**New Hampshire Ecological Conservation**

*Predicting Future Conflicts between Loon Habitats and Human Development in New Hampshire using NASA Earth Observations*

**Project Team**

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**Project Overview**

***Project Synopsis:***

The Common Loon (*Gavia immer*) is an aquatic diving bird occupying freshwater lakes that face threats from anthropogenic intrusion. In collaboration with the Loon Preservation Committee (LPC), we assessed impacts of urban development, water clarity, and land surface temperature on loon nesting habitats. We identified development between 2001 and 2019 and found relatively small increases in development and moderate areas suitable for future development. We observed higher average turbidity in less developed lakes that were farther north. Also, despite an average increase of 1.7 °F, loon presence persisted. Synthesized results can assist the LPC in future conservation efforts.

***Abstract:***

Bioindicator species monitoring allows researchers to infer the overall ecological health of a given area. Among these species, the Common Loon (Gavia immer), occupies the land-water interface on lakefront habitats in New Hampshire (NH) which exposes nest sites to human encroachment. In collaboration with the Loon Preservation Committee (LPC), we utilized NASA Earth Observations to predict future conflicts between loon habitats and human development in New Hampshire. Land use land cover (LULC), water clarity, and land surface temperature (LST) were analyzed to determine habitat suitability for loons. We used land cover classifications from the National Land Cover Database (NLCD) to analyze development around eight NH lakes (Canobie, First Connecticut, Massabesic, Newfound, Onway, Squam, Umbagog, and Winnipesaukee) from 2001 to 2019. Terra Moderate Resolution Imaging spectroradiometer (MODIS), Landsat 5 Thematic Mapper (TM), and Landsat 8 Operational Land Imager (OLI) data provided land surface temperature between 2000 and 2022. Additionally, we utilized Landsat 8 Operational Land Imager imagery to estimate water clarity between 2013 and 2022. LULC analysis identified areas of development around each lake for 2001, 2019, and land suitable for future development as of 2019. Assessment of mean summer LST revealed that loons' presence persists, despite increasing temperatures. We observed increased average water clarity in lakes that were more developed, in general the southernmost lakes analyzed within NH. We synthesized these results to assist the LPC in future conservation efforts.

***Key Terms:***

ACOLITE, Landsat 5, Landsat 8, land surface temperature, land use land change, Terra MODIS, turbidity

***National Application Area Addressed:*** Ecological Conservation

***Study Location:*** NH

***Study Period:*** 2000 to 2022 (May to August of each year)

***Community Concerns:***

* The Common Loon is a bioindicator species, meaning their health and abundance can help researchers infer the health of the surrounding environment. Maintaining a healthy loon population suggests conditions that support biodiverse freshwater environments.
* Loons have a positive impact on property values. Waterfront properties on lakes with loons are valued nearly $50,000 higher than lakes without loons.
* Increased human activity and shoreline development can negatively impact loon habitats by increasing boating activity, introducing lead fishing tackle, and increasing lake acidification and toxins.

***Project Objectives:***

* Assess past and predict future land use change to forecast potential threats to loon habitat
* Explore how water clarity impacts loon habitat selection
* Analyze potential effects of historical land surface temperature on loon breeding range

**Partner Overview**

***Partner Organization(s):***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Loon Preservation Committee (LPC)** | Harry Vogel, Director; John Cooley, Senior Biologist; Caroline Hughes, Volunteer and Outreach Biologist; Anne Kuhn-Hines, Board Member & EPA Research Ecologist | End User |

***Decision-Making Practices & Policies:***

The Loon Preservation Committee (LPC) is a non-profit organization committed to maintaining healthy loon populations in New Hampshire through field work, monitoring, and public education. The LPC relies primarily on volunteer biologists to collect field data for an extensive database of loon productivity and populations. From there, the committee works closely with federal and state agencies to implement policies. Thanks to this management the LPC has been able to help increase the loon reproductive success rate. Currently, the LPC does not use any Earth observations in their methodology.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor**  | **Parameter**  | **Use**  |
| **Landsat 5 TM**  | Land Surface Temperature | High-resolution temperature data across New Hampshire will be analyzed in relation to LPC’s loon presence and absence data.  |
| **Terra MODIS** | Land Surface Temperature | High-resolution temperature data across New Hampshire will be analyzed in relation to LPC’s loon presence and absence data.  |
| **Landsat 8 OLI**  | Land Surface Temperature | High-resolution temperature data across New Hampshire will be analyzed in relation to LPC’s loon presence and absence data.  |
| **Landsat 8 OLI**  | Water Clarity | Water clarity parameters, such as turbidity, will also be analyzed in relation to urban development and loon presence and absence data |

***Ancillary Datasets:***

* LPC Loon presence/absence dataset 1984-2002 – Long-term time series of abundance and distribution to compare to verify identification with Earth observations
* USGS/EROS NLCD 2001 & 2019 – Landsat-based land cover classifications used to identify areas of urban development
* New Hampshire GRANIT GIS Clearinghouse New Hampshire Conservation/Public Lands – To mask out areas of protected land that were unable to be developed
* New Hampshire GRANIT GIS Clearinghouse – New Hampshire Political Boundaries

***Software & Scripting:***

* Google Earth Engine – Land Surface Temperature data acquisition
* ArcGIS Pro 3.1.0 – Land Use Land Cover change analysis, Land Surface Temperature analysis, and map creation
* ACOLITE 20210802.0 – Landsat atmospheric correction procession & turbidity analysis
* MATLAB R2022b – Turbidity data value extraction
* SeaDAS 8.2.0 – Turbidity visualizations

***End Product(s):***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Land Cover Time Series and Development Maps** | N/A | The time series and development maps will allow the LPC to identify changes in urban development from 2001-2019 and where future development may occur as of 2019 and conflict with loon nesting sites.  | N/A |
| **Water Clarity Figures** | Landsat 8 OLI | These figures will detail the relationships between turbidity estimates, percentage of development, normalized number of nesting pairs observed at each lake, and latitude in eight lakes in NH which will help the LPC track spatial variations of turbidity. | N/A |
| **Land Surface Temperature Time Series Trends** | Terra MODISLandsat 5 TMLandsat 8 OLI | This time series will visualize LST changes from 2000-2022 (and 2000-2010, 2008-2015, and 2013-2022). Thus, the LPC can identify areas of extreme temperatures changes and loon nests located therein. | N/A |

***Product Benefit to End User:***

The end products will provide the LPC with spatiotemporal understandings of land use land cover change from 2001-2019, turbidity estimates of lakes from 2013-2022, and LST averages from 2000-2022. Also, the land suitable for future development as of the 2019 data will allow the LPC to target conservation efforts towards lakes that may have substantial conflicts between human encroachment and loon nesting territories. The complete LULC data tables will also allow data personnel at the LPC to calculate development statistics for any lake in NH that had a nesting pair present from 2001-2019. LST time series trends and water clarity maps will assist the LPC in developing more accurate future conservation plans and policies.

**References**

Kuhn, A., J. Copeland, J. Cooley, H. Vogel, K. Taylor, D. Nacci, & P. August. (2011). Modeling habitat associations for the Common Loon (Gavia immer) at multiple scales in northeastern North America. *Avian Conservation and Ecology* 6(1): 4. Retrieved from [http://dx.doi.org/10.5751/ACE-00451-060104](http://dx.doi.org/10.5751/ACE-00451-060104%C2%A0%C2%A0%C2%A0%C2%A0)

Lindsay, A. R., Gillum, S. S., & Meyer, M. W. (2002). Influence of lakeshore development on breeding bird communities in a mixed northern forest. *Biological Conservation*, *107*(1), 1-11.  [https://doi.org/10.1016/s0006-3207(01)00260-9](https://doi.org/10.1016/s0006-3207%2801%2900260-9)

Loon Preservation Committee. (n.d.). *Loon preservation in New Hampshire.* Loon Preservation Committee. Retrieved February 6, 2023, from [https://loon.org/about-the-common-loon/](https://loon.org/about-the-common-loon/%C2%A0)

Piper, W. H., Grear, J., Hoover, B., Lomery, E., & Grenzer, L. M. (2020). Plunging floater survival causes cryptic population decline in the common loon. *The Condor*, *122*(4). [https://doi.org/10.1093/condor/duaa044](https://doi.org/10.1093/condor/duaa044%C2%A0)

Tuttle, C. M., & Heintzelman, M. D. (2015). A loon on every lake: A hedonic analysis of lake water quality in the Adirondacks. Resource and Energy Economics, 39, 1-15. <https://doi.org/10.1016/j.reseneeco.2014.11.001>