to be used.

CNN Weed Classifier

This is an application for classifying weeds in wild blueberry fields using the MobileNet (Abadi et al., 2015) and EfficientNet-B0 (Chollet et al., 2020) networks. The currently supported weeds are: hair fescue, sheep sorrel, hawkweed, goldenrod, and bunchberry. MobileNet was trained on Google Colab (Bisogni, 2019) using TensorFlow (Abadi et al., 2015) and Keras (Chollet et al., 2020). The website runs on the ReactJS framework (Facebook Inc. & Molle, 2020) and processes images using TensorFlow.js (Abadi et al., 2015) in the users' web browser. TensorFlow.js (Smilkov et al., 2019). This application was presented at ASABE AIM 2021 with a corresponding paper in the conference proceedings.

To use the application, capture an image of the weed from directly above from a height of around 1 metre. Alternatively, download some sample images. Then, upload the image and let the deep learning algorithm do the work!



Bunchberry
Confidence level: 80.92%

Upload Image Identify Image

Management Options*

Bunchberry
Bunchberry [*Cornus canadensis* L.] is susceptible to spot treatments of tribenuron-methyl [Spartan], although it may require subsequent applications in future years (Government of New Brunswick, 2017, Yarmouth).

Goldenrod
Goldenrod [*Solidago* spp.] are best managed with mesonine [Collisto] or glyphosate [Roundup] (Farooq, 2018; Government of New Brunswick, 2017).

Hair Fescue
Pronamide [Kerb SC] is the best option for managing hair fescue [*Festuca filiformis* Pourr.] (Government of New Brunswick, 2017, White). Applications of glufosinate [Ignite SN] and fluroxuron [Optic 2.25 OD] suppress hair fescue [White, 2017].

Hawkweed
Hawkweeds [*Hieracium* spp.] are susceptible to cleopatra [Lontrel 360 EC] and dicamba [Banvel II], while hexazinone [Velpar DF] suppresses it (Evolve, 2019).

Sheep Sorrel
Dicamba [Banvel II] is currently the best option for managing sheep sorrel [*Rumex acetosella* L.] (Government of New Brunswick, 2017), while hexazinone [Velpar DF] and pronamide [Kerb SC] have varying levels of success (Hughes et al., 2016; Kennedy et al., 2010).

Acknowledgements
This work was supported by Mitacs through the Mitacs Accelerate Program (IT23150), in partnership with the Wild Blueberry Producers Association of Nova Scotia (WBPAN). The authors would like to thank the wild blueberry growers in Nova Scotia for use of their fields during image collection. Also, the authors acknowledge the efforts of the mechanized systems and precision agriculture research teams at Dalhousie University's Faculty of Agriculture.

Cite
If you wish to use this work, please cite our paper in the ASABE AIM 2021 conference proceedings:

```
const citation = () => {
  title = "Convolutional Neural Network Web Application for Aiding Field Management in Wild Blueberry";
  author = "Patrick J. Hennessy, Travis J. Esau, Arnold W. Schumann, Qamar U. Zaman, Scott N. White, Aitzaz A. Farooque";
  year = "2021";
  profTitle = "2021 ASABE Annual International Meeting";
  profCity = "Virtual";
  doi = "10.13031/aim.2109661";
```

References
Abadi, M., Agarwal, A., Barham, P., Brevdo, E., Chen, Z., Citro, C., et al. (2015). TensorFlow: Large-Scale Machine Learning on Heterogeneous Distributed Systems. In *Google Research Paper*. <https://doi.org/10.1145/2989050.2909057>

Bisogni, E. (2019). Google Colaboratory. In *Building Machine Learning and Deep Learning Models on Google Cloud Platform*. Research Council of Canada Discovery Grants Program (RGPIN-06295-2019), Doug Bragg Enterprises, Ltd and New Brunswick Canadian Agricultural Partnership (CAP). The authors would like to thank the wild blueberry growers in Nova Scotia (WBPAN).

Chollet, F., et al. (2020). Keras. GitHub Repository. <https://github.com/keras-team/keras>

Evolve, M. (2017). Management of Hawkweed (*Hieracium* spp.) in Wild Blueberry Fields on Prince Edward Island [M.Sc. Thesis, Dalhousie University].

Screenshots of the web application.

Conclusions

- This application will help growers use optimal management practices, thus increasing the sustainability of the industry.
- A better dataset and backend processing with EfficientNet-B0 will help improve classification.

Acknowledgements

This work was supported by Mitacs through the Mitacs Accelerate Program (IT23150), in partnership with the Wild Blueberry Producers Association of Nova Scotia. Additional funding for this research was provided by Natural Sciences and Engineering Research Council of Canada Discovery Grants Program (RGPIN-06295-2019), Doug Bragg Enterprises, Ltd, and New Brunswick Canadian Agricultural Partnership (CAP). The authors would like to thank the wild blueberry growers in Nova Scotia for use of their fields during image collection. Also, the authors acknowledge the efforts of the mechanized systems and precision agriculture research teams at Dalhousie University's Faculty of Agriculture.