ABMI Canadian toad recognizer progress report

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Project title: Mapping amphibian distribution and abundance in the Lower Athabasca of Alberta, with an emphasis on Canadian toads

Northern Alberta is experiencing change with the expansion of the energy sector, and there is a pressing need for an evaluation of the distribution of rare species. Companies within Alberta's oil sands are interested in developing techniques for monitoring amphibians, particularly the Canadian toad (*Anaxyrus hemiophrys*), a species of conservation concern. This study aims to better identify wetland types used by Canadian toads. Autonomous recording units (ARUs) were used to collect acoustic data from pre-selected potential Canadian toad habitats. Using results from ARUs, a habitat model for the Canadian toad will be constructed. This model can be used as part of adaptive monitoring, and provide information on this elusive species.

A total of 35 sites were deployed in the Lower Athabasca planning region (LAPR) from April 2014 to July 2014. Each site was composed of five ARU stations, and therefore, 175 unique locations were sampled. The ARUs were programmed for the first 10 minutes of every hour, and remained at a site for a minimum of 7 days. Data collected from this field season is currently being listened to by trained individuals using Adobe Audition CS6 (2012). To effectively decrease the amount of time spent listening to acoustic data, an automated recognizer was used to identify the call of the Canadian toad in all of the collected recordings. The computerized recognizer scans through all of the long audio recordings gathered in the field and locates the targeted vocalization made by the focus species (Wildlife Acoustics Inc 2011). Specific software, developed by Wildlife Acoustics Inc. (2011), uses sophisticated digital signal processing algorithms to compare and identify target vocalizations in long recordings.

Automated recognizers use a collection of annotated vocalizations to represent the typical call of the species of interest. A number of clear vocalizations must be confirmed to be that of the target species and then those calls in the recordings must be annotated to include in the recognizer. Annotated calls should include a small amount of background noise before and after the call to increase signal detection (Wildlife Acoustics Inc 2011). This is especially important for calls that do not change in frequency, similar to that of the Canadian toad. When the call is annotated without any background noise, the signal is not clear and the computer cannot identify the target vocalization. Once the recognizer has finished running through the recordings, a number of flags will be generated, identifying calls that meet the requirements of the recognizer. These flags must then be validated to be true detections of the target species by trained individuals. Digital call recognition is not comparable to recognition by the human brain, and false positives (vocalizations that are incorrectly identified as the target vocalization) are unavoidable (Wildlife Acoustics Inc 2011).

Wildlife Acoustics Inc.'s (2011) Song Scope software was used to develop an automated recognizer to detect the vocalization of the Canadian toad. The Canadian toad recognizer has finished analyzing the data collected in 2013, which was originally targeted to detect yellow rails (*Coturnicops noveboracensis*). The output generated by the recognizer is finished being validated by human listeners to confirm the call of the Canadian toad. The Canadian toad recognizer produced a total of 26939 flags. Of these, 2859 (10.6%) were validated to be true detections of Canadian toad calls; therefore, 24080 (89.4%) of the flags were false positives. False positives produced by the recognizer, included vocalizations produced by other boreal amphibian species (western toads (*Anaxyrus boreas*), boreal chorus frogs (*Pseudacris maculata*), and wood frogs (*Lithobates sylvaticus*)) and avian species (common loons (*Gavia immer*), Bonaparte's gulls (*Chroicocephalus philadelphia*), and common ravens (*Corvus corax*)). The recognizer also identified some non-vocal avian sounds, such as the winnow produced by the tail of the wilson's snipe (*Gallinago delicate*) and the drumming of woodpecker species. Low frequency industrial noise was also flagged by the recognizer, as some noises lie in the similar frequency range as the Canadian toad call (1000 -2000 Hz).

Considering only the 2013 acoustic data from the yellow rail study, human listening detected Canadian toads from 30 of the 2852 recordings analyzed. The recognizer was able to detect Canadian toads from only one of these recordings, resulting in an extremely high false negatives (confirmed target vocalizations not found by the recognizer) rate (96.7%). This high false negatives rate is likely a direct result of how the recognizer was built. The annotations used to make this recognizer were all clear and pristine toad calls. The majority of detections made by listeners coincide with background industrial noise and other masking sounds, such as full choruses of boreal chorus frogs. Those less than perfect toad calls would not have been detected by the recognizer, as they would not have matched the digital signal processing algorithm.

While the recognizer overlooked the majority of Canadian toad detections made by listeners, it has more than doubled the known locations where these toads occur on the landscape. Human listening of the 2013 yellow rail data resulted in only 6 unique Canadian toad stations in the LAPR (Figure 1). Examining the same data set, the automated recognizer identified 53 unique stations, as well as a single station that overlapped with those identified by human listening (Figure 2). Currently, human listening of data collected from 2012-14 has produced 36 stations with confirmed Canadian toads. Considering both the digital recognizer and human listening, there are now 89 unique Canadian toad locations (Figure 3). These stations are spread throughout the LAPR, ranging from sites near Cold Lake to north of McClelland Lake, Alberta. These unique locations will increase the power of the Canadian toad habitat model and provide information on suitable aquatic and terrestrial factors required by these toads.

Since the Canadian toad recognizer was run over all recordings of the 2013 yellow rail data, it was able to extract the hours of the day when these toads are the most vocal (Figure 4). From the recognizer data, it is clear that the optimal hours of calling for this breeding amphibian are between 12:00AM and 4:00AM. There is very low activity of this species during daylight hours, further indicating its nocturnal behaviour. This information not only assists in learning more about this data deficient species, but notes prime hours for surveying the Canadian toad. Moreover, the hours of 12:00AM, 1:00AM, 2:00AM and 3:00AM are to be prioritized for human listening to optimize the likelihood of detecting Canadian toads.

The constructed acoustic recognizer provided an increase in Canadian toad locations and information on calling patterns much more efficiently than the information previously gathered through only human listening. A total of 1140 minutes were spent to verify the output by the recognizer. Trained individuals were able to validate 23.6 Canadian toad flags found by the recognizer per minute; this resulted in 2.5 Canadian toad true positive flags per minute of listening. In comparison, considering only the 2013 yellow rail data, a total of 21300 minutes were spent analyzing the 2852 recordings. It took 1.34 minutes for trained observers to listen and analyze each minute of a recording. As only 30 recordings from this dataset were found to have Canadian toads, the rate at which this species was found by manual listening was 0.0014 toads per minute. If the number of unique stations counted as single detections, similar to human listening, the number of Canadian toads detected by the recognizer is 0.0047 per minute. It is clear that the recognizer has proven to be a more efficient means for collecting data on this species.

While the recognizer has done well and proved to be a beneficial tool in analyzing bioacoustics data, it did overlook a significant number of human-detected Canadian toad recordings (96.7%). Most of these recordings had examples of faint toad calls and calls that were masked by either other vocal species (ie. boreal chorus frogs) or industrial noise. With this in mind, adaptations are being made to the annotations that are used in the recognizer. Fainter Canadian toad calls from the overlooked sites and from other sources are being used to create a "less pristine" recognizer for this species. The hope is that the false negative rate will drop significantly if both the pristine-call recognizer and the masked-call recognizer are run simultaneously over the data. This new Canadian toad recognizer is currently being constructed and both recognizers will be used to evaluate the amphibian acoustic data collected in 2014.

The recognizer data will provide an assessment of emerging bioacoustics technology and will contribute to the further development of acoustic recordings as an efficient method for monitoring wildlife. This form of data collection has many applications for field biologists, and should be considered for studies involving species vocalization behaviour, evaluations on migration patterns and population density (Wildlife Acoustics Inc 2011). Automated recognizers have been shown to be an effective way to process long recordings that would be otherwise time consuming for human observers.

References:

Adobe Audition CS6 (2012) Adobe Systems Incorporated.

ESRI (2013) ArcGIS 10.2 for desktop.

Wildlife Acoustics Inc (2011) Song Scope: Bioacoustics Software Version 4.0 Documentation. 1–44.

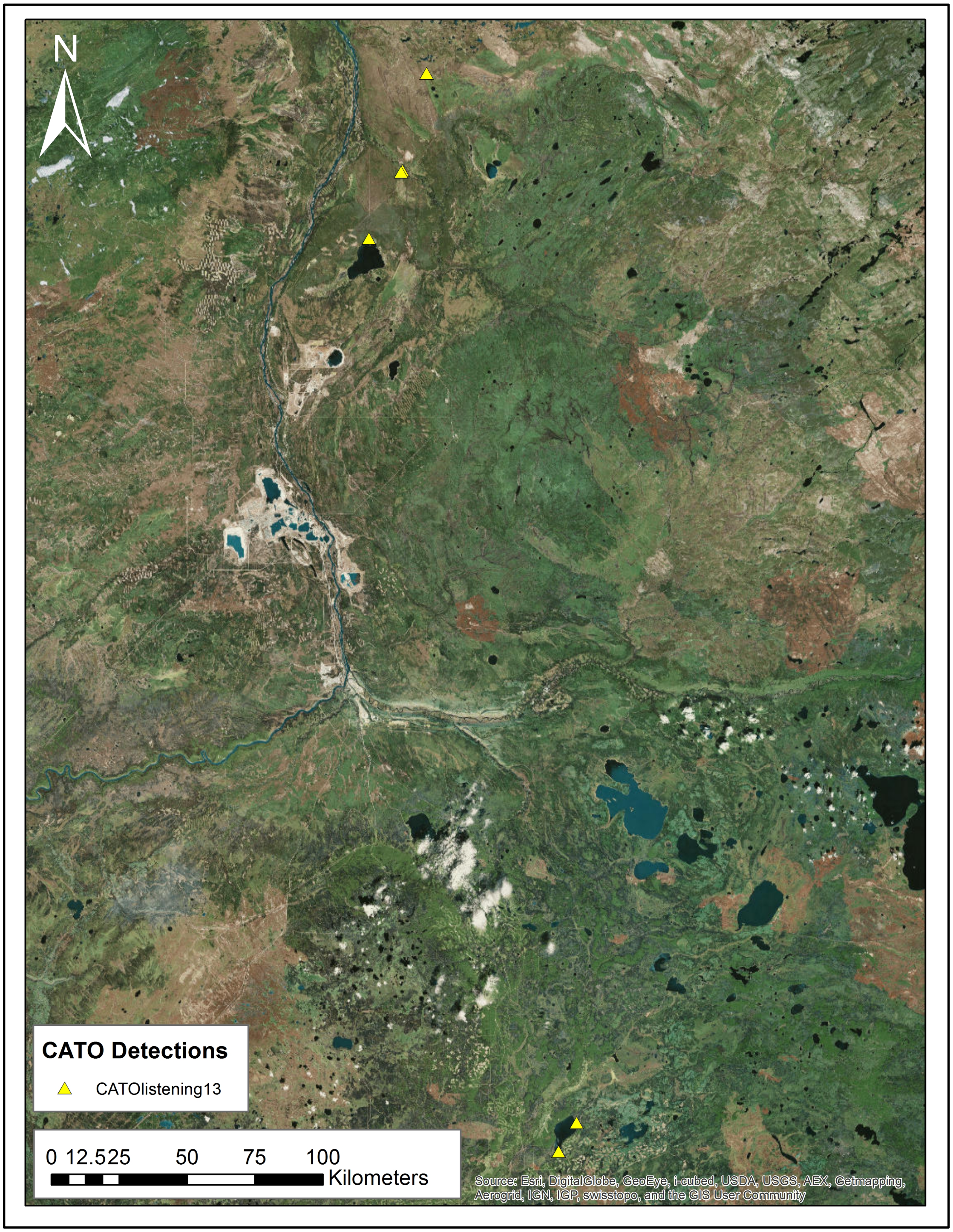

Figure 1. Canadian toad (*Anaxyrus hemiophrys*) detections made by human listening of the 2013 Yellow Rail data. Human listening produced 6 unique Canadian toad stations in the Lower Athabasca planning region of northeastern Alberta, which are represented by yellow triangles. Stations range from Janvier in the south to north of McClelland Lake. Map produced in ArcMap, an ArcGIS program (ESRI 2013).

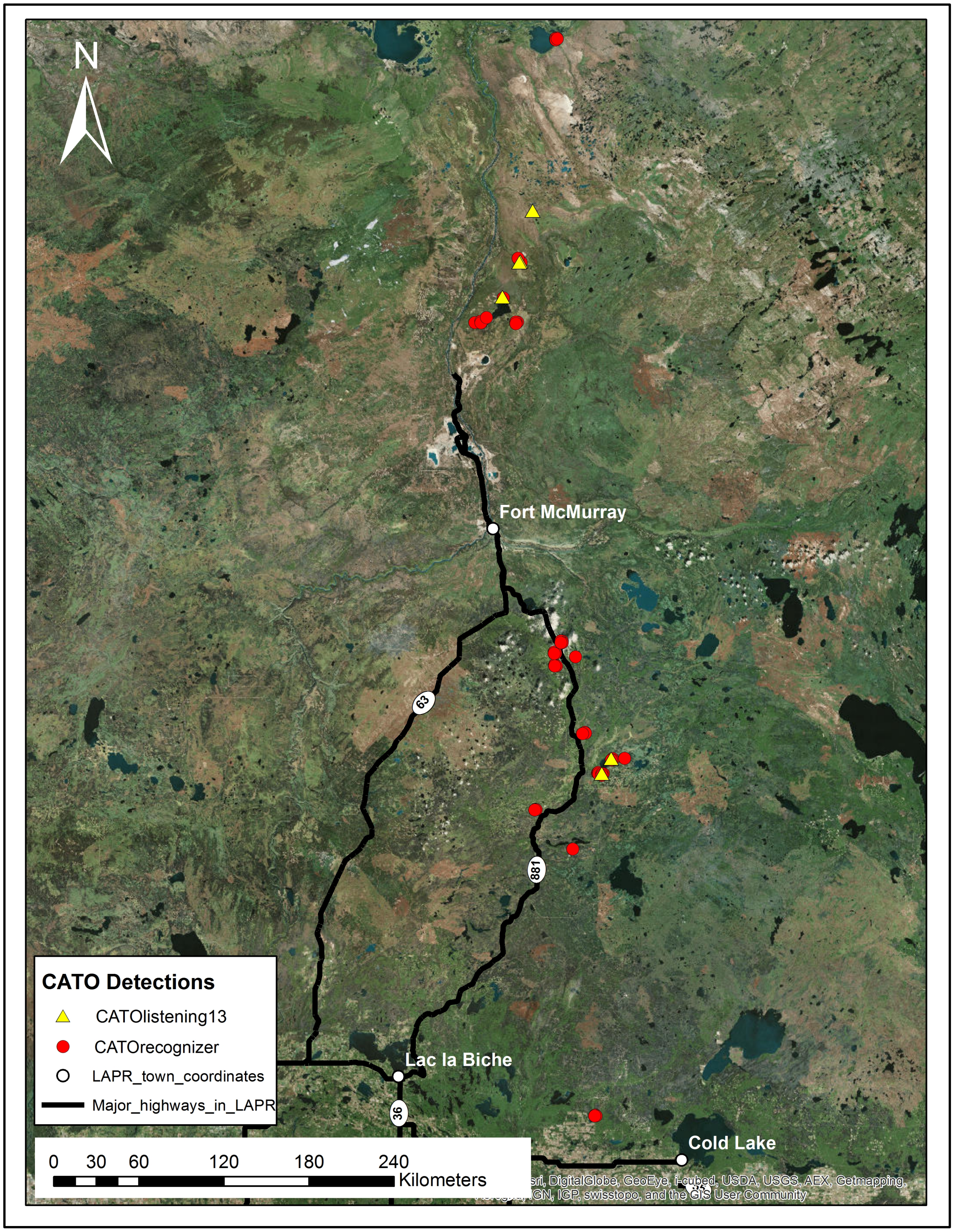

Figure 2. Canadian toad (*Anaxyrus hemiophrys*) detections found in the 2013 Yellow Rail data as a combination of human listening and automated recognition. Human listening produced 6 unique Canadian toad stations (yellow triangles) and the recognizer produced 54 unique stations (red circles) in the Lower Athabasca planning region of northeastern Alberta. Stations range from west of Cold Lake in the south to Richardson Lake in the north. Major towns (white circles) and major highways (black lines) are displayed. Map produced in ArcMap, an ArcGIS program (ESRI 2013).

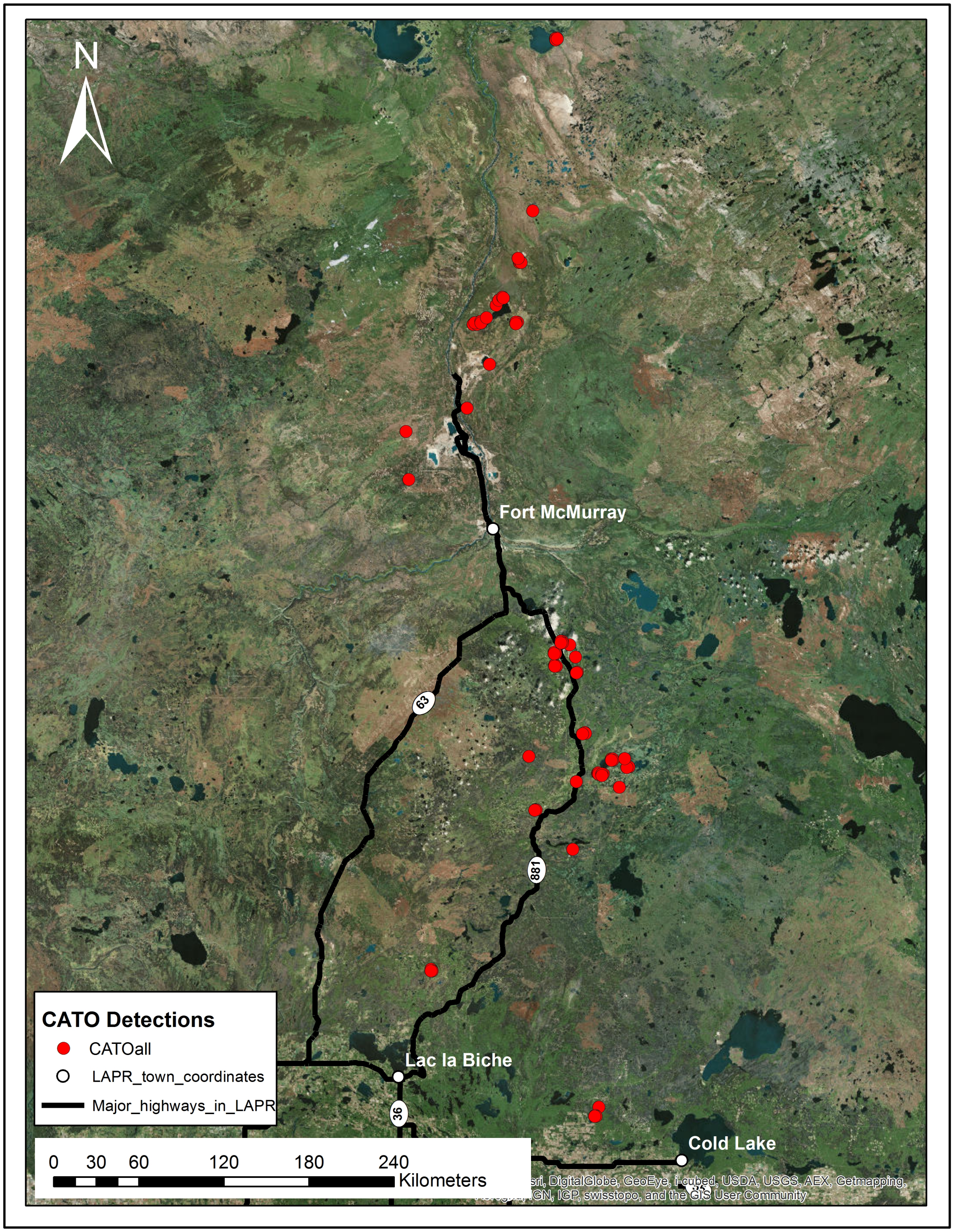

Figure 3. Canadian toad (*Anaxyrus hemiophrys*) detections from all data collected from 2012 to 2014, analyzed by both human listening and automated recognition. A total of 89 unique Canadian toad stations (red circles) have been found in the Lower Athabasca planning region of northeastern Alberta. Stations range from west of Cold Lake in the south to Richardson Lake in the north. Major towns (white circles) and major highways (black lines) are displayed. Map produced in ArcMap, an ArcGIS program (ESRI 2013).

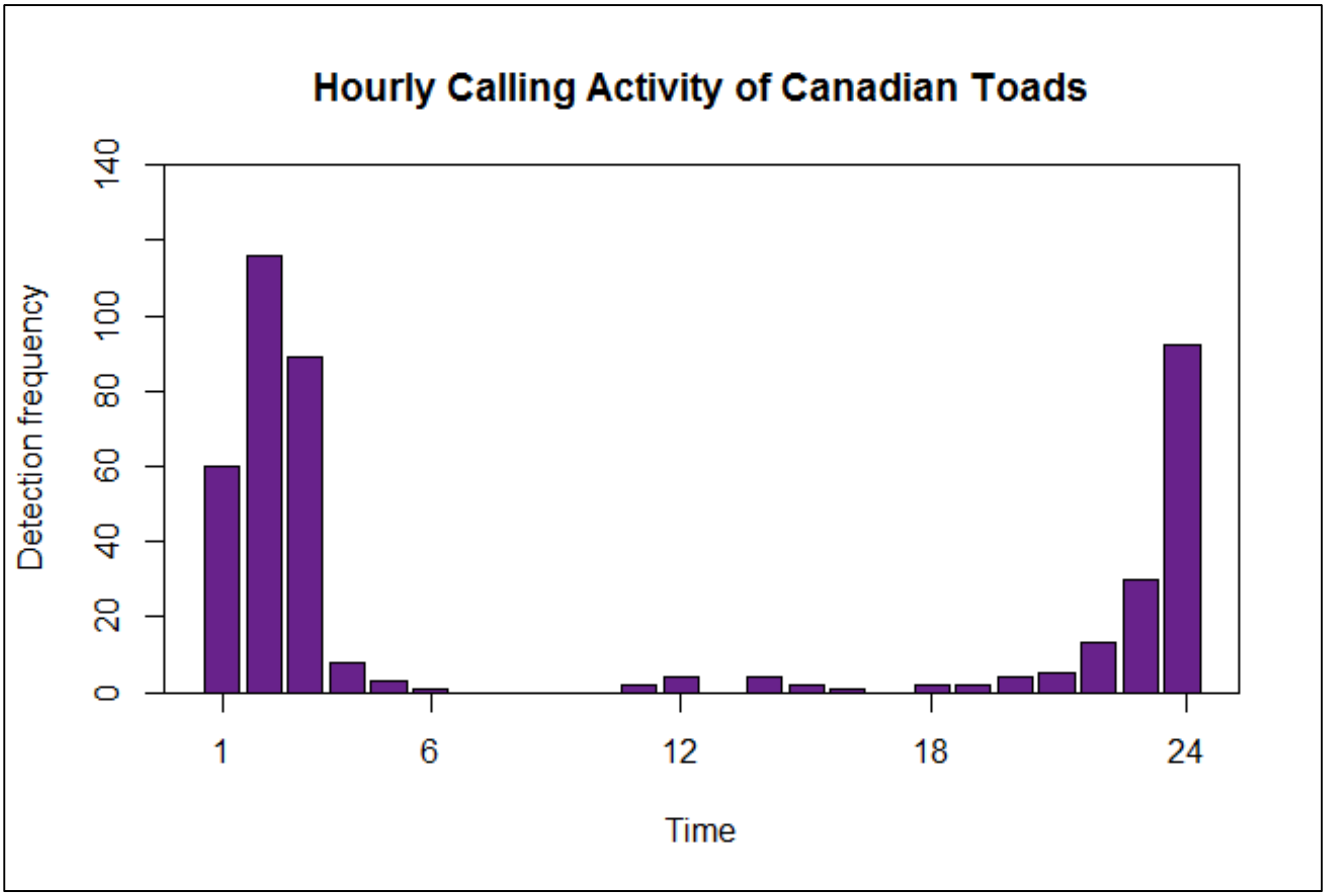

Figure 4. Optimal calling hours of the Canadian toad (*Anaxyrus hemiophrys*) shown by automated recognition of the 2013 Yellow Rail data. Time of day is indicated in the x-axis, and frequency of occurrence is noted on the y-axis. Highest calling activity shown to occur between the hours of 12:00AM and 4:00AM, with 2:00AM being the most active hour for Canadian toads.