

Does Zoning Winter Recreationists Reduce Recreation Conflict?

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Abstract Parks and protected area managers use zoning to decrease interpersonal conflict between recreationists. Zoning, or segregation, of recreation—often by non-motorized and motorized activity—is designed to limit physical interaction while providing recreation opportunities to both groups. This article investigated the effectiveness of zoning to reduce recreation conflict in the Vail Pass Winter Recreation Area in Colorado, USA. Despite a zoning management system, established groomed travel routes were used by both non-motorized recreationists (backcountry skiers, snowboarders, snowshoers) and motorized recreationists (snowmobilers). We hypothesized that persistent recreation conflict reported by non-motorized recreationists was the result of recreation occurring in areas of mixed non-motorized and motorized use, mostly along groomed routes. We performed a geospatial analysis of recreation [from Global Positioning System (GPS) points, $n = 1,233,449$] in the Vail Pass Winter Recreation Area to identify areas of mixed non-motorized and motorized use. We then surveyed non-motorized recreationists ($n = 199$) to test whether reported conflict is higher for respondents who traveled in areas of mixed-use, compared with respondents traveling outside areas of mixed-use. Results from the geospatial analysis showed that only 0.7 % of the Vail Pass

Winter Recreation Area contained recreation from both groups, however that area contained 14.8 % of all non-motorized recreation and 49.1 % of all motorized recreation. Survey analysis results showed higher interpersonal conflict for all five standard conflict variables among non-motorized respondents who traveled in areas of mixed-use, compared with those traveling outside mixed-use areas. Management implications and recommendations for increasing the effectiveness of zoning are provided.

Keywords GIS · Geospatial analysis · Parks and protected areas · Recreation conflict · Survey analysis · Zoning

Introduction

Recreation in American parks and protected areas (PPAs) increased dramatically after World War II (Cordell et al. 2008; Jensen and Guthrie 2006), and estimates indicate that overall participation will continue to climb in coming decades (Bowker et al. 2012). Recreation research since the 1960s has developed in two directions. First, a considerable body of research exists on recreation ecology, or the effects recreation has on the ecosystems in which it occurs (e.g., Hammitt and Cole 1998; Liddle 1997; Monz et al. 2010). The second direction has focused on describing patterns of recreation use and how those patterns may affect the availability or quality of recreational experiences (Manning 2011). Research provides insights into the sources of common recreation issues such as crowding, conflict and dissatisfaction that evolved around the idea of a social carrying capacity (Cole 2004; Manning 2011; Shelby and Heberlein 1986; Wagar 1964). PPA managers have responded to recreation issues with various planning

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frameworks such as the limits of acceptable change (Stankey et al. 1985), visitor impact management framework (Kuss et al. 1990) and visitor experience and resource protection (NPS 1997) designed to help managers identify recreation issues and take steps to minimize them in recreation planning.

An increasing demand for abundant and high-quality recreation opportunities in PPAs can create conflict between recreationists competing for their desired recreation experience. Decades of research on recreation conflict and management practices have focused on two common strategies for limiting conflict between recreationists (Graefe and Thapa 2004; Lindberg et al. 2009; Lucas 1964). First, PPA managers limit the amount of interaction between groups by zoning recreation into areas open to a particular recreation activity while being closed to another (Leung and Marion 1999; Wagar 1964). Zoning is designed to separate activities and reduce interpersonal conflict. Interpersonal conflict occurs when the physical presence or behavior of an individual or group interferes with the goals of another individual or group (Graefe and Thapa 2004; Jacob 1977; Jacob and Schreyer 1980). Research shows interpersonal conflict often occurs between non-motorized and motorized recreation groups, for example between canoers and motorboaters (Adelman et al. 1982), between cross-country skiers and snowmobilers (Jackson and Wong 1982; Knopp and Tyger 1973; Vaske et al. 2007), and between back-country skiers and helicopter-assisted skiers (Gibbons and Ruddell 1995).

Second, PPA managers use an active management approach to visitor education and enforcement of zoning boundaries. A primary aim of active management is to limit social values conflict (Miller and Vaske 2016; Vaske et al. 2007). Social values conflict occurs between groups who may not share similar norms or values about an activity (Rudell and Gramann 1994; Vaske et al. 1995). Social values conflict can occur between recreationists even with no direct contact between the groups (Carothers et al. 2001; Vaske et al. 2007). One group of recreationists may philosophically disagree about allowing another recreationist activity (e.g., Blahna et al. 1995; Vaske et al. 1995), so long-term education efforts are used to target the commonly held norms a group may have. For example, a Colorado Parks and Wildlife education program focused on the benefits of a regulation (C.R.S. 25-12-110) that limits off-highway vehicle noise pollution. Snowmobile noise pollution is often reported as a source of animosity from non-motorized recreationists towards motorized recreationists (Lindberg et al. 2009; Vittersø et al. 2004). The education program on the noise regulation was designed to minimize social values conflict by demonstrating that snowmobiles are quieter now compared with in the past. Active management may coincide with a fee for recreation use in the

PPA. Fee revenue is used in supporting an active management approach with field-going employees educating visitors on zoning boundaries and enforcing regulations.

While interpersonal and social values conflicts exist with distinct underlying drivers, they are closely related. Managers of PPAs have looked to zoning and active management to more fully address conflict between recreation groups (Leung and Marion 1999; Miller and Vaske 2016; Schneider 2000; Vaske et al. 2007). There is limited empirical research measuring the effectiveness of zoning and active management. Early notions of recreation zoning come from planning frameworks such as Clark and Stankey's (1979) Recreation Opportunity Spectrum (ROS). The ROS codified the idea of spatial separation of incompatible uses, for example mechanized and non-mechanized, to mitigate potential conflict between groups. In proceeding decades, managers have implemented zoned recreation management plans, especially in high-use areas like national parks (Leung and Marion 1999). Few studies have tested the effectiveness of recreation zoning, however. Marion et al. (1993) report on actions taken by National Park Service managers to reduce conflict. They found respondents had taken management actions to segregate use geographically (27 % of respondents) and zone trails by use (12 % of respondents). An example of active management was reported by Marion et al. (1993) who found 40 % of the respondents indicated that they had "inform[ed] visitors about conflicting uses they may encounter in certain areas" (p. 27). Leung and Marion (1999) have shown that zoning and active management are used by PPA managers, but not whether they are effective at reducing conflict.

Miller and Vaske (2016) examined changes in reported interpersonal and social values conflict over a 10-year plus period at the Vail Pass Winter Recreation Area (VPWRA), a busy (over 35,000 winter recreationist visits per season), actively managed and zoned recreation area in central Colorado. The results showed interpersonal conflict which decreased over the period for both non-motorized and motorized recreationists. Both groups, however, continue to report interpersonal conflict even with an established zoning system. Despite an established active management approach at the VPWRA, social values conflict among non-motorized recreationists increased over the period. One important finding was that despite a system of zoning at the VPRWA, there are areas with both non-motorized and motorized recreationists present. These mixed-use areas, it was hypothesized, may have been responsible for much of the lingering interpersonal and social values conflict.

The analysis reported in this article builds on previous research at the VPWRA to better understand the extent to which areas of mixed-use recreation influences levels of conflict reported by non-motorized recreationists. Specifically, we used two distinct methodologies to more clearly

describe the nature of winter recreation at the VPWRA and identify factors responsible for persistent conflict among non-motorized recreationists. First, we performed a Geographic Information System (GIS) analysis of recreation GPS data, collected over two winter seasons at the VPWRA. The GIS analysis provides a more complete objective for characterization of how recreationists move through a winter dispersed recreation landscape. The extent to which recreation is dispersed will have direct effects on the level of interaction the recreation groups will have. This high resolution analysis quantifies where and when recreation use occurs in the VPWRA to better understand the level of mixed-use in a zoned recreation system. Second, we used a survey to test whether there are reported differences among non-motorized recreationists who traveled in areas of mixed-use, compared with those who did not travel in mixed-use areas.

Hypotheses

Based on previous winter recreationist conflict research and observations of recreationists at the VPWRA, the following three hypotheses were advanced:

H₁ Despite a zoning management plan, due to the presence of established travel routes, a disproportionate amount of recreation at the VPWRA will occur in mixed-use areas, compared with areas of no mixed-use.

H₂ Among non-motorized respondents, those traveling in mixed-use areas within the VPWRA will report a higher level of interpersonal conflict compared with those recreationists who did not travel in mixed-use areas.

H₃ Among non-motorized respondents, those traveling in mixed-use areas within the VPWRA will report a higher level of social values conflict compared with those recreationists who did not travel in mixed-use areas.

Methods

Study Site

The VPWRA encompasses 20,240 ha of sub-alpine and alpine terrain ranging from 2652 to 3869 m and is managed by the White River National Forest (WRNF). The area is located immediately south of Vail Mountain Resort, west of the Eagles Nest Wilderness Area, and north of the Copper Mountain Resort (Fig. 1). Both Vail Mountain Resort and Cooper Mountain hold special-use permits from the WRNF for ski operations on public land. Interstate 70 crosses through the eastern portion of the VPWRA, which is a one and a half hour drive to the Denver Metro Area and other

Colorado Front Range communities. US Highway 24 forms the western boundary of the VPWRA connecting the mountain communities of Leadville and Minturn.

Visitors to the VPWRA are required to pay an entrance fee (currently \$6 per person per day), of which 95 % is given to the WRNF to be used for trail grooming and full-time paid rangers who provide active management in the form of parking lot management, enforcement of regulations, and public education. The VPWRA sees approximately 35,000 visitors per winter season (USDA Forest Service 2015). The majority of visitors access the VPWRA from four primary portals, the busiest adjacent to Interstate 70, and three along the west side of the VPWRA (Fig. 1).

The current zoning boundaries at the VPWRA reflect more than 20 years of collaboration between the WRNF and local stakeholders to provide access to high quality non-motorized and motorized backcountry terrain (Miller and Vaske 2016; USDA Forest Service 2015). Approximately 47 % of the winter recreation area is closed to motorized use (Table 1), while 45 % is open to motorized use. There are 1338 ha (7 %) of terrain designated for hybrid use. These areas allow motorized use along designated routes to provide access to skiers and snowboarders.

Backcountry hut users account for approximately 11,000 users annually (USDA Forest Service 2015). There are six backcountry huts located within the VPWRA, which are either operated privately with special-use permits from the WRNF on public lands, or located on private inholdings (Fig. 1). Hut users are predominately non-motorized recreationists, as motorized use is not permitted at most huts. The majority of recreationists access the huts from the main VPWRA portals, however, some visitors travel directly between huts, including from huts located outside the VPWRA.

Data Collection

Two datasets were used in the analysis. First, a geospatial dataset was used to examine the overlapping use of non-motorized and motorized recreationists in the VPWRA. The GPS point dataset allows for a more reliable analysis of recreation patterns at higher spatial resolutions than traditional methods such as electronic trail counters or exit interviews with visitors, which do not provide a complete picture of how recreationists move through a landscape (Cole and Daniel 2003; Hallo et al. 2012). Use of GPS units to study recreation is increasing (e.g., D'Antonio et al. 2010; Hallo et al. 2012; Lai et al. 2007; Rupf et al. 2011; Shoval and Isaacson 2006) as units become smaller and less expensive (Wing et al. 2005). Second, data were obtained from a survey of both non-motorized and motorized recreationists at the VPWRA. Data from the non-motorized group were the focus of this article since they reported

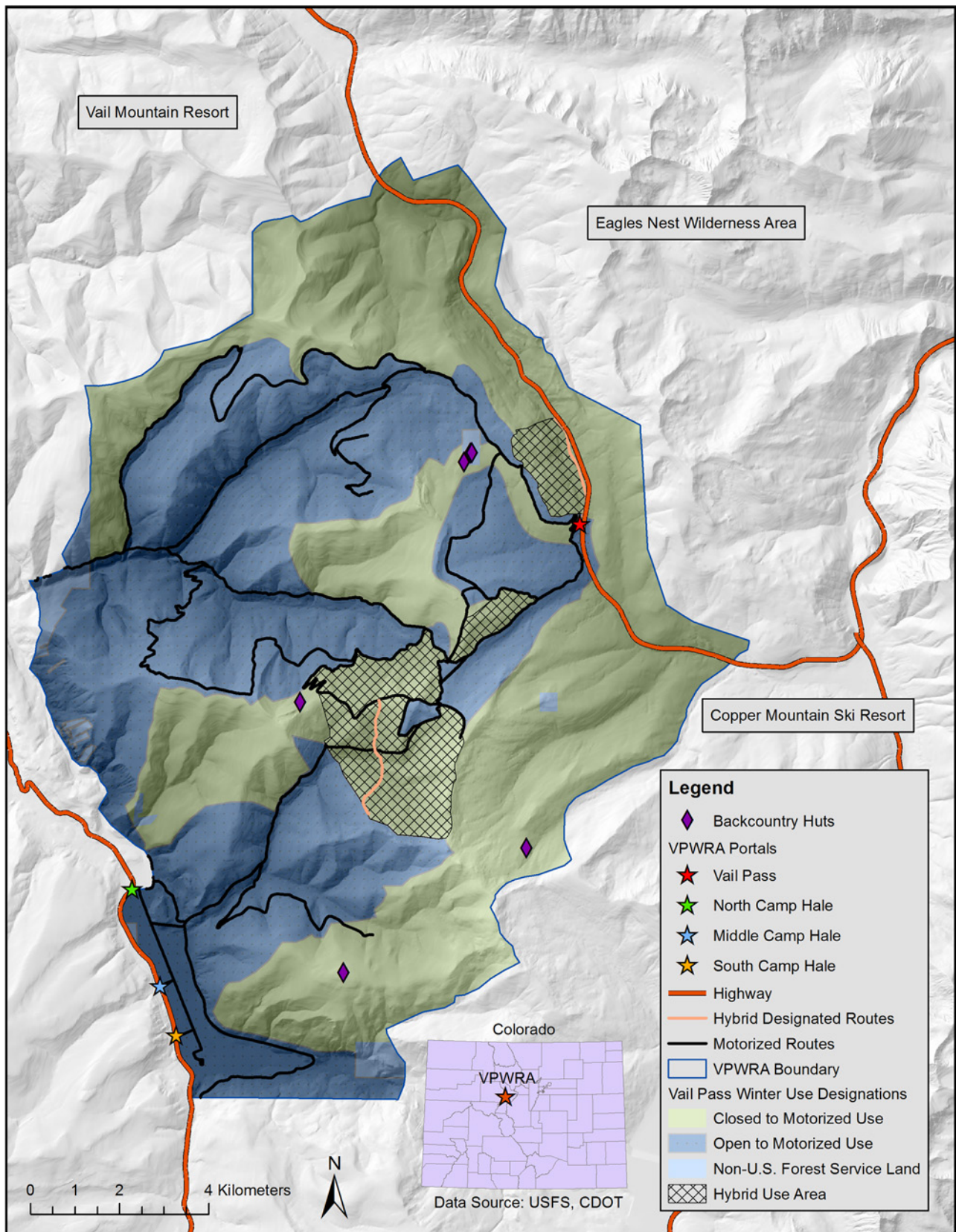


Fig. 1 The vail pass winter recreation area (VPWRA) and recreation zoning designations and established groomed routes. See Miller and Vaske (2016) for history of recreation zoning at the VPWRA. The six backcountry huts (diamonds) and four primary access portals (stars) are also shown

Table 1 Recreation zoning designations and distributions at the VPWRA, Colorado

Zoning designation	Hectares	Of total VPWRA (%)
Closed to motorized	9515	47
Open to motorized	9020	45
Open to motorized for hybrid access only	1338	7
Non-US forest service land	366	2
Total	20,240	

higher levels of interpersonal conflict than the motorized group (Miller and Vaske 2016).

Geospatial Data

The GPS data were collected from the VPWRA during the winters of 2010 and 2011 as part of a larger study on the movement patterns of winter recreationists and Canada lynx (*Lynx canadensis*). Recreationists were asked to carry a small GPS unit (Qstarz, model BT-Q1300), which stored a GPS point every 5 s throughout their visit to the VPWRA. In addition to logging the geographic coordinates, the GPS unit also captured the speed, altitude, and turn-angle of each point but had no user-interface or remote tracking capability. Sampling occurred on all seven days (during daylight hours only) over the period from early January to the first week of April in both 2010 and 2011. A network of infrared and magnetic trail counters was used to verify the sampling procedure, which showed the busiest days at the VPWRA were weekends with over 95 % of use occurring between 8am and 5pm. A greater number of tracks was collected on weekend days, which reflected the higher weekend visitation to the VPWRA. Researchers asked a visitor from every fourth vehicle in the parking lot to carry the unit (response rate = 90 %). One unit was carried per group. The number of people in the group, the mode of travel, the portal from which the unit was distributed, and the unit identification number were recorded. As an incentive for carrying the GPS unit, visitors could voluntarily provide an email address to which the GPS track was sent as a Google Earth file. Recreationists dropped the GPS units into a collection bin at the end of their visit to the VPWRA. The researchers collected the units and downloaded the data in a computer.

GPS data were categorized by the mode of travel: (1) snowmobile, (2) hybrid, where a snowmobile or snowcat is used to access remote ski/snowboard terrain, (3) backcountry ski/snowboard, and (4) snowshoe/cross-country ski, generally travel routes through less-steep terrain. Data were saved for each track and contained all GPS points associated with the route taken by the recreationist. In some

cases, GPS units were used for multiple days by recreationists staying at backcountry huts. In these cases, a separate track was saved for each day the unit was used.

Survey Data

Survey data were collected in the winter of 2014. Both an on-site and an online version of the survey were used. On-site surveys were distributed at the Vail Pass parking area to all recreationists after their recreation experience. Two versions of the survey were developed with the same questions, one for motorized recreationists and one for non-motorized recreationists. This article focused on the non-motorized recreationists. Non-motorized activities include backcountry skiing and snowboarding, cross-country or nordic skiing, and snowshoeing. Hybrid users were categorized as motorized respondents and were not included in this analysis.

On-site surveys were distributed on weekend days; most VPWRA visitation occurs on weekends. An online version of the survey was also created to capture visitation to the backcountry huts located in the VPWRA. Some hut users do not access the VPWRA through the primary portals, entering instead from Copper Mountain or on a route from other backcountry huts outside of the VPWRA. The online survey was necessary to reach these respondents. Hut users (specifically the trip leader listed on the reservation) were provided the non-motorized survey because motorized use is not allowed at huts where respondents were staying. Surveys from hut users were collected from weekdays in addition to weekends. Trip leaders were emailed information about the survey and a link to complete it online within three days of their visit to the VPWRA. The average response time for the online survey was 2.5 days. Completed surveys were collected from a total of 199 non-motorized respondents. The majority were collected from the online survey ($n = 180$, response rate = 71 %), compared with the 19 on-site surveys (response rate 88 %).

Variables Measured

Geospatial Data

The geospatial variable of interest for this analysis was the spatial distribution of recreation use across the VPWRA. Specifically, this analysis focused on the extent to which non-motorized and motorized recreationists' terrain selection overlapped spatially.

Survey Data

The conflict variables were identical to previous recreation research (i.e., Carothers et al. 2001; Miller and Vaske 2016;

Vaske et al. 1995 2007). Respondents initially indicated how frequently they (1) saw motorized user traveling out of control, (2) saw motorized user being rude and discourteous, (3) saw motorized user pass too closely, (4) saw motorized user not yielding the right of way, and (5) saw motorized user disturb wildlife. Response categories were “never,” “1–2 times,” “3–5 times,” and “almost always.” Based on previous research (Carothers et al. 2001; Miller and Vaske 2016; Vaske et al. 1995 2007), these responses were recoded into “not observed” (i.e., respondent reported it never happened) or “observed” (i.e., respondent reported it happened at least once). Respondents were then asked if they believed each of these questions was a problem. The responses were initially coded on a four-point scale: “not a problem,” “slight problem,” “moderate problem,” and “extreme problem.” As with the above questions, the responses were recoded into either “no problem” or “problem.”

Consistent with previous research (Carothers et al. 2001; Miller and Vaske 2016; Vaske et al. 1995, 2007), combining the frequency of occurrence (observed, not observed) variables with the corresponding perceived problem (no problem, problem) variables for each respondent produced conflict typologies with the three possible attributes: (1) no conflict, (2) interpersonal conflict, and (3) social values conflict. Individuals who observed or did not observe a given event, yet did not perceive it to be a problem were considered to have experienced no conflict (i.e., no interpersonal or social values conflict). Those who never saw a given event, but believed that a problem existed for the event were considered to be expressing a conflict in social values. Conversely, those who witnessed a particular event and believed that it had caused a problem were judged to be indicating interpersonal conflict.

Data Analysis

Geospatial Analysis

The geospatial data included 903 GPS tracks comprising a total of 1,444,054 GPS points from 2010 and 2011 (Table 2; Fig. 2). The dataset was analyzed using ArcGIS 10.2. Points were categorized as non-motorized or motorized by the respondent’s mode of travel. Ski/board and snowshoe/XC-ski were categorized as non-motorized. The hybrid points falling within 20 m of an established route, along with snowmobile points were categorized as motorized. The hybrid points greater than 20 m from an established route were not included in the analysis because, they could not be accurately categorized as non-motorized or motorized.

Once the GPS points were categorized, a raster analysis was performed converting the points into a new 10 m resolution output raster layer for non-motorized points and a

Table 2 Summary of recreation GPS tracks and points collected by mode and year

Year	Mode	Tracks	Points
2010	Snowmobile	131	223,943
	Hybrid	127	316,761
	Ski/Board	73	171,128
	Snowshoe/XC-ski	16	41,685
	2010 Total	347	753,517
2011	Snowmobile	191	211,832
	Hybrid	169	233,035
	Ski/Board	176	221,163
	Snowshoe/XC-ski	20	24,507
	2011 total	556	690,537
Overall total		903	1,444,054

second layer for motorized points that contained the number of points located within each 10 m² cell. A relatively high-resolution raster of 10 m was used to capture the spatial relationship between established routes and the recreationist carrying the GPS unit. Each raster layer was then reclassified into six categories based on the number of points contained within each cell. Classification based on discrete bins was used to assist in consistent visualization of the data results for the motorized and non-motorized layer. The intensity of recreation use, however, was a continuous variable used in computation. Six bins were created for both motorized and non-motorized use. The bins were labeled as very low use (10 points or fewer), low use (11–25 points), moderate use (26–100 points), high use (101–250 points), very high use (251–500 points), and extreme use (greater than 500 points). Raster algebra was then used to identify the cells that contained both non-motorized and motorized recreation, at a resolution of 10 m². The final output raster contained all possible density combinations of overlapping non-motorized and motorized use (Table 3).

Finally, the mixed-use layer was intersected with the original non-motorized and motorized GPS points to determine the proportion of recreation use occurring inside the mixed-use area, compared with the recreation occurring outside the area. One limitation of the analysis was that some physical terrain covered by recreationists between the GPS units collecting points was not captured.¹ To more accurately capture the terrain, recreationists moved across while carrying the GPS unit; we buffered the mixed-use area by 10 m. We then calculated the number of non-motorized and motorized GPS points intersecting the

¹ The analysis was performed directly on the GPS points rather than on the GPS tracks because the straight lines drawn between points did not necessarily accurately represent the path taken by the recreationist. We found the point analysis to be more accurate at this spatial resolution.

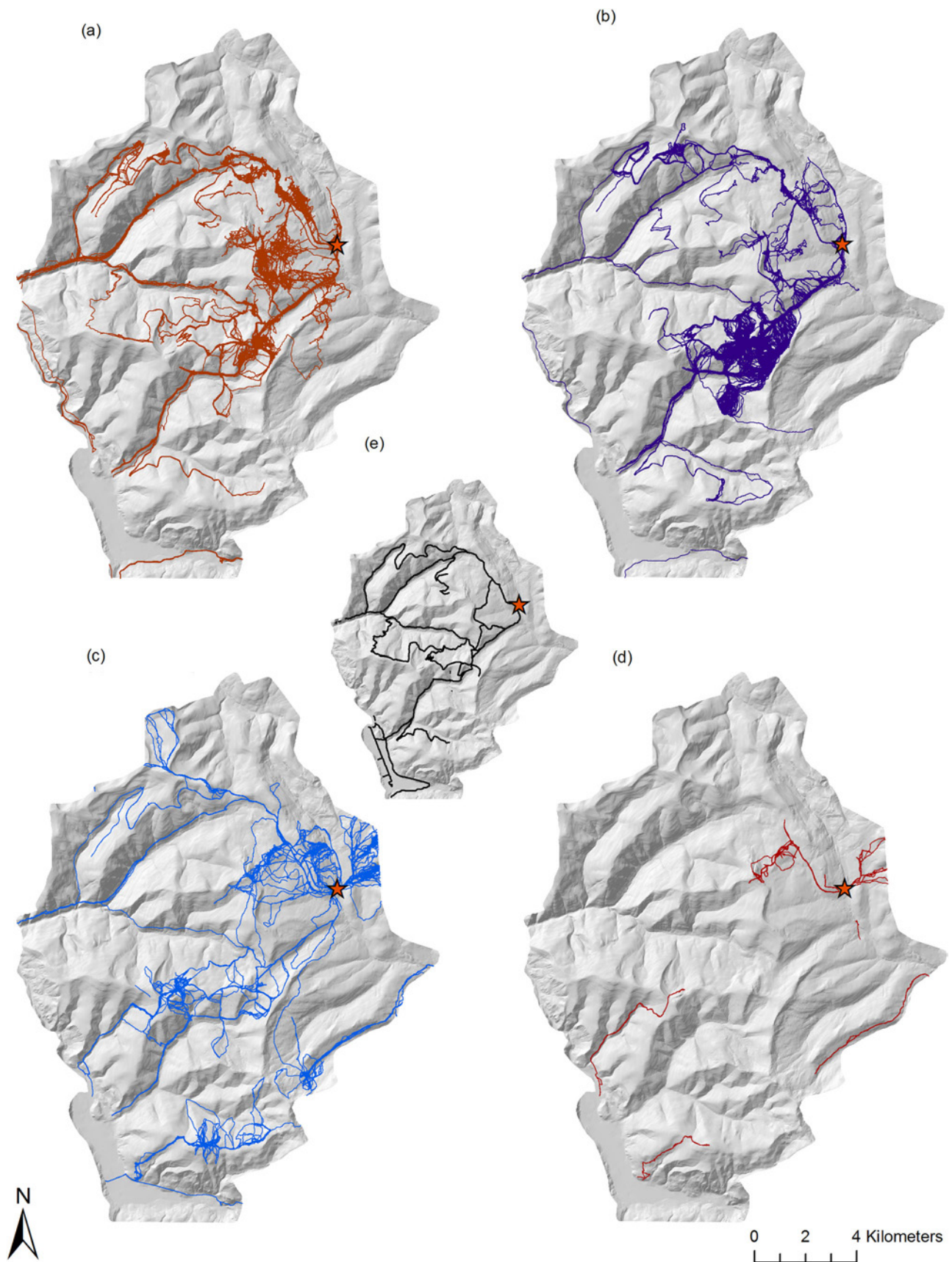


Fig. 2 Recreation GPS tracks by mode of travel, including **a** snowmobile, $n = 322$; **b** hybrid snowmobile and ski/snowboard, $n = 296$; **c** backcountry ski/snowboard, $n = 249$; and **d** snowshoe/cross-country ski, $n = 36$. The

network of groomed routes is also depicted **e**. The star represents the location of the primary portal adjacent to Interstate 70 at Vail Pass

buffered mixed-use area. This approach further revealed differing use patterns between motorized and non-motorized recreationists.

Survey Analysis

Areas of mixed-use were identified from the GIS analysis. Respondents were categorized as either having traveled in a mixed-use area or not, based on the locations they selected on the survey as ones visited during their trip (locations identified in Fig. 3). Locations were based on popular points of interest within the VPRWA. For example, if a respondent selected only Corral Creek/Uneva Peak as the location he/she traveled to during the trip, the survey was categorized as no mixed-use because motorized travel is not permitted along any possible travel route to reach this location after departing from the access portal. However, if the respondent selected a location that would require travel through a mixed-use area, the survey was categorized as mixed-use. Of the eight possible locations, a respondent could have visited and selected on the survey, two had no overlapping non-motorized and motorized use (some limited mixed-use occurs in and adjacent to the access portal at Vail Pass). The other six locations required travel through mixed-use areas.

χ^2 was then used to test for differences in each of the five conflict variables between respondents who traveled in mixed-use areas and those who did not.² Depending on the conflict variable measured, there were roughly four times more respondents who traveled in mixed-use areas compared with those who did not.

Results

Geospatial Analysis

The distribution of recreation in the VPWRA varied by mode of travel (Fig. 2). A total of 1,233,449 GPS points were used in the analysis. There were 210,605 points that were not included in the analysis because they were hybrid recreation points greater than 20 m from an established route. The mean length of a motorized track was longer (45.8 km, SD 22.5 km) for motorized recreationists

Table 3 Final mixed-use raster layer showing combinations of intensity of non-motorized and motorized recreation use

Level of non-motorized use	Level of motorized use	Number of 10 m ² cells	Total of mixed-use area (%)
Very low	Very low	6310	44.63
Very low	Low	2505	17.72
Very low	Moderate	3072	21.73
Very low	High	735	5.20
Very low	Very high	92	0.65
Very low	Extreme	44	0.31
Low	Very low	320	2.26
Low	Low	205	1.45
Low	Moderate	352	2.49
Low	High	218	1.54
Low	Very high	12	0.08
Low	Extreme	3	0.02
Moderate	Very low	119	0.84
Moderate	Low	43	0.30
Moderate	Moderate	37	0.26
Moderate	High	34	0.24
Moderate	Very high	5	0.04
Moderate	Extreme	7	0.05
High	Very low	7	0.05
High	Low	5	0.04
High	Moderate	3	0.02
High	High	2	0.01
High	Very high	3	0.02
High	Extreme	0	0
Very high	Very low	1	0.01
Very high	Low	2	0.01
Very high	Moderate	1	0.01
Very high	High	0	0
Very high	Very high	0	0
Very high	Extreme	1	0.01
Extreme	Very low	0	0
Extreme	Low	0	0
Extreme	Moderate	0	0
Extreme	High	0	0
Extreme	Very high	0	0
Extreme	Extreme	0	0

² Similar to Miller and Vaske (2016) and Vaske et al. (2007), a *K*-means cluster analysis was performed on the non-motorized dataset. Unlike in those analyses, however, no convergence was reached with a 2, 3, or 4 cluster solution and, therefore, the cluster analysis was not included in this analysis. The relatively small sample size of the non-mixed-use respondents could be responsible for the lack of convergence.

compared with non-motorized (mean of 9.1 km, SD of 8.2 km; Table 4), and the mean speed was faster for motorized (22.9 km/h, SD 20.0 km/h), compared with non-motorized recreationists (3.4 km/h, SD 5.2 km/h). Non-motorized

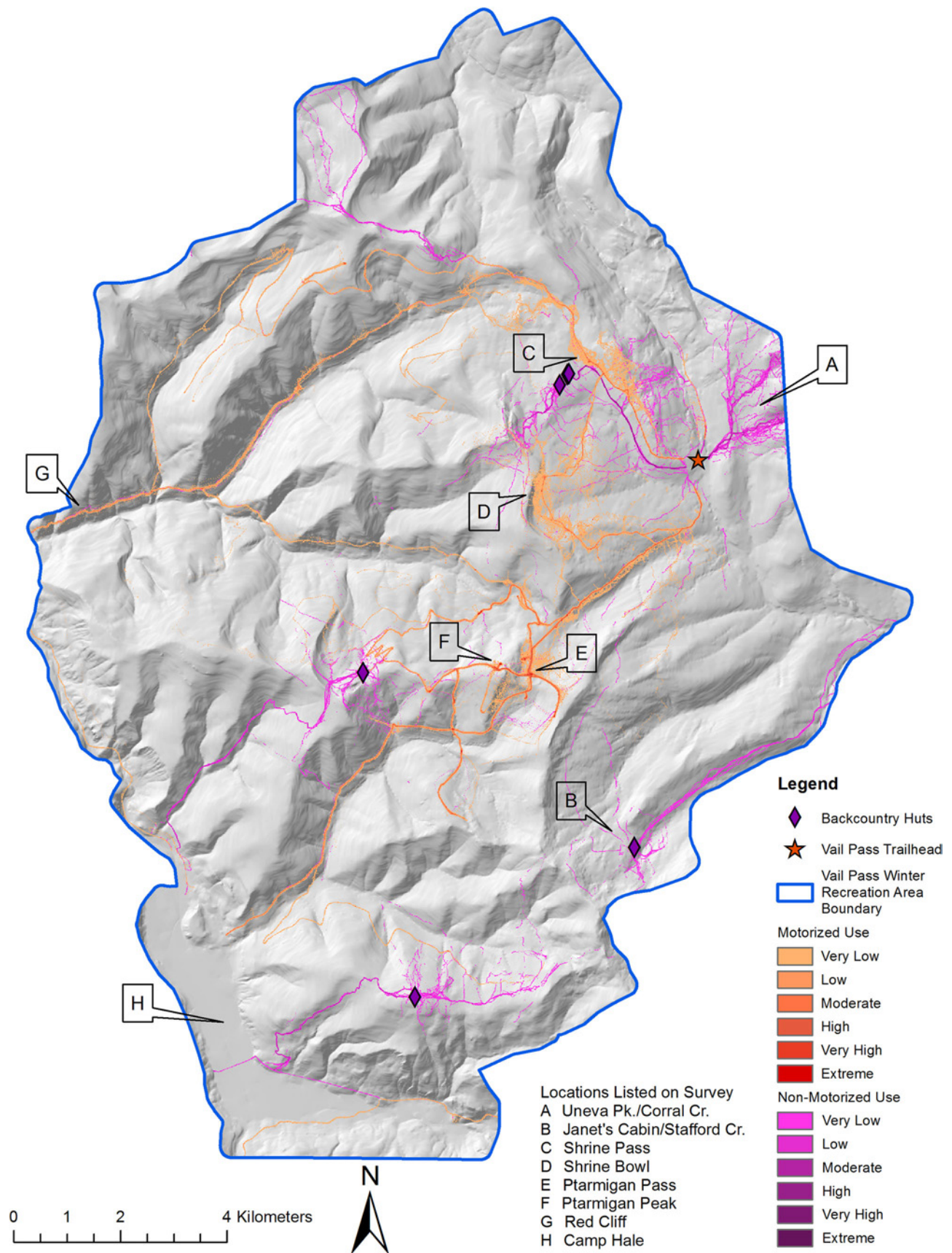


Fig. 3 Spatial distribution and density of GPS points collected from non-motorized and motorized recreation with the locations listed on survey given to recreationists

Table 4 Summary of recreation GPS tracks and points used in geospatial analysis

	Non-motorized			Motorized		
	Total	Mean	SD	Total	Mean	SD
GPS points	458,463	1609 ^a	1407 ^a	774,986	1254 ^a	1110 ^a
Tracks	285			618		
Track length (km)	2589	9.1	8.2	28,272	45.8	22.5
Time elapsed per track (h:min)		2:14	:44		1:44	:40
Speed (km/h)		3.4	5.2		22.9	20.0
Altitude (m)		3324	235		3380	200
Group size		5.3	4.9		4.0	2.7

^a Points per track

recreationists, however, spent more time in the VPWRA with a mean of 2 h and 14 min spent on recreation (SD 44 min), compared with a mean of 1 h and 44 min for motorized recreationists (SD 40 min). The mean elevation of GPS points analyzed was similar for both groups (3324 m, SD 235 m for non-motorized points and 3380 m, SD 200 m for motorized points). Finally, non-motorized recreationists traveled in larger groups, on average, with a mean group size of 5.3 (SD 4.9) compared with a mean group size of 4.0 (SD 2.7) for motorized recreationists.

The geospatial analysis revealed distinct movement patterns for the recreation groups. The areas of highest density—in other words, the areas with the greatest number of GPS points per cell—were located near established routes and points of interest (Fig. 3). In this case, points of interest are common destinations and main intersections along the route network, especially passes and peaks offering good viewsheds, as well as backcountry huts. The network of established groomed routes (approximately 105 km) received predominately motorized use, but non-motorized recreation did occur as well. Backcountry skiers, snowboarders, cross-country skiers and snowshoers used established groomed routes, which required less physical exertion compared with the travel-off established routes. Overlap between motorized and motorized recreation was especially prevalent at points of interest (Fig. 4).

The area of mixed use was calculated by summing the number of 10 m² cells that contained at least one GPS point. Using this metric, non-motorized recreation occurred on only 2.7 % of the entire 20,240 ha of the VPWRA (Table 5). Motorized recreation occurred on 3.5 % of the land area. Finally, only 141 ha, or 0.7 % of VPWRA contained both non-motorized and motorized recreation. Despite the small area of mixed-use recreation, these cells contained nearly 15 % of non-motorized and 49 % of motorized recreation (Table 5), supporting Hypothesis 1. Further, once the mixed-use cells were buffered by 10 m to account for some

of the potential gaps in the terrain covered by the recreationists moving at higher speeds, the area of mixed-use was calculated as 415 ha, or 2.1 % of the entire VPWRA. This area contained 18.2 % of all non-motorized GPS points (an increase of 3.4 % over the original mixed-use area). The buffered mixed-use area also contained 80.6 % of all motorized GPS points (an increase of 31 %), and further highlighted how much of the recreation occurs in a small land area on and near established travel routes and points of interest.

Survey Analysis

The survey results indicated differences in reported levels of interpersonal and social values conflict among non-motorized recreationists at the VPWRA (Table 6). Respondents who traveled in mixed-use areas reported higher interpersonal conflict for each conflict variable, compared with respondents who traveled in areas with no mixed-use, supporting Hypothesis 2. Respondents who traveled in mixed-use areas, however, reported lower social values conflict compared with respondents who traveled in areas with no mixed-use, not supporting Hypothesis 3. For example, for the conflict variable “motorized recreationist being rude or discourteous” of the respondents who traveled in mixed-use areas, 25 % reported interpersonal conflict, compared with 6 % for respondents who did not travel in mixed-use areas. Contrarily, 24 % of mixed-use respondents reported social values conflict, compared with 52 % of respondents who did not travel in mixed-use areas ($n = 166$, $\chi^2 = 11.59$, $p = .003$, Cramer’s $V = .261$). Levels of interpersonal conflict were lower for respondents in areas with no mixed-use, however with four of the five conflict variables, some level of interpersonal conflict lingers (between 6 and 12 % of respondents reporting it).

Discussion

This analysis showed the complexity of recreation zoning and conflict. Managers of PPAs have implemented zoning after recognizing the contentious use of terrain by non-motorized and motorized recreationists. However, since the emergence of the ROS and other planning documents in the 1970s, which gave PPA managers indicators for identifying conflict and designs for spatial segregation, research has been lacking on what characteristics make a zoned system effective at reducing conflict. Our study showed how small spatial overlap between uses, which exist despite a zoning system, can result in persistent interpersonal conflict. Affordable and accurate GPS technologies for measuring the movement and terrain selection of recreationists are being used in recreation research (e.g., D’Antonio et al.

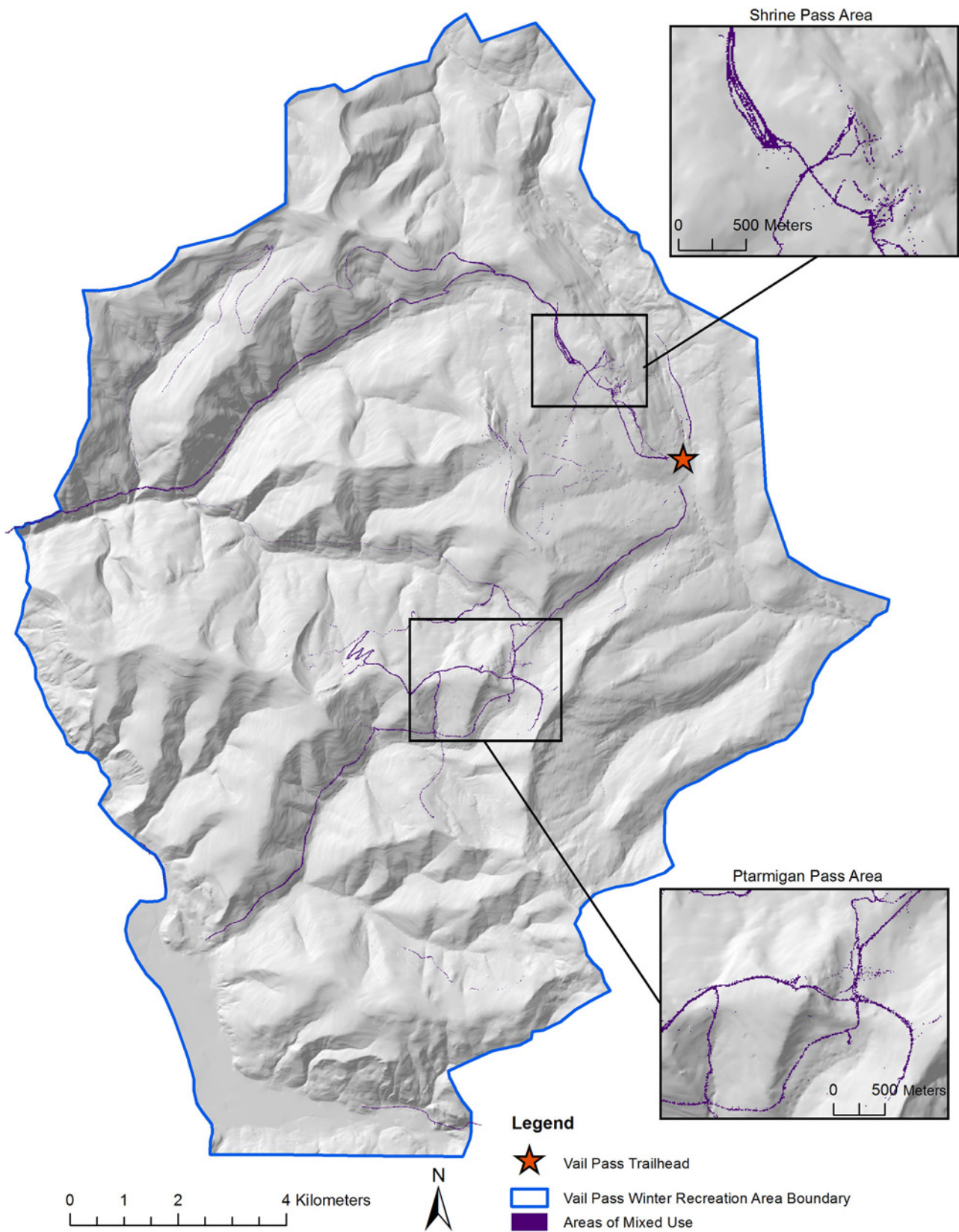


Fig. 4 Spatial distribution of mixed-use areas in the VPWRA at 10 m resolution. Cells containing both non-motorized and motorized GPS points sum to 141 ha, or 0.7 % of the total land area of the VPWRA and

are most abundant around points of interest such as Shrine Pass and Ptarmigan Pass

Table 5 The area within the VPWRA with observed recreation use and the number of GPS points intersecting both the area of mixed non-motorized and motorized use and the buffered (10 m) mixed-use area

	Hectares	Points	Of total (%)
Area of observed recreation ^a			
Non-motorized only	547		2.7 ^b
Motorized only	713		3.5 ^b
Mixed non-motorized and motorized use	141		0.7 ^b
Mixed-use area, 10 m Buffer	415		2.1 ^b
Points intersecting mixed-use area			
Non-motorized points		67,984	14.8 ^c
Motorized points		380,593	49.1 ^c
Points intersecting 10 m buffer of mixed-use area			
Non-motorized points		83,382	18.2 ^d
Motorized points		624,738	80.6 ^d

^a Area calculated by summing all 10 m² cells containing at least 1 GPS point

^b The percent of land area of the total land area of the VPWRA (20,240 ha)

^c The percent of total points located inside the mixed-use area

^d The percent of total points located inside the 10 m buffer of the mixed-use area

2010; Hallo et al. 2012; Lai et al. 2007), which provide a more complete picture of what kind of experience winter recreationists are seeking.

Our geospatial analysis provided an objective measure of where recreation occurred within the VPWRA. It also identified through a large sample size and high spatial resolution, novel characteristics of winter recreation patterns not previously quantifiable at fine spatial scales. Our results indicated a spatial pattern of recreation that was not well dispersed across the VPWRA. Overall, a large proportion of total recreation occurred along established routes, points of interest and access portals (Figs. 4 and 5). This was especially true for motorized recreation where 49 % of the GPS points collected were located inside the area of mixed-use identified in the analysis (0.7 % of entire VPWRA area). When we buffered this mixed-use area by 10 m, over 80 % of motorized use sampled occurred in only 2.1 % of the area of the VPWRA. There were clear differences between the way non-motorized and motorized recreationists moved through terrain. While non-motorized recreationists were more dispersed in their use of terrain, 18 % of total points collected were located in the buffered mixed-use area. The consequence of low dispersion is that recreationists are more likely to encounter other recreationists during a typical

Table 6 Differences in recreation conflict reported by non-motorized recreationists based on whether or not the respondent traveled through a mixed-use area

Variable	Type of conflict	Mixed-use area visitors		χ^2 ^a	<i>p</i>	Cramer's <i>V</i>
		No (%)	Yes (%)			
Riding out of control		<i>n</i> = 32	<i>n</i> = 137	3.715	.156	.125
	No conflict	41	49			
	Interpersonal	0	4			
	Social values	59	46			
Being rude or discourteous		<i>n</i> = 31	<i>n</i> = 135	11.588	.003*	.261
	No conflict	42	51			
	Interpersonal	6	25			
	Social values	52	24			
Passing too closely		<i>n</i> = 30	<i>n</i> = 138	9.166	.010*	.231
	No Conflict	43	43			
	Interpersonal	13	36			
	Social values	43	21			
Not yielding right of way		<i>n</i> = 31	<i>n</i> = 132	7.822	.020*	.210
	No conflict	48	51			
	Interpersonal	7	24			
	Social values	45	25			
Disturbing wildlife		<i>n</i> = 34	<i>n</i> = 135	1.137	.566	.080
	No conflict	35	36			
	Interpersonal	12	19			
	Social values	53	45			

* Significant to $p < 0.05$

^a Likelihood ratio

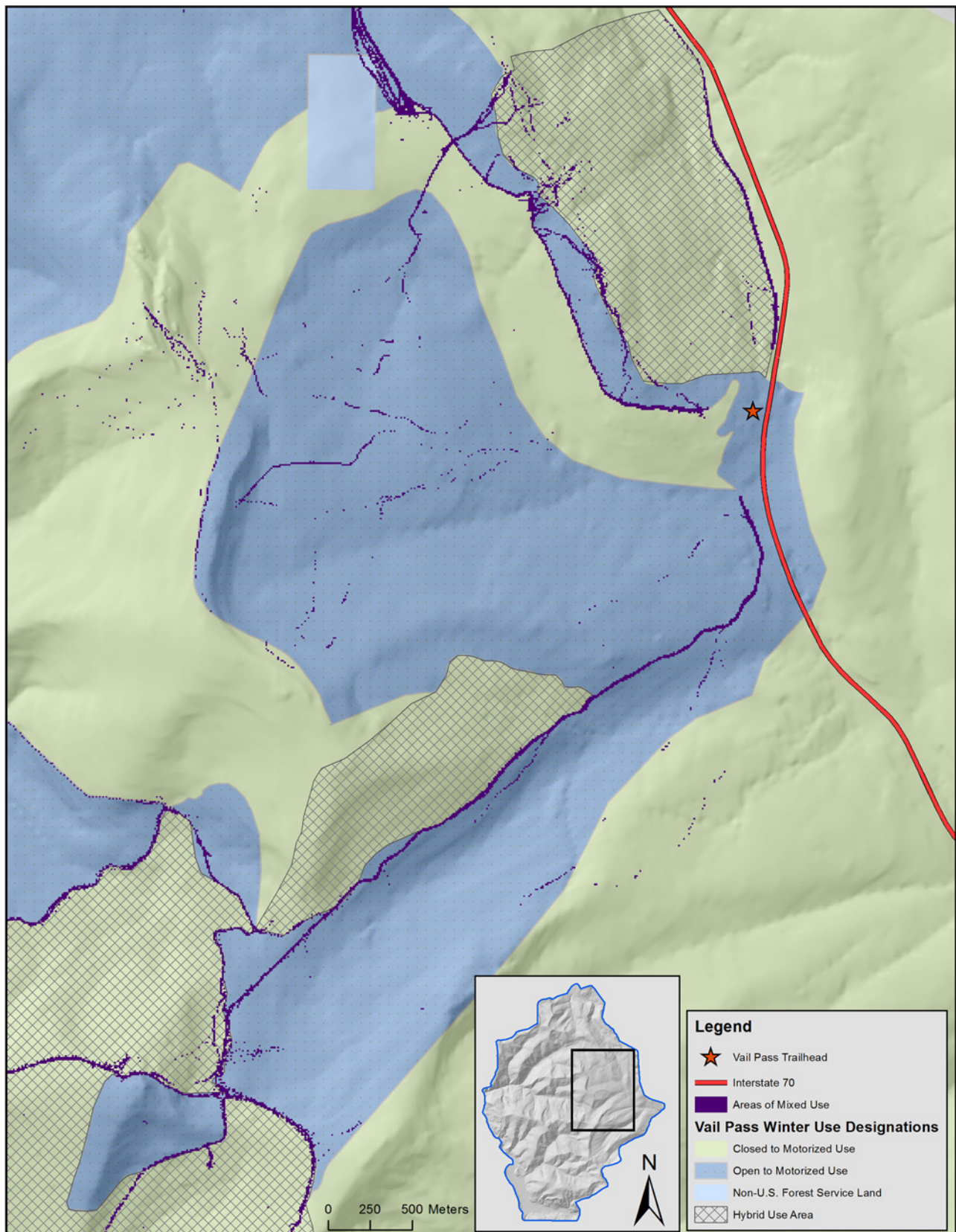


Fig. 5 Cells with both non-motorized and motorized recreation, most of which are located along established groomed travel routes and are less abundant as distance away from established routes increases

recreation experience, increasing the opportunity for interpersonal conflict.

Furthermore, despite separating non-motorized and motorized recreationists, there are areas where zones are small enough that non-motorized recreationists are likely to still hear and perhaps see motorized recreationists. For example, on the top of Vail Pass, the primary recreation portal adjacent to Interstate 70, recreationists used established routes that were in close proximity to one another, on parallel travel corridors (Figs. 6 and 7). Parallel corridors are designed to separate non-motorized and motorized use, while still providing both groups access to points of interest. However, if the corridors are too close together, they may not provide enough segregation to effectively limit interpersonal conflict. It is likely that parallel corridors were more effective at limiting interpersonal conflict than multiple-use routes, but ample space, with a consideration for topography and sound pollution, is necessary between the routes.

An effective zoning system also requires an effective active management system. Because there is a high density of use in a small proportion of the entire recreation area, PPA managers should focus their active management efforts in these mixed-use areas where messaging and public contacts are likely to reach the greatest number of visitors. However, this analysis revealed a more dispersed movement pattern for non-motorized recreationists, compared with motorized recreationists. Messaging and education efforts aimed at non-motorized recreationists will require efforts beyond the mixed-use areas. Since backcountry hut visits account for nearly a third of all visits to the VPWRA and are most frequented by non-motorized recreationists, they may be an important place for PPA managers to focus their active management program.

The survey analysis revealed lower interpersonal conflict among those non-motorized recreationists who traveled through terrain without mixed-use. However, a small amount lingers with these non-motorized respondents. One possible explanation is the effect of access portals, and specifically parking areas, which are mixed-use, small in geographic size, and have high numbers of recreationists at peak times. A backcountry skier's itinerary may be in an area closed to motorized use, but the time spent getting from a parking spot to entering the backcountry may be enough to see, hear and smell snowmobiles and may therefore create interpersonal conflict.

Survey respondents also reported higher levels of social values conflict when traveling in areas of no mixed-use. One possible explanation for this could be that these recreationists chose to travel in area without motorized use precisely to avoid contact with motorized users. They may hold negative attitudes towards the use of snowmobiles and avoid being in mixed-use areas when feasible. Managers of

PPAs should consider how they might be able to reach these recreationists who are generally traveling in areas of low (mixed and non-mixed) use and who may require messaging targeted to the negative attitudes towards motorized use.

Management Recommendations

Providing recreation opportunities to both non-motorized and motorized groups with more effective spatial zoning is likely to further erode persistent interpersonal conflict among non-motorized recreationists. Two management suggestions are evident from the analysis. First, PPA managers should consider the logistical feasibility of providing separate non-motorized and motorized access portals. At the Vail Pass portal, non-motorized and motorized users park in separate lots, however, access to established routes and the backcountry at large, require travel in mixed-use areas, even if for short distances. An established non-motorized route exists from the Vail Pass portal to the popular Shrine Pass. In 2014, rangers at the VPWRA allowed non-motorized use on the groomed motorized route to Shrine Pass, reversing previous management practices. This analysis suggested separation of use in cases such as Shrine Pass will limit interpersonal conflict and would enhance the recreation experience. If PPA managers could provide more direct access from parking areas to zoned terrain for both recreation groups, reducing the time a recreationist spends in a mixed-use area, zoning is more likely to be effective at limiting interpersonal conflict.

PPA managers could also consider alternative methods for zoning in these high-use areas. For example, temporal zoning, which limits use in certain areas on certain days and has been implemented by the National Park Service (Manning and Anderson 2012), may segregate use more effectively, while still providing equal access to both groups. Or additional grooming for non-motorized users (perhaps with a small snowmobile attachment rather than the full-size groomer used on main route network) could provide a greater incentive for non-motorized users to travel off the routes open to motorized use. There are additional administrative costs to this kind of active management and the costs would need to be weighed against the potential decreases in interpersonal conflict.

Second, PPA managers should consider how education campaigns could more effectively reach those non-motorized recreationists reporting social values conflict. Separation alone is not sufficient to address underlying attitudes and norms around snowmobile use in backcountry terrain. Targeted messaging to non-motorized recreationists around modern advances in snowmobile noise and pollution control may be one way to address the attitudes and norms. More research is needed on what kind of education and

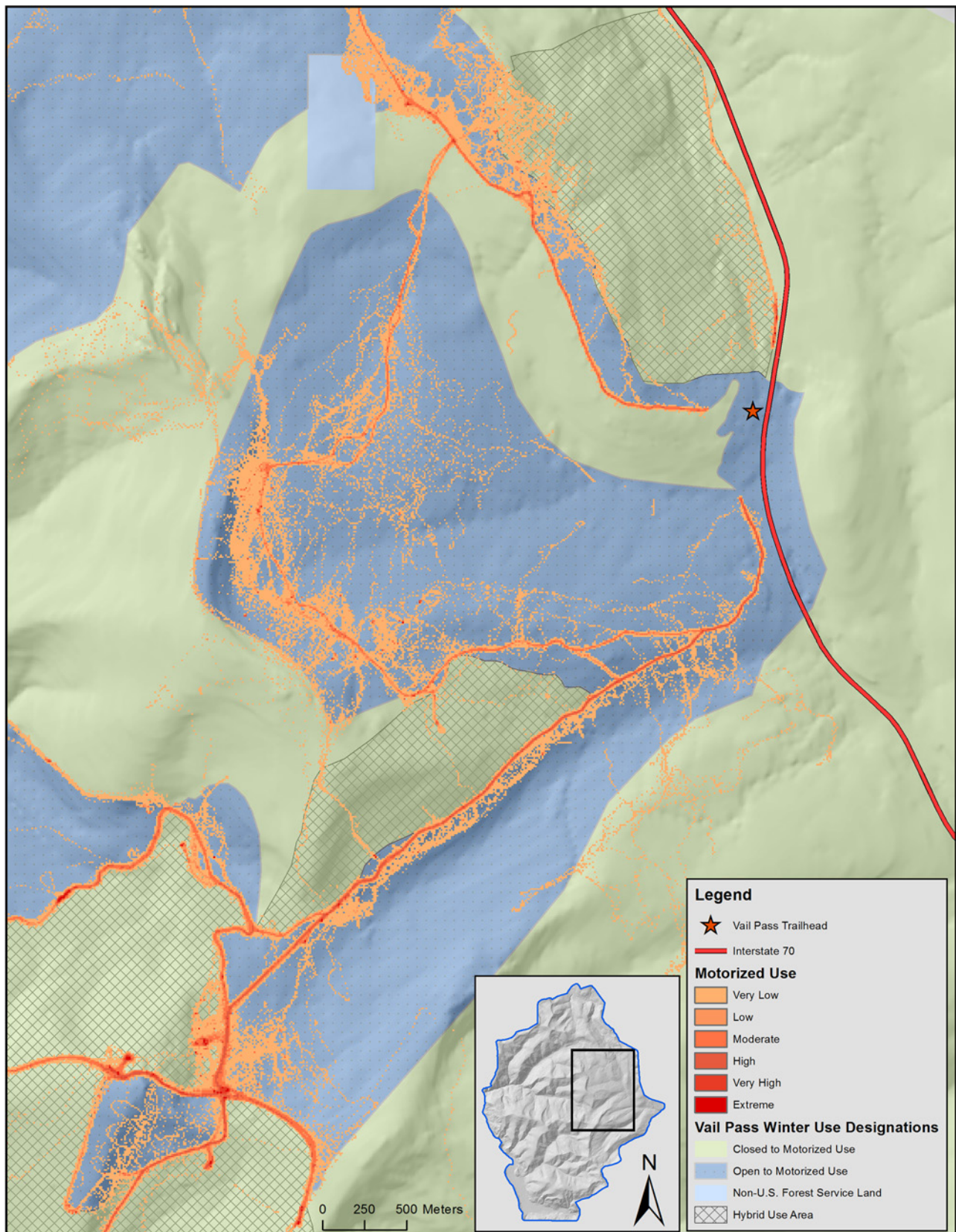


Fig. 6 Density of GPS points per cell ranging from very low to extreme for non-motorized recreation near the Vail Pass portal, the primary access point to the VPWRA. Zoning designations are also depicted

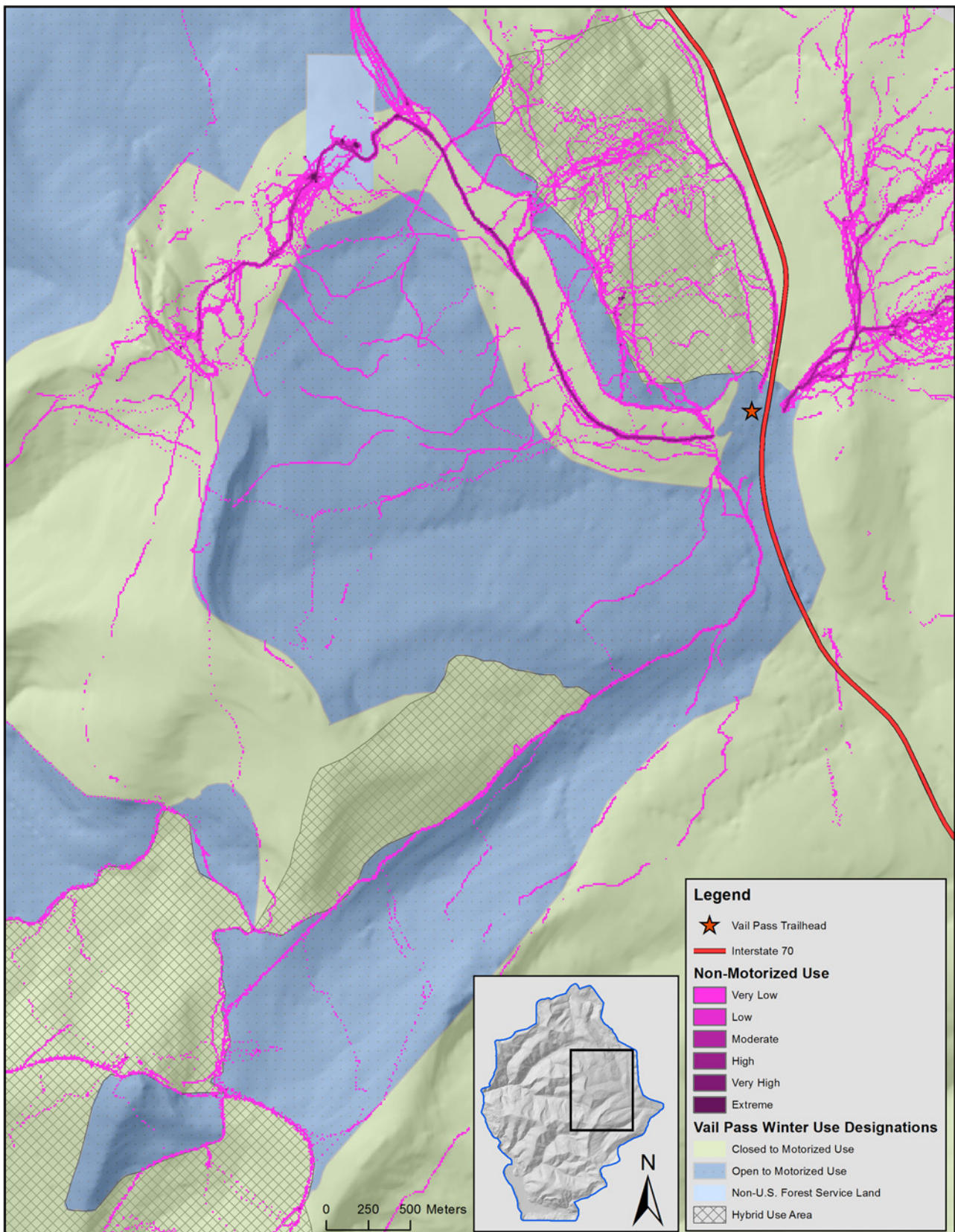


Fig. 7 Density of GPS points per cell ranging from very low to extreme for motorized recreation near the Vail Pass portal, the primary access point to the VPWRA. Zoning designations are also depicted

messaging is most effective in reaching these recreationists. Managers could set lower sound and emission limits as the National Park Service has done in Yellowstone National Park (National Park Service 2013) or encourage or require the use of a four-stroke engine to reduce pollution. However this could face strong resistance by members of the snowmobile community and managers may decide the cost is not worth bearing to further decrease recreation conflict. Finally, as detailed in Miller and Vaske (2016), for areas with contentious and volatile recreation conflict—as was the case in the VPWRA in the 1990s—the collaborative process fostered by local stakeholders and PPA managers to design a zoning system with equitable access to terrain for both non-motorized and motorized recreationists is an essential first step to reduce conflict. However, designing a zoning system should include consideration for small areas of potential spatial overlap between groups, especially near access portals and along route networks.

Conclusions

Our results demonstrated the complex relationship between recreation zoning and decreasing recreation conflict. Recreation Managers must decide how best to design and implement recreation zoning based on historical use patterns for the area, topographic features and considerations (such as access portals and parallel corridors), equitable access to favorable terrain for each group, and practical managerial considerations (e.g. maintenance of signs along zoning boundaries). This analysis has shown that zoning does decrease interpersonal conflict among non-motorized recreationists, however, despite a zoning management system, recreationists at the VPWRA are likely to still share terrain, which permits interpersonal conflict to persist.

PPA managers should design a zoning system that limits spatial overlap between non-motorized and motorized recreationists as much as is feasible, including around the access portals, and may consider alternative or additional tools such as temporal zoning depending on the intractability of the conflict. The VPWRA zoning and active management model for a busy winter recreation area is effective at reducing interpersonal conflict, however, zoning adjustments are needed to extinguish the conflict. The model is less effective at limiting social values conflict among non-motorized recreationists. Active management should be adjusted to specifically target the attitudes and norms of non-motorized recreationists, especially those traveling in low-use areas with no motorized use.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no competing interests.

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