



Photo: Brendan Wiltse

Balancing Recreation and Wildlife in the Adirondack High Peaks: Report to the Waterman Fund



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Introduction

Protected areas are commonly established with a dual mandate to provide public access for outdoor recreation, education, and other human activities while also protecting plant and animal species, habitats, and ecological processes. Outdoor recreation has many human health (Frumkin 2001) and economic benefits (OIA 2012); it also influences people's political and financial support for land and wildlife conservation (Zaradic et al. 2009). Population growth and expanding residential development near protected areas provide people with greater access to recreation opportunities (Wade and Theobald 2010), and rates of visitation to protected areas and participation in outdoor recreation are increasing rapidly. Across the U.S., per capita days of participation in nature-based activities increased by more than 22% between 2000 and 2007 (Cordell 2008).

Although the deleterious effects of extractive and consumptive human land uses within protected areas are well known (Liu et al. 2001, DeFries et al. 2005), outdoor recreation is often assumed to be compatible with species protection and is permitted in most protected areas globally. However, a growing body of research demonstrates that outdoor recreation can negatively impact plant and animal communities. Recreation is the second-leading cause of endangerment to species occurring on U.S. federal lands (Losos et al. 1995), and negative effects of recreation activities have been demonstrated for many taxa (Liddle 1997). For example, recreation has been linked to declines in species abundance, occupancy, or density (Banks and Bryant 2007, Reed and Merenlender 2008), changes in spatial or temporal habitat use (George and Crooks 2006, Cardoni et al. 2008), increased physiological stress (Arlettaz et al. 2007), reduced reproductive success (Finney et al. 2005), and behavioral effects such as flight and increased vigilance (Taylor and Knight 2003).

The 24,000 km² Adirondack Park in northern New York State is the largest protected area in the continental U.S. It is located within a day's drive of 100 million people, and outdoor recreation has been a cornerstone of the Park's culture and economy throughout its history (Jenkins and Keal 2004). Currently, the Park receives an estimated 7-10 million visitors per year, with the majority (>90%) participating in non-consumptive, nature-based activities (Dawson 2012). New York State continues to add protected lands to the Adirondack Park, many of which are highly desirable for recreation use and important for the local tourism economy. Yet, few studies have investigated how the increase in visitation affects the ecological integrity of the park or quantified the benefits that result from encouraging public access.

The Waterman Fund supported our research to investigate bird and mammal community characteristics and their relationship to recreational use intensity on High Peaks trails and alpine areas in the Adirondack Park to help inform future management decisions about trail use and recreation management. Our objectives were to (1) inform future High Peaks management policies for trail use and recreation management using scientifically supported information by (2) applying existing data to investigate the relationship between recreation visitation and the composition and structure of bird and mammal communities in the High Peaks region of the

Adirondacks, to determine which species may be most sensitive to disturbance by recreation and in which locations.

Study Area

New York's Adirondack Park encompasses approximately 61 townships in an area of 19,700 km² located in one of the most heavily populated regions of eastern North America. Elevations range from 30 to 1600 m. The park contains mixed deciduous–coniferous forest (maple–beech–birch [*Acer* spp., *Fagus grandifolia*, *Betula* spp.]) and spruce–fir–hemlock forest [*Picea* spp., *Abies balsamea*, *Tsuga canadensis*] and encompasses several ecological zones. The High Peaks region contains the highest and most rugged areas in the park, with elevations ranging from 305 to 1629 m. Average annual summer temperatures in the park as a whole range between 18 and 21°C and winter temperatures between 1 and 5°C. Average snowfall is between 102 and 356 cm (Glennon and Porter 2005). High elevation rocky habitats of the Adirondacks include alpine, cliff and talus, and outcrop and summit scrub. These habitats are a small percentage of the overall landscape (< 1%), of small average patch size (2–7 acres), and well represented on state and easement lands (Glennon and Curran 2013). They include ecological communities such as the alpine zone, which hosts some of the rarest plants in the state (Slack and Bell 2006) and provides critical habitat to montane species such as the Bicknell's thrush (*Catharus bicknelli*), peregrine falcon (*Falco peregrinus*), and common raven (*Corvus corax*).

Methods

Mammals

Survey method

As a component of a broad scale socioecological investigation of the dynamic human–environmental interactions that result from people's visitation of protected areas (National Science Foundation Coupled Natural and Human Systems program, award # 1716533), we collected mammal occurrence data along sections of 33 trails in the northern Adirondacks. Potential study locations were chosen from within a radius of approximately 25 miles around an area encompassing Paul Smith's College and Saranac Lake, NY, from which field operations were based. We identified an original set of 130 possible trail locations located in the region of interest, and from them selected those that were at least 1km in length and associated with a trail register according to the New York State Department of Environmental Conservation (NYSDEC; gis.ny.gov/gisdata). We then used ArcMap to buffer paved roads by 400m and identified sections of trails that consisted of relatively uniform Northern Hardwood and Conifer habitat as mapped by Ferree and Anderson (2013) resulting in 86 trails with majority elevations of 400–600m. Next, we joined trail attribute information from the NYSDEC trails database to filter and select 50 trails that were classified as foot trails or multipurpose trails on which bikes and mechanized access were forbidden. Among these 50, we selected a final set of 33 (Table 1)

using information from Beier and Larkin (2014) combined with personal consultation with NYSDEC Forest Rangers to ensure that a range of potential human use levels were represented.

Table 1. Study trails in the northern Adirondack Park sampled in 2020-2021.

Trail	Latitude	Longitude	Elev. (m)	Description
ALOJ	44.183	-73.959	667	Adirondack Loj main trail
AMPS	44.250	-74.237	497	Ampersand Mtn trail
BAKE	44.331	-74.112	546	Baker Mtn trail
BPND	44.435	-74.299	512	Black Pond trail, Paul Smith's VIC
CASC	44.217	-73.885	720	Cascade Mtn trail
CATA	44.446	-73.880	520	Catamount Mtn trail
CHUB	44.260	-74.103	589	Northville Placid trail along Chubb River
CLEM	44.302	73.767	400	Clements Pond trail
CONE	44.101	-74.527	567	Coney Mtn trail
COPP	44.334	-73.897	575	Copperas Ponds trail
CROW	44.264	-73.734	705	Trail to Big and Little Crow
DEER*	44.261	-74.353	516	Deer Pond loop trail
GIAN	44.210	-73.679	406	Giant Mtn trail
GOOD	44.117	-74.534	505	Goodman Mtn trail
GULF	44.259	-73.731	697	Gulf Brook trail
HAYS	44.295	-74.051	542	Haystack Mtn trail
HBRK	44.484	-74.276	503	Hays Brook trail
HU9N	44.213	-73.720	596	Hurricane Mtn trail from Route 9N
HURE	44.236	-73.687	679	Hurricane Mtn trail from East trailhead
INDI	44.184	-73.968	673	Indian Pass trail from AMR
JAYM	44.316	-73.717	501	Jay Mtn trail
JBRK	44.187	-73.819	503	John's Brook trail from Garden trailhead
LOJO	44.178	-73.967	686	Adirondack Loj old trailhead
MOOS	44.373	-74.087	481	Moose Pond trail
NOON	44.147	-73.772	467	Noonmark Mtn trail
PITC	44.243	-73.849	622	Pitchoff Mtn trail
RAMR	44.148	-73.767	469	Round Mtn trail, Adirondack Mountain Reserve
ROOS	44.185	-73.791	327	Roostercomb Mtn trail
RPND	44.129	-73.729	526	Round Pond trail
SILV	44.514	-73.849	537	Silver Lake Mtn trail
STRE	44.428	-74.299	509	St. Regis Mtn trail
WINN	44.314	-74.011	648	Jackrabbit trail from Whiteface Inn Rd
WMTN	44.393	-73.840	435	Whiteface Mtn trail

Mammals were sampled using Bushnell trail cameras (Trophy Cam) deployed in pairs at 2 locations on each trail. A pair of cameras was placed at 250m from the trail register and a second pair at 750m. At each of these locations, one camera (camera A) was positioned to record wildlife activity on the trail and mounted on a tree approximately 3-5m from the trail of interest at a height of 1m and at a 45° angle to the travel path. Shaded locations were used when available and cameras were pointed slightly downward to maximize the detection of a range of mammalian body sizes. A second camera (camera B) was deployed in the vicinity of

the trail-facing camera but positioned to record off-trail wildlife activity. Nearby game trails or obvious movement pathways were utilized where possible.

Cameras were set to capture a series of 3 images with a 10 second interval between captures. All cameras were deployed for a period of 10 days per sample site and then rotated to a new location. The start of our sampling season in 2020 was delayed by the Covid-19 pandemic and the period of camera deployment in 2020 ranged from 23 July to 20 October. In 2021, all cameras were deployed between 16 June and 8 August.

Trail Use

In addition to detections of humans from trail cameras, we employed several means to gauge levels of use recreational use on study trails (Table 2). Trail registers are used by the NYSDEC throughout the Adirondacks at a high proportion of trailheads and some boat launches. Information recorded from sign-ins and sign-outs provides critical data for NYS Forest Rangers and other search and rescue personnel in the event of missing or delayed individuals. Though not all users sign the register book, at least one past study has found that the proportion of trail users who do register is high (Dawson 2012) and trail register data have also provided important information on recreational use patterns to inform management (Beier and Larkin 2014). From the register books located at study trailheads we recorded the (1) first date in the register book, which provided information on the duration of time elapsed since the book was last replaced, (2) number of sign-ins on the most recent Saturday, and (3) number of sign-ins during the prior 2-week period. We also conducted a 1-hour long tally of individuals observed entering the trail between 10 – 11 am on days field staff were present at trailheads for the purpose of collecting social survey data. We repeated these measures each time we visited a trailhead. Some trailheads were visited more often than others in order to meet sample size requirements for the social survey component of the broader project. We calculated the average counts across all visits for each of the trail register methods and the 1-hour tally to gauge use. We compared mean detections of humans on our cameras to the estimated use measured with alternate count methods at trailheads to determine the degree of agreement among methods for gauging recreational use levels. We also used cluster analysis (K means) to group trails into broad categories of low, medium, and high use based on detections of humans on cameras.

Habitat characteristics

We recorded several habitat characteristics associated with study trails to account for variability in mammal detections that result from habitat rather than any influence of human recreational use. For each camera location, we recorded elevation (elev), distance to road (distroad), and distance to water (distwater). Trail sections were originally selected to minimize habitat variability and consisted predominantly of northern hardwood and conifer vegetation. However, to account for the influence of large-scale habitat characteristics on richness and abundance of mammals detected, we also summarized habitat diversity (nohabs),

Table 2. Recreational use data collected from 33 trails in the Adirondack Park in 2020-2021 depicting total number of visits made to trailhead, days since trail register book replacement, number of sign-ins on most recent Saturday, number of sign-ins in previous 2-week period, number of people observed in 10-11am tally, number of detections of humans on cameras, and trail use class as determined by K-means clustering of camera detections. Visits are totals made in 2020-2021, all other values are averages between the two study years.

Trail	Visits	Days since replacement	Sign-ins Saturday	Sign-ins 2 weeks	Hour-tally	Camera detections	Use class
ALOJ	9	28	184	525	30	1127	High
AMPS	9	125	24	217	15	780	High
BAKE	7	75	21	183	26	1089	High
BPND	6	331	1	12	1	110	Low
CASC	10	40	64	397	20	1239	High
CATA	12	125	10	105	3	216	Low
CHUB	14	273	6	52	1	114	Low
CLEM	6	288	1	17	1	72	Low
CONE	12	141	21	147	12	1020	High
COPP	11	197	6	70	5	553	Med
CROW	9	196	11	115	5	358	Med
DEER*	7				2	108	Low
GIAN	12	136	9	80	6	332	Med
GOOD	10	125	15	157	8	318	Med
GULF	11	184	20	104	5	413	Med
HAYS	13	114	23	109	10	357	Med
HBRK	7	303	2	10	1	32	Low
HU9N	12	81	20	177	6	487	Med
HURE	6	474	3	18	1	51	Low
INDI	11	122	21	211	12	464	Med
JAYM	10	137	11	67	4	281	Low
JBRK	8	28	43	325	9	660	Med
LOJO	11	372	5	61	2	101	Low
MOOS	10	134	5	57	4	247	Low
NOON	11	265	4	42	3	144	Low
PITC	11	168	2	17	1	30	Low
RAMR	11	353	2	20	1	19	Low
ROOS	11	61	17	236	13	437	Med
RPND	5	138	10	55	1	202	Low
SILV	9	272	9	72	7	411	Med
STRE	11	89	26	268	14	546	Med
WINN	11	237	9	78	6	140	Low
WMTN	10	151	9	94	2	214	Low

* Deer Pond did not have a trail register.

encompassing large forest block size (lgforblk), and ecological integrity (IEI) surrounding each trail. To do so, we buffered the trail section and camera locations by 500m and summarized the number of habitats present according to ecosystem types mapped by Ferree and Anderson

(2013). Within the same polygons, we summarized a mean index of ecological integrity. McGarigal et al. (2018) mapped a landscape index of ecological integrity (IEI) for all terrestrial and aquatic ecosystem types in the Northeast, defining ecological integrity as the ability of an area to support native biodiversity and the ecosystem processes necessary to sustain it over the long term. This comprehensive index combined multiple intactness (i.e. stressor) and resilience metrics and has demonstrated utility and been partially validated in terrestrial and aquatic settings (McGarigal et al. 2013, McGarigal et al. 2018). Last, we recorded large forest block size from a map developed to aid land use planning processes in New York State in which blocks are designated as regionally significant, locally important, or stepping stone forests (NALCC 2016).

Statistical Analysis

We reviewed all photos from trail cameras using IrfanView, a freely-available image viewer, editor, and organizer, which we found to be easier and less time consuming than available camera photo tagging software with regard to the characteristics of our dataset. For each folder of images from each camera, we copied the address of the folder in Windows Explorer and pasted it into a web browser. This process created a file list containing an image number, size, timestamp, and name for each photo which we then pasted back into an excel file, resulting in a list of all photos and their timestamps for each camera. We set the parameters for thumbnail view in IrfanView to display 3 photos at a time at a large enough size and resolution to allow for species identification. This allowed for quick review of each set of 3 photos captured at a time by each camera and allowed for scrolling relatively rapidly through sets of photos that were very obviously human beings on trails. We retained all images and recorded all wildlife to species level where possible. Wildlife that could not be identified to species level definitively were recorded as unknown mammals and removed from analysis. We labeled photos of our trail crew setting up and taking down cameras as separate from detections of other humans on the trail. The majority of detections of non-human mammals were of only one individual though we did note when more than one individual animal was present for all non-human mammals. We did not count individual humans in each photo but did record all humans that were accompanied by one or more dogs or other domestic animals.

We split the 10-day camera deployment into 2 separate 5-day survey periods for the purpose of analysis and compiled counts of each species within the first and second survey periods for all 4 cameras at all trail locations. We filtered camera captures to remove those within 2 seconds of other photos for both humans and non-human mammals when compiling counts. We considered a detection to be independent for non-human mammals if it was separated by other detections of the same species by at least 30 minutes (O'Connor et al. 2017). We did not apply the same 30-minute threshold for detection of humans and dogs since these species far outnumbered other mammals captured on camera and the majority continued immediately past the camera without pausing. To maximize our statistical power for non-human mammals and to investigate the potential influence of recreational use intensity on mammal community composition, we summed the non-human or domestic animal detections into functional groupings consisting of sensitivity (human-sensitive, human-adapted), diet (carnivore,

herbivore, omnivore), body size (small, medium, large), and home range size (small and large) as per Farr et al. (2017; Table 3).

Table 3. Mammals detected on cameras from trails and functional groups used for analysis.

Species	Scientific name	Detections*	Functional groups
Snowshoe hare	<i>Lepus americanus</i>	21	S, H, SB, SHR
Coyote	<i>Canis latrans</i>	49	S, O, MB, LHR
Gray fox	<i>Urocyon cinereoargenteus</i>	16	S, C, MB, SHR
Red fox	<i>Vulpes vulpes</i>	22	A, O, MB, LHR
Bobcat	<i>Lynx rufus</i>	6	S, C, MB, SHR
Weasel	<i>Mustela</i> spp.	1	S, C, SB, SHR
Fisher	<i>Martes pennanti</i>	3	S, C, MB, LHR
American marten	<i>Martes americana</i>	5	S, C, SB, LHR
Northern raccoon	<i>Procyon lotor</i>	8	A, O, MB, SHR
Black bear	<i>Ursus americanus</i>	12	A, O, LB, LHR
Mouse	<i>Peromyscus</i> spp.	2	A, O, SB, SHR
N. Am. Porcupine	<i>Erethizon dorsatum</i>	4	S, H, MB, SHR
Eastern chipmunk	<i>Tamias striatus</i>	60	A, H, SB, SHR
Eastern gray squirrel	<i>Sciurus carolinensis</i>	3	A, O, SB, SHR
Red squirrel	<i>Tamiasciurus hudsonicus</i>	77	A, H, SB, SHR
Flying squirrel	<i>Glaucomys</i> spp.	9	S, H, SB, SHR
Woodland jumping mouse	<i>Napaeozapus insignis</i>	2	S, O, SB, SHR
Moose	<i>Alces alces</i>	1	S, H, LB, LHR
White-tailed deer	<i>Odocoileus virginianus</i>	162	A, H, LB, LHR
Horse	<i>Equus caballus</i>	5	-
Domestic cat	<i>Felis catus</i>	2	-
Domestic dog	<i>Canis familiaris</i>	2,404	-
Human	<i>Homo sapiens</i>	25,325	-

* Detections are summed across both years and all cameras (on- and off-trail; n = 264). Detections of non-human mammals are corrected such that values approximate numbers of individual animals; detections of humans are not (Methods). Individual humans in photos were not counted, though most photos with humans contained more than one person.

Our data were too sparse for non-human mammals to allow for the use of N-mixture models which estimate abundance while accounting for detection probability (Royle 2004). Instead, we treated counts of wild mammals as presence or absence and used occupancy models (MacKenzie et al. 2006) to determine the influence of recreational use and habitat characteristics on mammalian occupancy patterns. Counts of species that do not account for the variability in detection probability that can arise from a variety of sources (e.g., weather, date, time of day, observer, survey method) are known to be biased (MacKenzie et al. 2006). Occupancy modeling accounts for the detection process and uses a logit link and a maximum likelihood approach to linearize the relationships among independent covariates and the probability of occupancy (Ψ) and detection (p), given the species is present (MacKenzie et al. 2006). Again, due to the relatively sparse number of detections of wild mammals in comparison to humans and dogs, we relaxed the closed population assumption of the single-season occupancy model and combined information from 2020 and 2021 to model detections

across 4 possible survey periods, two 5-day camera trapping periods in each year. As such, the sampling season was defined to encompass both years and the occupancy estimator is interpreted as the probability of “use” by each functional group rather than probability of occupancy (MacKenzie et al. 2006, Dewan et al. 2009). We conducted all analyses in PRESENCE (Hines 2006) and used a 2-step process, first modeling detection while holding the occupancy estimator constant, and subsequently modeling occupancy/use while incorporating the best predictors of detection probability for each group (Table 4).

Table 4. Single-season models applied to test effects of human and dog use of trails on mammal community structure. All models were applied to each of 10 functional groups; simultaneous modeling of detection incorporated best predictors for each mammal group.

Occupancy Model Parameterization
$\Psi(\text{humans}), p(\text{detection})$
$\Psi(\text{humans}, \text{elevation}), p(\text{detection})$
$\Psi(\text{humans}, \text{number of habitats}), p(\text{detection})$
$\Psi(\text{humans}, \text{distance to road}), p(\text{detection})$
$\Psi(\text{humans}, \text{distance to water}), p(\text{detection})$
$\Psi(\text{humans}, \text{large forest block size}), p(\text{detection})$
$\Psi(\text{humans}, \text{index of ecological integrity}), p(\text{detection})$
$\Psi(\text{dogs}), p(\text{detection})$
$\Psi(\text{dogs}, \text{elevation}), p(\text{detection})$
$\Psi(\text{dogs}, \text{number of habitats}), p(\text{detection})$
$\Psi(\text{dogs}, \text{distance to road}), p(\text{detection})$
$\Psi(\text{dogs}, \text{distance to water}), p(\text{detection})$
$\Psi(\text{dogs}, \text{large forest block size}), p(\text{detection})$
$\Psi(\text{dogs}, \text{index of ecological integrity}), p(\text{detection})$

For each functional group, we modeled the influence of year alone and in combination with survey-specific characteristics of date, total precipitation, and mean temperature during the survey period, as well as camera placement, and mean number of detections of humans, all of which were hypothesized to have a potential influence on detectability of mammals. Camera placement was generally good, but in a very small number of cases, imperfect placement resulted in impeded camera view because of vegetation overhanging the trail that may have precluded detection of smaller animals. We therefore modeled the influence of camera placement both in terms of on vs off trail and in terms of deployment (good vs impeded). It is possible that human recreational use of trails affects not only mammal use of trails but also our ability to detect mammals on trails and, as such, mean detections of humans were considered for their influence on both detection and occupancy probability. After identifying the best predictors for the detection process, we used them in combination with site-covariates to model the probability of use for each mammal functional group on our study trails. We were primarily interested in the degree to which human use of trails influences mammal habitat use and, as such, we modeled humans alone and in combination with each of the individual habitat covariates including distance to road, distance to water, habitat diversity, large forest block size, and mean ecological integrity as predictors of the occupancy process. Because it is also

possible that dogs accompanying humans influence mammal use of trails, we also modeled dogs alone and in combination with site characteristics for a total of 14 possible models applied to each functional group (Table 4). We used Akaike's Information Criterion (AIC) to identify best models of mammal habitat use ($\Delta AIC \leq 2$, Burnham and Anderson 2002) and plots of mean human and dog detections per camera against predicted psi (Ψ) values to investigate the direction and effect size for any detected influence on mammal community characteristics.

Birds

Survey Method

Data for this portion of the project came from the Mountain Birdwatch Program (MBW). Mountain Birdwatch (MBW, Hill and Castriotta 2021) is a long-term high elevation bird monitoring program of the Vermont Center for Ecostudies (VCE) that has monitored the status of alpine birds since 2000. MBW is a citizen science program in which participants adopt one of the routes available and conduct counts of songbirds and red squirrels using an established point count protocol (VCE 2022) on mountaintops throughout the Northeast. This protocol consists of a timed count period during which all visual or aural detections of a set of target species are recorded, with 5 different stops along each mountain summit serving as spatial replicates. One of the primary focal species of the program is Bicknell's thrush, the Northeast's only endemic songbird and a species with very limited range in both the breeding and wintering seasons. The geographic coverage of the MBW program matches the approximate range of the Bicknell's thrush within the US and includes routes on 130 summits in 4 states stretching from the Catskills to northern Maine. The protocol and set of study mountains underwent a reevaluation and update after the first decade of the program and therefore the data from 2000-2010 are not fully comparable with the data collected since 2011. Our original intent was to make use of MBW 1.0 (VCE et al. 2015) data because during that period, project participants were encouraged to record detections of all species if they had sufficient skill to do so, which would allow for a more comprehensive analysis of the potential impact of recreational use intensity on alpine bird community structure. We found, however, that no reliable source of trail use data could be found for the 2000-2010 period. In the more recent MBW protocol, participants are not asked to monitor all species, but the potential target list has increased from the 5 original species to 10 songbirds in addition to red squirrel. We compared the set of peaks included in MBW 2.0 (VCE 2022) to peaks for which there were known or potential sources of trail use data available including Beier and Larkin (2014). In this case, again however, the number of mountain summits for which both bird and reliable trail use information were available was extremely low. As such, we opted to limit our analysis to MBW data from 2021 only and make use of a novel source of recreational use data.

Trail Use

Though trail registers are present at most Adirondack trailheads, their original purpose was search and rescue rather than monitoring of trail use and these paper records are seldom digitized. We explored Strava data, an alternate source of recreational use information which

spans the extent of the entire MBW program and increased the number of sites we could include in a comparison of alpine bird data with potential trail use intensity. The Strava heat map (Strava 2022) is an online map in which the accumulated tracks of Strava users are represented across the globe. Strava was originally used primarily by the biking community but has grown to encompass numerous forms of recreation and is employed by an ever-growing user community both to document personal trips and to search for potential new destinations. Because the purpose of the Strava heat map is primarily for recreational users to view and explore routes online, data are challenging to obtain for analytical use, though some types of Strava data have been purchased and used in recreation studies (Muskawa and Selala 2016, Sun and Mobasheri 2017, Sun et al. 2017). Given the broad spatial coverage of the heatmap and the lack of alternative sources of recreational use data on MBW summits, we employed a qualitative approach to assess broad categories of use and compare them to bird data.

The Strava heatmap represents “heat” made by aggregated public activities over the last year and, as such, we limited our analysis to 2021, the most recent year for which MBW data were available at the time of this analysis. Coordinates of each MBW sample location across the 130 northeast summits were imported into Google Earth. We then used a side-by-side comparison of Google Earth and the Strava heatmap to locate all routes and visually assess them. We set the Strava heatmap to be displayed in red with a hybrid image underlay and 80% heat opacity and displayed only foot-based activity. With these settings, areas of high use appear as thick red lines and areas of low use are blue (Figure 1). Areas where use falls somewhere in between are tracks in which both red and blue hues are mixed. We used these relatively simple distinctions to sort MBW routes into broad categories of low (blue), medium (mixed red and blue), and high (thick red) use (Table 5).

Figure 1. Strava Global Heatmap example of Heart Lake area near Lake Placid, Adirondack Park, NY.



Statistical Analysis

We downloaded raw MBW 2.0 data from the KNB online data repository and filtered it to select count information from 2021 only. We summarized raw counts of the 10 target bird species and red squirrel (*Tamiasciurus hudsonicus*) across count periods and across sample locations, resulting in raw, route level sums for each species. Target bird species for MBW 2.0 include yellow-bellied flycatcher (*Empidonax flaviventris*), winter wren (*Troglodytes troglodytes*), black-capped chickadee (*Poecile atricapillus*), boreal chickadee (*Parus hudsonicus*), Bicknell's thrush, Swainson's thrush (*Catharus ustulatus*), hermit thrush (*Catharus guttatus*), fox sparrow (*Passerella iliaca*), white-throated sparrow (*Zonotrichia albicollis*), and blackpoll warbler (*Setophaga striata*). Though detection probability of birds and other animals are known to be influenced by survey-specific conditions including time, date, temperature, and observer (MacKenzie et al. 2006), a full occupancy analysis of this dataset was beyond the scope of this project given that the recreational use data to which they were to be compared was somewhat subjective and associated with its own set of limitations. MBW data are regularly analyzed and corrected for detection and elevation and these route-level abundance estimates should be used in any future analyses. We have requested route-level abundance estimates from MBW and have not yet received a reply. Nevertheless, we compared the available raw counts of each bird species among low, medium, and high use sites using analysis of variance with elevation included as a covariate. Analyses were conducted in Systat 12.

Results

Recreational Use

Our trail cameras captured a total of 167,093 photos and the majority of photos in all locations were of humans using the trail. For several reasons, human counts reported here should be interpreted as number of detections of humans, which may mean one or more individuals. We did not count individual humans on trail camera photos although, in our observation, most photos with humans had more than one person in them and these numbers may therefore be lower than the number of actual users on the trail. Similarly, we did not make any attempt to identify individuals and, to the extent possible, placed cameras such that faces were not captured. We also did not apply a time filter to the photos with humans other than to eliminate those occurring within 2 seconds of each other which reflected the 3 shots each camera was programmed to take. The majority of people observed on trails traveled directly past the camera without stopping, though on occasion a group would stop in front of the camera for a period of time. Though a more thorough analysis of these data could be made in an attempt to count individuals, the time required would be extensive and we feel that numbers of detections are at least as valuable an index as other means of assessing recreational trail use intensity.

We compared detections of humans on trails to each of the other indices we used to gauge use at trailheads (Table 2). Because we perceived a higher use of trails in 2020 and, at the same time, a hesitation among users to sign in to register books because of the Covid pandemic, we

Table 5. Mountain Birdwatch 2.0 routes in ME, NH, VT, and NY (Adirondacks NYA and Catskills NYC) and use classes assigned to them by visual estimation from Strava Global Heatmap foot-based activity data.

Name	Rt #	Region	Use	Name	Rt #	Region	Use
Abraham	128	ME	High	Big Slide E	60	NYA	High
Baldpate	107	ME	High	Big Slide S	151	NYA	Med
Caribou Valley	89	ME	Med	Dix Mt S	68	NYA	High
Katahdin	76	ME	High	Hedgehog	154	NYA	High
Katadhin South	1	ME	High	Hopkins Mt S	136	NYA	Low
Kibby	111	ME	Low	Hurricane	156	NYA	High
Lone Mt SW	101	ME	Low	Jay Mt	50	NYA	High
Old Blue Mt	137	ME	Med	Loon Lake Mt	20	NYA	Med
Sabbath Day Pond	118	ME	Low	Lower Wolfjaw	122	NYA	High
Saddleback Jr	126	ME	Med	Lyon Mt	48	NYA	High
Speck Pond	77	ME	Med	Morgan Mt	134	NYA	Low
Sugarloaf ME	69	ME	Med	Porter	161	NYA	Med
Bunnell Notch	91	NH	High	Saddleback E	132	NYA	High
Chocorua	127	NH	High	Soda Range	21	NYA	Med
Crescent	112	NH	Med	Whiteface NY	165	NYA	Med
Eisenhower	90	NH	Med	Hunter N	146	NYC	High
Hancock	92	NH	Low	Hunter S	124	NYC	High
Huntington Ravine	6	NH	Low	Hunter W	149	NYC	High
Isolation	119	NH	Med	Plateau Mt N	147	NYC	High
Jefferson Ravine	79	NH	Low	Plateau Mt S	148	NYC	High
Madison E	131	NH	High	Slide	150	NYC	High
Magalloway	73	NH	Med	Battell N	11	VT	Med
Moosilauke	44	NH	Med	Battell S	43	VT	Med
Moosilauke N	30	NH	Low	Big Jay	27	VT	Med
Mount Blue E	115	NH	High	Bolton E	93	VT	Low
Mount Martha	108	NH	Med	Bolton Mt	104	VT	High
Nelson Crag	117	NH	Low	Bolton SW	170	VT	High
North Peak	96	NH	High	Bread Loaf Mt	171	VT	Med
Osceola	47	NH	High	Burnt Mt	166	VT	Low
Passaconaway	13	NH	High	Cleveland	87	VT	Med
Pierce E	143	NH	Low	Dorset Peak	75	VT	Med
Pierce W	25	NH	High	East Mt	7	VT	Low
Resolution	81	NH	Low	Equinox	147A	VT	Med
Sandwich Dome	66A	NH	Low	Ethan Allen	152	VT	Med
Sleepers	24	NH	Med	Gillespie Peak	139	VT	Med
South Twin	51	NH	High	Gilpin	146A	VT	Med
South Twin W	62	NH	Low	Hunger	54	VT	Med
Stairs	18	NH	High	Killington N	157	VT	High
Success	84	NH	High	Mansfield	155	VT	Med
Tremont	39	NH	Med	Mansfield Adams Apple	172	VT	Low
Washington W	102	NH	High	Mansfield Nose	169	VT	High
Whitewall N	42	NH	Low	Stark S	3	VT	High
Wolf	22	NH	Med	Styles Peak	28	VT	High
Algonquin S	158	NYA	Med	Worcester	19	VT	Med
Armstrong	167	NYA	High	Worcester	133	VT	Med
Big Slide	145	NYA	Med				

compared camera data to other indices separately within each year. There was generally high agreement between 2021 and 2022 for all indices ranging from the highest between camera detections ($R = 0.83$), to tallied individuals ($R = 0.76$), sign-ins during the previous 2 weeks ($R = 0.72$), sign-ins on the previous Saturday ($R = 0.70$), and days since the trail register was replaced ($R = 0.54$). According to all indices, use was higher in 2020 than 2021, consistent with observations of high recreation rates during the initial year of the pandemic when many other activities were impossible.

Among these measures, the days since the trail register book was replaced is probably the least accurate index of use. Although the books can fill up very quickly and it is not uncommon to encounter a book with no spaces left for sign-ins, the rate at which they are replaced varies for reasons other than use alone and may include location of the trailhead and degree to which the associated forest ranger has time available outside of other duties to replace register books. Within years, there was better agreement between camera detections and other trail use indices in 2021 than there was in 2020, which may reflect the hesitation on the part of users to sign in during the height of the Covid. Many people were observed to be hiking with masks in 2020 and reported to our field technicians that they did not want to touch the pencil or pen in the trail register box and therefore did not sign in. Nonetheless, there was still fairly good agreement between camera detections and other use indices in both years, with the exception of the days since the trail register book was replaced (Figure 2). In 2020, correlations coefficients between camera detections and additional use measures ranged from 0.57 for sign-ins during the prior 2 weeks to 0.63 for both sign-ins on the prior Saturday and the one-hour tally. In 2021, the correlation coefficient between camera detections and other indices was 0.81 for the one-hour tally and the sign-ins during the prior 2 weeks and was 0.84 between camera detections and sign-ins on the most recent Saturday.

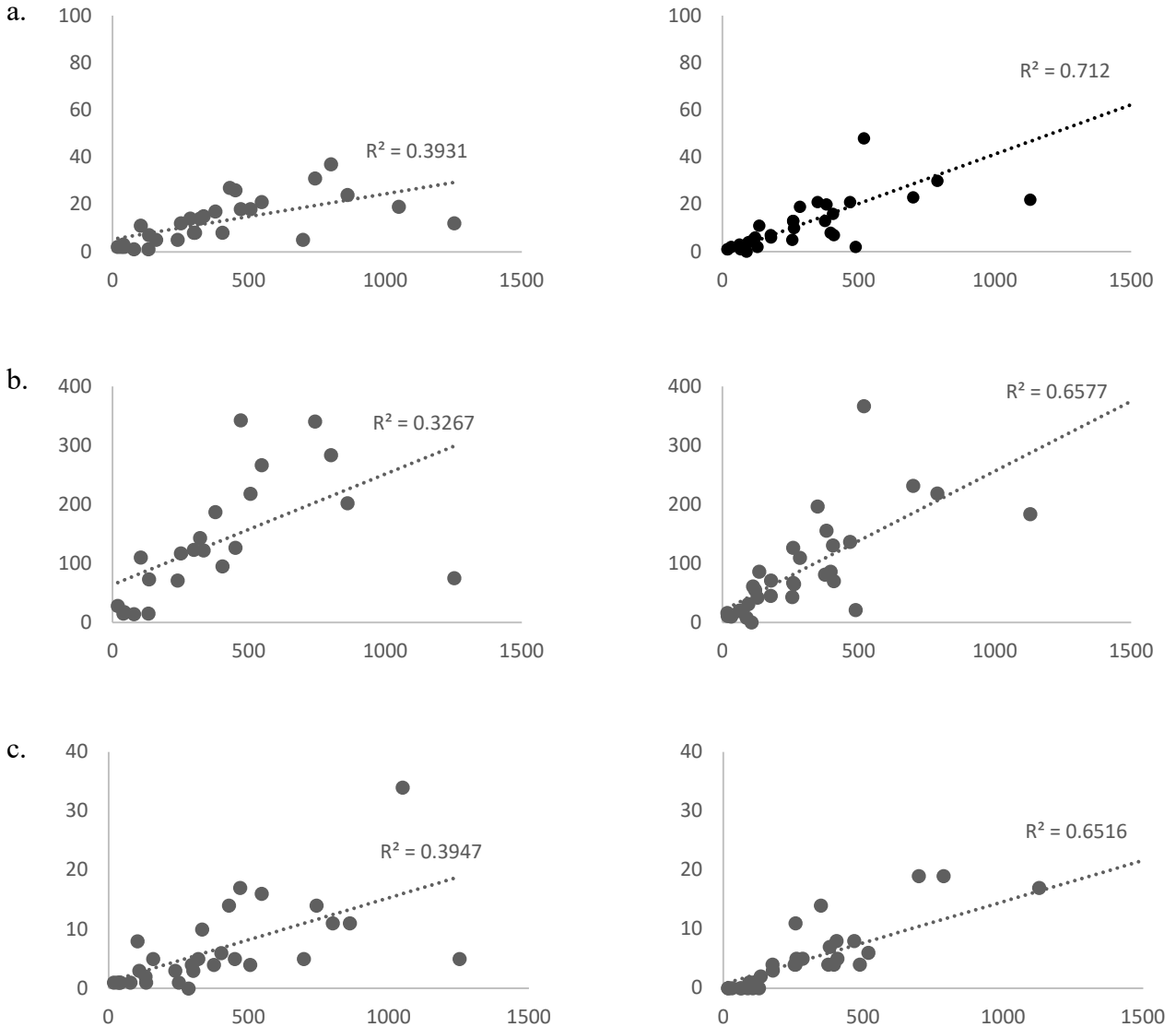
Agreement between the sets of cameras on each trail was also high. The correlation between numbers of detections of humans on near (250m) and far (750m) cameras was 0.84 in 2020 and 0.92 in 2021. In both years, detections at far cameras were approximately 15% lower than those at near cameras, which may reflect the proportion of hikers who turn around for whatever reason within the first 750m of the trail.

Mammals

General patterns

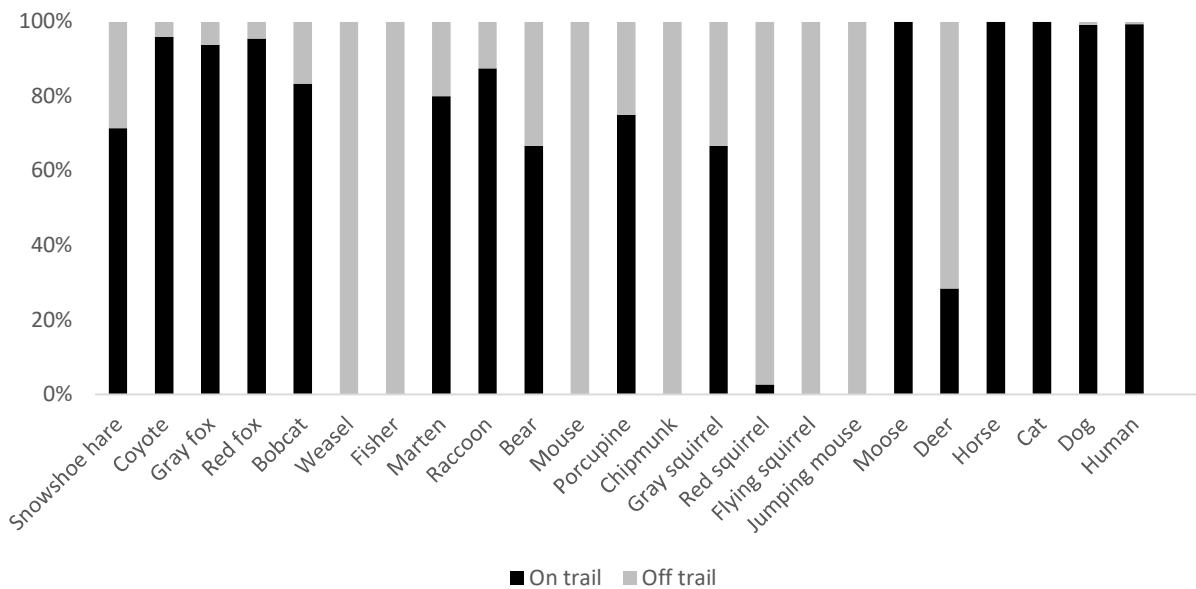
We detected 19 native mammals, with highest occurrence for white-tailed deer, red squirrel, Eastern chipmunk, and coyote (Table 3). We also detected domestic mammals, the majority of which were dogs, but humans were also accompanied by horses on one trail, and by domestic cats (confined by a leash or backpack) on two occasions. Mammals were detected on both on- and off-trail cameras. Larger mammals were more often found on trails, while several rodents were most often detected on off-trail cameras in association with nearby downed logs or stumps. Detections of domestic mammals were nearly always on trails (Figure 3).

Figure 2. Agreement between camera detections of humans (x axis) and number of trail register sign-ins on most recent Saturday (a), number of sign-ins during previous 2-week period (b), and humans counted in a 1-hour tally from 10-11am at 33 trailheads in the Adirondack Park in 2020 (left column) and 2021 (right column).



Detections of humans occurred at all hours but were concentrated in the daylight hours and primarily between 10am and 4pm. Detections of native mammals, by contrast, were more common in the early morning and late evening. This temporal separation was more pronounced in 2020 than in 2021 (Figure 4). We did not explicitly record whether dogs were leashed or not, although the majority appeared to be. The proportion of hikers accompanied by dogs was approximately 11% in 2020 and 8% in 2021. Though these are likely to be overestimates of leash use, if we make the broad assumption that dogs captured in photos alone were off-leash and those captured in the same frame as humans were leashed, the proportion leashed was ~86% in 2020 and ~80% in 2021.

Figure 3. Proportion of mammal detections from on- and off-trail cameras from 33 trails in the Adirondack Park, 2020-2021.



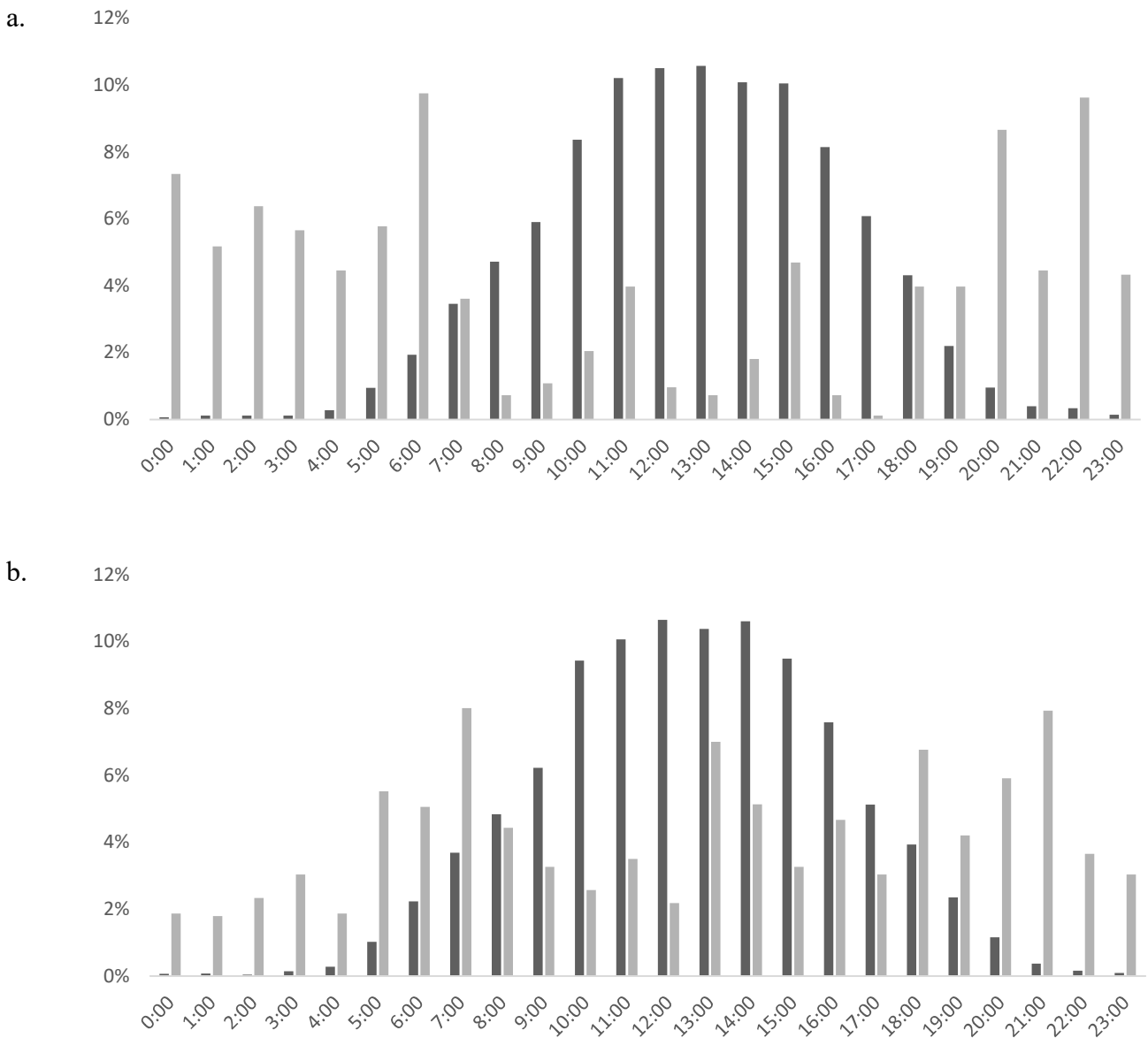
Effect of recreational use intensity

For most mammal functional groups, a range of 1-4 models could be identified as best models ($\Delta AIC \leq 2$) of mammal trail use in response to human use and other characteristics (Table 6). The exceptions were mammals of medium body size and those with small home ranges, for which no models clearly rose to the top as the best explanations of use for these groups. We used model averaging across all models to calculate predicted habitat use across individual trails and compared it to detections of humans on the same trails to examine the strength and direction of any influence of recreational use intensity on each mammal group. We found that the effect was most consistent, and negative, for human-adapted, herbivore, omnivore, and small-bodied species (Figure 5). The effect of humans on trails was less consistent for other functional guilds. Additional trail characteristics also influenced probability of use by mammals. The strongest effect by cumulative model weight was elevation (2.7), followed by ecological integrity (1.6), habitat diversity (1.3), distance to roads (1.3) and water (1.1), and large forest block size (0.8), though the effects of these characteristics were mixed among functional groups. Similarly, cumulative model weights suggest that mammals are more likely responding to overall human use of trails (5.7), rather presence of dogs (4.3) though most dogs in our observation appeared to be leashed.

Birds

Of the 130 total Mountain Birdwatch Routes across the Northeast, 101 were surveyed in 2021 and provided information against which to compare recreational use. This set was further reduced to 91 routes when we removed those for which the Strava global heatmap showed no

Figure 4. Proportions of detections by time of day for humans (black) and native mammals (gray) in 2020 (a) and 2021 (b) from cameras on 33 trails in the Adirondack Park, 2020-2021.



data. It is likely that this means that these routes have low use, but we removed them from analysis given our uncertainty. Eight of 10 species monitored by Mountain Birdwatch had highest raw counts on low use summits and 3 showed a consistent pattern of declining abundance with increasing use while others had highest abundance on low use peaks but variable abundance on medium and high use peaks. Only the two sparrow species had highest counts on the highest use peaks (Figure 6). Mean counts reflect those that have been adjusted for any effect of elevation, which was included as a covariate in our analysis of variance. These differences were statistically significant for boreal chickadee ($P < 0.005$) and for yellow-bellied flycatcher at an alpha level of 0.1 ($P < 0.073$).

Table 6. Model selection results from single-season occupancy models to assess effect of recreational trail use on habitat use by mammalian functional groups. Only the results of top models ($\Delta AIC \leq 2$) are shown.

Group	Model	*AIC	ΔAIC	Wt	Likel	Par	-2LogL	
Adapted	$\Psi(\text{humans, elev}), p(\text{year, placement})$	598.55	0	0.27	1	6	586.55	
	$\Psi(\text{dogs, elev}), p(\text{year, placement})$	600.04	1.49	0.13	0.47	6	588.04	
Sensitive	$\Psi(\text{humans, distroad}), p(\text{year, offtrl})$	383.05	0	0.20	1	6	371.05	
	$\Psi(\text{dogs, distroad}), p(\text{year, offtrl})$	383.73	0.68	0.14	0.71	6	371.73	
	$\Psi(\text{humans}), p(\text{year, offtrl})$	384.08	1.03	0.12	0.60	5	374.08	
Carnivore	$\Psi(\text{humans}), p(\text{year, offtrl})$	384.7	1.65	0.09	0.44	5	374.7	
	$\Psi(\text{dogs, IEI}), p(\text{year, date, offtrl})$	187.54	0	0.30	1	7	173.54	
	$\Psi(\text{humans, IEI}), p(\text{year, date, offtrl})$	187.79	0.25	0.27	0.88	7	173.79	
	$\Psi(\text{dogs, distwater}), p(\text{year, date, offtrl})$	188.64	1.1	0.17	0.58	7	174.64	
Herbivore	$\Psi(\text{humans, distwater}), p(\text{year, date, offtrl})$	188.8	1.26	0.16	0.53	7	174.8	
	$\Psi(\text{dogs, nohabs}), p(\text{year, offtrl, humans})$	578.94	0	0.50	1	7	564.94	
Omnivore	$\Psi(\text{humans, IEI}), p(\text{year, offtrl})$	413.79	0	0.46	1	6	401.79	
Small	$\Psi(\text{humans, lgforblk}), p(\text{year, offtrl})$	358.1	0	0.17	1	6	346.1	
	$\Psi(\text{humans}), p(\text{year, offtrl})$	358.66	0.56	0.13	0.76	5	348.66	
	$\Psi(\text{humans, distroad}), p(\text{year, offtrl})$	358.7	0.6	0.13	0.74	6	346.7	
	$\Psi(\text{dogs, lgforblk}), p(\text{year, offtrl})$	358.87	0.77	0.12	0.68	6	346.87	
	$\Psi(\text{dogs}), p(\text{year, offtrl})$	359.84	1.74	0.07	0.42	5	349.84	
Medium	$\Psi(\text{humans, distroad}), p(\text{year, offtrl})$	334.79	0	0.12	1	6	322.79	
	$\Psi(\text{humans}), p(\text{year, offtrl})$	334.86	0.07	0.11	0.97	5	324.86	
	$\Psi(\text{humans, distwater}), p(\text{year, offtrl})$	335.14	0.35	0.10	0.84	6	323.14	
	$\Psi(\text{dogs}), p(\text{year, offtrl})$	335.25	0.46	0.09	0.79	5	325.25	
	$\Psi(\text{dogs, distwater}), p(\text{year, offtrl})$	335.46	0.67	0.08	0.72	6	323.46	
	$\Psi(\text{dogs, distroad}), p(\text{year, offtrl})$	335.47	0.68	0.08	0.71	6	323.47	
	$\Psi(\text{humans, IEI}), p(\text{year, offtrl})$	335.64	0.85	0.07	0.65	6	323.64	
	$\Psi(\text{humans, elev}), p(\text{year, offtrl})$	336.04	1.25	0.06	0.53	6	324.04	
	$\Psi(\text{dogs, elev}), p(\text{year, offtrl})$	336.07	1.28	0.06	0.53	6	324.07	
	$\Psi(\text{dogs, IEI}), p(\text{year, offtrl})$	336.07	1.28	0.06	0.53	6	324.07	
	$\Psi(\text{humans, nohabs}), p(\text{year, offtrl})$	336.7	1.91	0.04	0.38	6	324.7	
	$\Psi(\text{humans, lgforblk}), p(\text{year, offtrl})$	336.75	1.96	0.04	0.38	6	324.75	
	Large	$\Psi(\text{dogs, elev}), p(\text{year, placement, humans})$	509.71	0	0.41	1	7	495.71
		Small HR	$\Psi(\text{dogs}), p(\text{year, date, offtrl})$	432.63	0	0.14	1	6
	$\Psi(\text{humans}), p(\text{year, date, offtrl})$		432.78	0.15	0.13	0.93	6	420.78
$\Psi(\text{dogs, lgforblk}), p(\text{year, date, offtrl})$	433.13		0.5	0.11	0.78	7	419.13	
$\Psi(\text{humans, lgforblk}), p(\text{year, date, offtrl})$	433.26		0.63	0.10	0.73	7	419.26	
$\Psi(\text{dogs, distroad}), p(\text{year, date, offtrl})$	433.73		1.1	0.08	0.58	7	419.73	
$\Psi(\text{humans, distroad}), p(\text{year, date, offtrl})$	433.77		1.14	0.08	0.57	7	419.77	
$\Psi(\text{dogs, elev}), p(\text{year, date, offtrl})$	433.97		1.34	0.07	0.51	7	419.97	
$\Psi(\text{humans, elev}), p(\text{year, date, offtrl})$	434.12		1.49	0.06	0.47	7	420.12	
$\Psi(\text{dogs, IEI}), p(\text{year, date, offtrl})$	434.62		1.99	0.05	0.37	7	420.62	
Large HR	$\Psi(\text{humans, elev}), p(\text{year, placement})$		591.42	0	0.58	1	6	579.42
	$\Psi(\text{humans, elev}), p(\text{year, placement})$		592.11	0.69	0.41	0.71	6	580.11
Native	$\Psi(\text{humans, elev}), p(\text{year, placement})$	665.43	0	0.26	1	6	653.43	
	$\Psi(\text{humans, distroad}), p(\text{year, placement})$	666.9	1.47	0.12	0.48	6	654.9	
	$\Psi(\text{humans}), p(\text{year, placement})$	666.97	1.54	0.12	0.46	5	656.97	

* Column headings as: Akaike's information criteria (AIC), change in AIC over prior model (ΔAIC), model weight (Wt), model likelihood (Likel), number of parameters (Par), and -2 Log Likelihood (-2LogL).

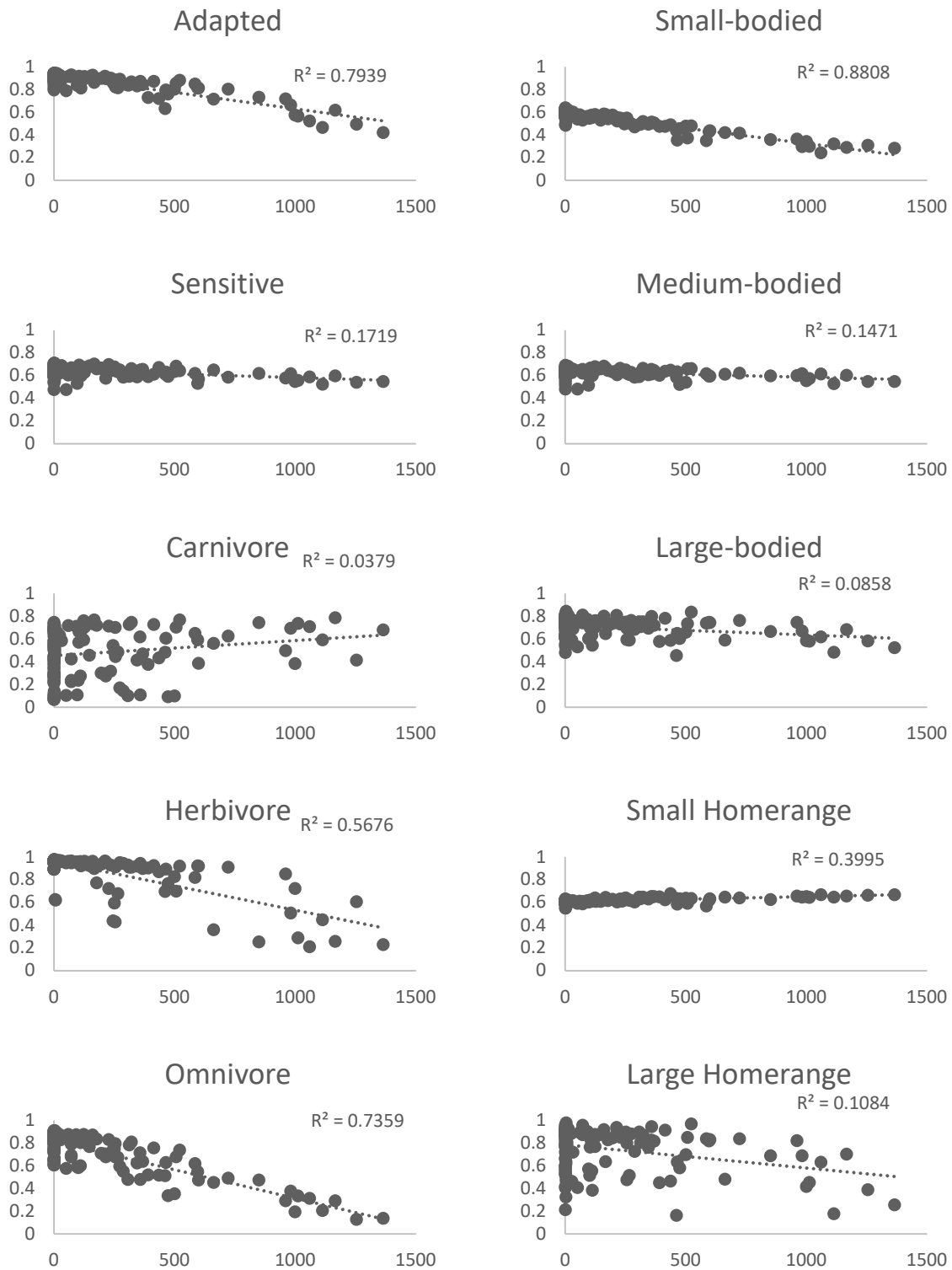
Discussion

The purpose of this project was to investigate bird and mammal community characteristics and their relationship to recreational use intensity on High Peaks trails and alpine areas in the Adirondack Park to help inform future management decisions about trail use and recreation management. The Waterman Fund fosters the spirit of wilderness and strengthens the stewardship and understanding of the alpine areas of Northeastern North America to conserve their ecological, cultural, and recreational values. Wildlife are an integral component of Northeast forest and alpine communities and a large proportion of hikers visiting Adirondack trails report that viewing wildlife is one of the motivations for their doing so. A number of authors have suggested that recreational disturbance to wildlife communities can result in biotic homogenization – a process of ecological simplification in which a large number of diverse and specialized species are replaced by a smaller number of generalists (Miller et al. 1998, DeVictor et al. 2008); our prior efforts in the Adirondack Park have suggested the same (Glennon and Reed 2014). If the presence of high recreational use in some areas is altering the characteristics of bird and mammal communities, this may also be affecting the spirit of wildness that users are experiencing both on the trail and on the summit and in particular those who are seeking the bird and mammal species that are unique in the region and strongly associated with the alpine zone. Our purpose in investigating these patterns on Adirondack trails and summits is to arm managers and decisionmakers with information and management recommendations, and thereby influence the stewardship of these natural communities and contribute toward their protection and capacity for fostering the spirit of wildness for all visitors.

We made use of existing data to investigate the relationship between recreation visitation and the composition and structure of bird and mammal communities in the High Peaks region of the Adirondacks and the broader Northeast. Our camera traps collected more than 100,000 images on 33 trails in the northern Adirondacks, from which we were able to gain an understanding of trail use by humans and other non-human mammals. Human use of trails was higher in 2020 than 2021, most likely due to the Covid-19 pandemic when alternate forms of recreational entertainment were limited. Nonetheless, spatial patterns of use were consistent between the 2 study seasons, with the same trails exhibiting high use in both years.

Based on a prior study also conducted in the High Peaks region of the Adirondacks (Glennon and Reed 2014), we hypothesized that among mammals – native, specialist, smaller-bodied, and rare species would be more sensitive than non-native, generalist, larger-bodied, and widespread species to levels of recreational trail use. Our findings confirm these predictions in several ways and contrast them in others. Native species were more sensitive than non-native species, and small-bodied species were more clearly affected than large-bodied as predicted. We also found, however, that the effect of trail use was clearly negative for human-adapted, herbivorous, and omnivorous species. The effect of humans on trails was less consistent for other functional guilds. Although the effect size was small for most functional groups, for most the effect was negative. No threshold response was observed; rather, in most cases, increasing use of the trail by humans resulted in slowly decreasing probability of use by other mammals.

Figure 5. Effect of human recreational use intensity as measured by camera detections (x-axis) on probability of habitat use for 10 mammalian functional groups in the Adirondack Park, NY.

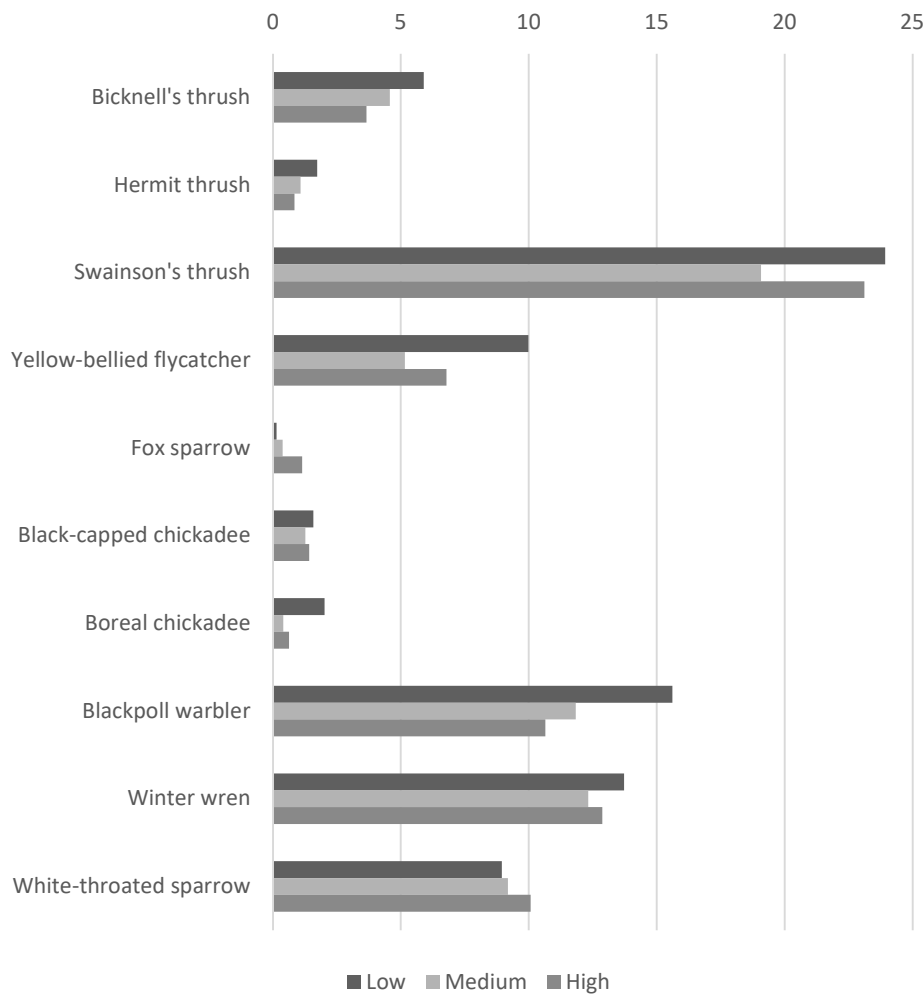


Our statistical power was increased by pooling detections across our 2 study seasons, but still suffered from very low detections of all mammals relative to the number of detections of humans. It is perhaps telling that we had low detections of mammals relative to humans even though cameras were operating around the clock. Although humans were detected at all hours, most human activity occurred during the daylight hours. It is possible that even nocturnal species have altered their behavior patterns to avoid trails with particularly high use, given that mammals are well known to use trails and some species have higher probability of detection on trails than off (Reilly et al. 2017, Kays et al. 2016). The observed temporal separation of human and non-human mammal detections is also illustrative of the displacement effect that may be occurring in some locations. Varying degrees of spatial and temporal displacement of mammals by recreation have been demonstrated for bobcats, coyotes (George and Crooks 2006), mountain lions (Jalkosky et al. 1997), opossum, and striped skunks (Reilly et al. 2017) among other species.

Our investigation of potential recreation effects on alpine bird communities was less robust due to severe limitations in availability of recreational use data for most locations. We increased our sample size by expanding the question to encompass all of the Mountain Birdwatch region and making use of a novel source of user data. Because our methods were largely qualitative however, findings should be interpreted as preliminary at best. We did nonetheless observe that 8 of 10 bird species monitored by MBW had highest raw abundance on peaks with low use, as estimated from Strava heatmap data. Given that the MBW routes are characterized by a relatively uniform habitat type and that elevation was incorporated into our analysis, these preliminary findings appear to warrant additional investigation to determine if recreational use levels are impacting alpine birds. Work in other regions has found that abundance, song occurrence, singing consistency, and predation pressure on subalpine birds can be impacted by recreational intrusion (Gutzwiller and Anderson 1999, Gutzwiller et al. 1997, Gutzwiller et al. 2002). Winter recreation has demonstrated negative impacts to black grouse (*Tetrao tetrix*), a species indicative of treeline ecosystems in the European Alps (Arlettaz et al. 2013).

Our study focused on one aspect of recreation ecology and asked whether levels of trail use have discernable impacts on mammal and bird communities. The recreation literature is large and growing, however, and several researchers have provided critical meta-analysis and overview of the diversity of wildlife impacts resulting from recreation including community level impacts to richness and abundance and individual and population-level impacts such as induced stress, altered flight response distances, reduced reproductive success, and spatial displacement or extirpation (Boyle and Samson 1985, Knight and Cole 1995, Gaines et al. 2003, Sato et al. 2013, Larson et al. 2016, Larson et al. 2019, Dertien et al. 2021).

Figure 6. Counts of 10 high elevation bird species on mountain summits throughout the Northeast with low, medium, and high levels of recreational use.



Recommendations

Drawing upon information from this research and our own past studies and those of other scientists (Larson et al. 2016, Kretser et al. 2019, IVUMC 2016), we recommend consideration of the following management options with respect to the critical challenge of balancing recreational use with maintenance of ecological integrity and wildness in natural systems:

- Consider decisions of whether or not to construct trails to be at least as important as questions of trail location
- Designate trail-free areas within protected areas to ensure maintenance of zones free of human disturbance; consider closing alternate trails when new trails are built
- Include “herd paths” that receive significant use in calculations of trail mileage

- Consider limiting the number of visitors or making use of permit systems in sensitive areas or times of the year
- Consider leash laws and make efforts to restrict human use to trails
- Implement spatial and/or temporal zoning within protected areas to protect priority wildlife species
- Conduct and support ongoing landscape-level and cross-jurisdictional conservation planning and management of recreation and conservation
- Use outreach and education to establish and sustain a collaborative and inclusive culture to support the balance of recreation access and wildlife conservation
- Identify cost-effective means of measuring and modeling spatial and temporal patterns of recreational use
- Implement the Visitor Use Management (VUM) framework as a proactive and adaptive process for managing the characteristics of visitor use and the natural and managerial setting using a variety of strategies and tools to achieve and maintain desired resource conditions and visitor experiences

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