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Article

An Ecosystem Approach to Recreation Location Quotients

Andrew Oftedal [1,*], Mae Davenport [1], Ingrid E. Schneider [1], Cindy Zerger [2], Brian Schreurs [2] and Mary Vogel [2]

[1] Department of Forest Resources, University of Minnesota, 115 Green Hall, 1530 Cleveland Ave. N., St. Paul, MN 55108, USA; E-Mails: mdaven@umn.edu (M.D.); ingridss@umn.edu (I.S.)

[2] Center for Changing Landscapes, University of Minnesota, 151 Rapson Hall, 89 Church St. S.E., Minneapolis, MN 55455, USA; E-Mails: czerger@umn.edu (C.Z.); bschreur@umn.edu (B.S.); vogel001@umn.edu (M.V.)

***** Author to whom correspondence should be addressed; E-Mail: ofte0036@umn.edu; Tel.: +1-612-624-3400; Fax: +1-612-625-5212.

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Abstract: Despite the widespread agreement on the importance of preserving ecological integrity in conservation and outdoor recreation decision-making processes, traditional metrics analyzing the supply of and demand for conservation and recreation resources have focused on geographical and population-centric units of measurement rather than ecological ones. One tool past researchers have used to inform recreation resource planning is the recreation location quotient (RLQ). While simple park-to-population ratios or acres-per-capita metrics provide a base measure of carrying capacity and are often useful to set broad recreation supply standards, the RLQ offers a more nuanced snapshot of supply and demand by comparing regional ratios to a standardized reference region. The RLQ is thus able to provide a statistic or quotient that highlights regions where recreation resources are particularly abundant and/or scarce relative to a reference area. This project expands the past RLQ analyses by investigating the distribution of recreation resources across the 10 ecological sections found within the US state of Minnesota. RLQs were calculated using recreation trail mileage, natural resource and recreation area acreage data, and recreation facility data from federal, state, and local agencies. Results found notable differences in supply of recreation resources across ecological sections. Some sections were considerably underrepresented in recreation resources-per area (e.g., Red River Valley and North Central Glaciated Plains) while others were underrepresented in recreation resources-per

capita (e.g., Minnesota and Northeast Iowa Morainal). The RLQ statistics and resulting maps illustrating relative surplus or deficiencies can inform future land acquisition decisions and highlight the need for cross-jurisdictional planning in order to ensure outdoor recreation systems are ecologically representative. Possible implications and recommendations for future planning decisions are discussed.

Keywords: recreation management; recreation resource inventory; geo-spatial analysis; ecosystem management

1. Introduction

As the US urbanizes and competition among land uses intensifies, ecosystem protection and management for recreation become increasingly important. Since conservation and recreation planning is not commonly coordinated across administrative systems vertically (e.g., between municipal, county and state land management agencies) or horizontally (e.g., between county land management agencies), decision-making often occurs at the local level with minimal accounting for the ecological and/or cultural significance of particular ecosystems at regional and statewide scales. Altogether these phenomena may result in outdoor recreation resources that are disconnected and disproportionately distributed across ecosystems. The underrepresentation or under-protection of particular ecosystem types (e.g., prairielands, forested wetlands) in publicly-available outdoor recreation and conservation systems can have both ecological and cultural implications including decline in biodiversity, loss of natural/cultural heritage values, diminished recreation opportunities, and deficient environmental education and stewardship programming. Many agencies, especially at the federal level, are beginning to recognize the serious limitations inherent in unit-by-unit focused resource management. For example, in its proposed planning rule, the United States Department of Agriculture (USDA) Forest Service emphasizes a need for a "landscape-scale context in unit-level management" in which conditions and trends are examined across ownership boundaries [1]. To ensure the protection of ecosystem diversity and the provision of opportunities for citizens to experience and learn about diverse ecosystems, resource professionals, community planners and local decision-makers must consider the distribution and extent of conservation and recreation resources at broader scales—across ecosystems, ownership boundaries, and management jurisdictions. Decisions regarding the acquisition, protection or development of conservation and recreation resources must address fundamental questions such as "to what extent are diverse ecosystems protected across existing resources?" and "are opportunities currently available for citizens to experience and learn about a full complement of ecosystems?" In the US state of Minnesota, these questions are particularly relevant as concerns about forest parcelization, shoreline development, and recreation access for a growing and diversifying populace continue to escalate [2].

This study investigates recreation and conservation resources across ecological classifications, federal agencies, the Minnesota Department of Natural Resources (MNDNR), and select county and regional park boards, municipalities, and non-profit organizations using recreation location quotient (RLQ) analysis of select resource attributes including size and extent of specific recreation facility

characteristics. Study findings offer a systematic and comprehensive understanding of the relative supply of publicly-available outdoor recreation and conservation resources within and across ecosystems. Conservation and recreation resource managers, community planners and local decision-makers can use the study findings and RLQ analysis protocol to prioritize protected area land acquisition, protection, and development based on ecosystem protection and representation in outdoor recreation systems. The findings also may serve as a baseline to monitor trends in ecosystem protection and representation in conservation and recreation systems across time.

2. Literature Review

The basic tenets of ecosystem management establish an environmental management approach to protect ecological integrity; address ecological, social and economic goals; and operate at ecological rather than political or administrative boundaries [3]. Applying this approach requires the collection and integration of scientific data across disciplines and scales [4]. Outdoor recreation management researchers have long been keenly aware of the need for, and inherent challenges in, cross-scale integration of ecological and social data. In their seminal work, for example, Clawson and Knetsch [5] highlight the difficulties of classifying and measuring recreation resources because of their multiple spatial, biophysical, social and managerial attributes. Simply monitoring the frequency or size of recreation resources ignores other important features including geographical location and distribution, biophysical characteristics, design and programming elements, and administration. Such difficulties, echoed by later researchers [6-9], require careful consideration be taken when developing acquisition and monitoring guidelines or standards of adequacy. Furthermore, conservation and recreation resource standards and policies are inherently values driven [4]. Clawson and Knetsch caution, "standards can never be rigid; each community must determine what its citizens want, and what role they assign to recreation… hence standards can be only general guides" [5].

Outdoor recreation monitoring programs typically have assessed conservation and recreation resources based on spatial supply and demand standards or by tracking supply and demand performance temporally. The first parks and open space supply and demand indicators were introduced by Butler and were designed specifically for urban spaces [10]. Butler broadly proposed a standard of 10 acres of park and open space per 1,000 residents. Such acre-per-capita standards remain in place today. The 1995 adoption of 25 acres per 1,000 residents by the National Recreation and Park Association [11], for example, is used by various state-wide monitoring and planning initiatives across the United States as of 2011, e.g., see [12-14]. Nation-wide monitoring assessments have generally avoided supply standards, and instead scrutinize acre-per-capita metrics temporally with some geographical comparisons [7,15-17].

A closely related yet alternative strand of monitoring focuses on relative regional supply of recreation resources. English and Cordell [18], building on past research [6,7], developed the Effective Recreation Opportunity Set (EROS) index to measure recreation opportunities available to a household in a given location relative to households in other locations. Monitoring conservation and recreation resources relative to their regional context is informative in that it highlights characteristics often lost in nation-wide analyses [19]. Such regional analyses offer general science-based guidelines for protected area planning, while acknowledging that policy decisions around resource adequacy are

ultimately based on human values and preferences for endpoints. While science alone cannot determine objectively if Region X has an *adequate* supply of recreation resources, science can provide metrics to objectively compare the *extent and distribution* of recreation resources of Region X with Region Y. Extending this regional analysis approach, Marcouiller *et al.* [8,20] introduced recreation location quotient (RLQ) analysis. RLQ analysis generates standardized scores as measurements of relative differences in recreation supply and potential demand across a geographical area. Recreation resources of a given locale are compared to those of a reference region. For example, to compare the recreation resources of different counties (*i.e.*, locales), each county might be compared to the state (*i.e.*, reference region) in order to produce standardized scores. Such metrics provide standardized comparisons within a regional context and readily identify relative abundance or shortages in spatial distributions of recreation resources.

While comparative regional analyses of recreation supply—such as the RLQ—remain relatively underused, the applications of such studies in land use planning are apparent. Marcouiller and Prey [20] found the supply of recreation sites, expressed by the RLQ, had a statistically significant relationship to regional tourism dependency. In addition, research has identified a positive relationship between the relative abundance of recreation resources and lower obesity rates [21,22]. Comparative regional analyses have also assessed recreational supply in Europe, both at the state [23] and continent level [24].

The work of Marcouiller *et al.* [8] is instructive in two primary ways. First, RLQ and similar analyses can emphasize regional disparities in recreation supply, explore linkages with population distribution or social characteristics, and inform broad planning decisions. Second, research suggests RLQ analysis has great potential as a planning tool because of its adaptability to time, space, and purpose. Researchers have focused on the question of whether a region's supply of recreation resources is above or below a reference baseline either in extent (e.g., recreation resource acreage per county land area) or per capita (e.g., recreation resource acreage per county population). However, no published study has used similar analyses to explicitly explore whether the supply of conservation and outdoor recreation resources protects and represents diverse ecosystems. This study expands the RLQ analysis beyond its original focus on regional political boundaries to the ecosystem level.

3. Methods

3.1. Study Area

Minnesota is a medium-sized state in the northern mid-western region of the United States. Famous for its 10,000 lakes, Minnesota is an ecologically diverse state with prairielands, wetlands, rolling river valleys, deciduous and coniferous forestlands, and rugged rock outcroppings along the shores of Lake Superior, the largest of the North American Great Lakes. The state is also home to a strong legacy of environmental conservation and boasts one of the oldest state park systems in the United States [25]. In 2008, Minnesota voters confirmed that the protection of conservation and recreation areas continues to be valued in the passing of the Clean Water, Land and Legacy Amendment [26]. The "Legacy Amendment" dedicates funds garnered by a three-eighths of one percent increase in sales tax revenue for the protection of diverse terrestrial and aquatic ecosystems and to support parks and trails development.

In addition to the public support for, and history of, state parks and recreation areas, Minnesota's outdoor recreation system's goals make it an ideal site to apply the RLQ at the ecosystem level. Minnesota's outdoor recreation system, as laid out in the Outdoor Recreation Act of 1975, strives to serve two primary purposes: "(1) preserve an accurate representation of Minnesota's natural and historical heritage for public understanding and enjoyment, and (2) provide an adequate supply of scenic, accessible, and usable lands and waters to accommodate the outdoor recreational needs of Minnesota's citizens" [27]. Of those two purposes, the second has received the most attention. Like other US states, Minnesota has monitored performance standards and trends in acres of parks-per-capita. For instance, since 1974, the Metropolitan Council, a regional land use planning body, has maintained a goal of a minimum of 25 acres of recreation open space per 1,000 residents. More recently, this standard has been applied to other growing population centers across the state [28]. Concomitantly, the Minnesota Department of Administration, Office of Geographic and Demographic Analysis has maintained an online database of outdoor recreation trail miles and acres of parkland-per-capita since 1991 [29].

The first purpose outlined in Minnesota's Outdoor Recreation Act, however, remains relatively unexplored and is the impetus for the current study. Analyses proceeded through 3 steps. First, an updated inventory of Minnesota's recreation outdoor system was compiled. Second, the updated inventory of outdoor recreation resources was classified into ecological sections using the Ecological Classification System. Third, RLQs were calculated for each ecological section in Minnesota.

3.2. Conservation and Recreation Resources Inventory

Existing recreation and conservation resources data in Minnesota were compiled between September 2009 and October 2010. Geospatial point, line and polygon data were synthesized from federal and state resource management agencies and from local or regional agencies managing regionally significant parks and trails [30-34]. Data tables included acres of conservation and recreation resources, miles of recreation trail miles, and frequency of recreation sites with select facilities. Supply metrics were analyzed separately for forestland, nature preserves, parklands, summer motorized trails, summer non-motorized trails, water trails, winter non-motorized trails, snowmobile trails, and facilities (Table 1).

Due to the study's purpose analyzing the dispersion of outdoor recreation resources across ecological sections rather than political jurisdictions, the variety of park designations present across Minnesota were synthesized into three broad headings. Forest lands managed for multiple uses including timber production and recreation were classified as "forestland." For our purposes, this classification consists of State Forests managed by MNDNR and National Forests managed by the USDA. Lands dedicated primarily for wildlife habitat, scientific exploration, and/or open space preservation were classified as "nature preserves." This category consists of lands managed by MNDNR including State Scientific and Natural Areas and State Wildlife Management Areas, and National Wildlife Refuges managed by the US Fish and Wildlife Service. Outdoor lands dedicated primarily for public use and recreation were classified as "parklands." This classification consists of lands managed by MNDNR including State Parks, State Recreation Areas, and State Waysides; and lands managed by the US Department of Interior including National Monuments, National Parks, National Recreation Areas, National Scenic Rivers, and regionally significant parks managed at a variety of local providers, defined by [30-34].

Table 1. Inventoried supply types.

Acres:	**Miles:**
Forestland	• Summer non-motorized trails
• State forests	• Summer motorized trails
• National forests	• Water trails
	• Winter non-motorized trails
Nature preserve	• Snowmobile trails
• State scientific and natural areas	
• State wildlife management areas	**Frequency of sites with presence of:**
• National wildlife refuges	• Camping facilities, any type
	• Developed campground
Parkland	- Recreational vehicle (RV)/camper accessible
• State parks	- Americans with Disabilities Act compliant (ADA)
• State recreation areas	• Group camping
• State waysides	• Primitive camping
• National monuments	• Picnic area
• National parks	• Fishing pier
• National recreation areas	• Play ground
• National scenic rivers	• Visitor center
• Regionally significant parks [30-34]	• Equipment rental

3.3. Minnesota Ecological Classification Sections

For RLQ analysis at the ecological scale, the inventory of Minnesota's outdoor recreation resources was classified using the Ecological Classification System [35]. Ecological sections are generally defined as areas with similar sub-regional climate, geomorphic process, stratigraphy, geologic origin, topography, and drainage networks [35]. Minnesota is divided into 10 ecological sections (Figure 1; Table 2).

3.4. Recreation Location Quotient Analysis

Guided by previous research, RLQ analysis was conducted and scores calculated for each of Minnesota's 10 ecological sections. The formula for calculating the RLQ was first introduced by Marcouiller and Prey [8,20] and is shown in Equation (1):

$$RLQ_s^i = \left(\frac{r_s^i}{base_s}\right) \Big/ \left(\frac{r_n^i}{base_n}\right) \quad (1)$$

where r is the amount of recreation supply (measured by acreage, miles, or frequency), i is the recreation type, s is the ecological section, n is the reference region, and *base* is a regional characteristic providing a reference point. Our analysis used two different base metrics as rough estimates for recreational demand: area and population. Results for the two metrics were analyzed independently.

Figure 1. Minnesota's ecological sections.

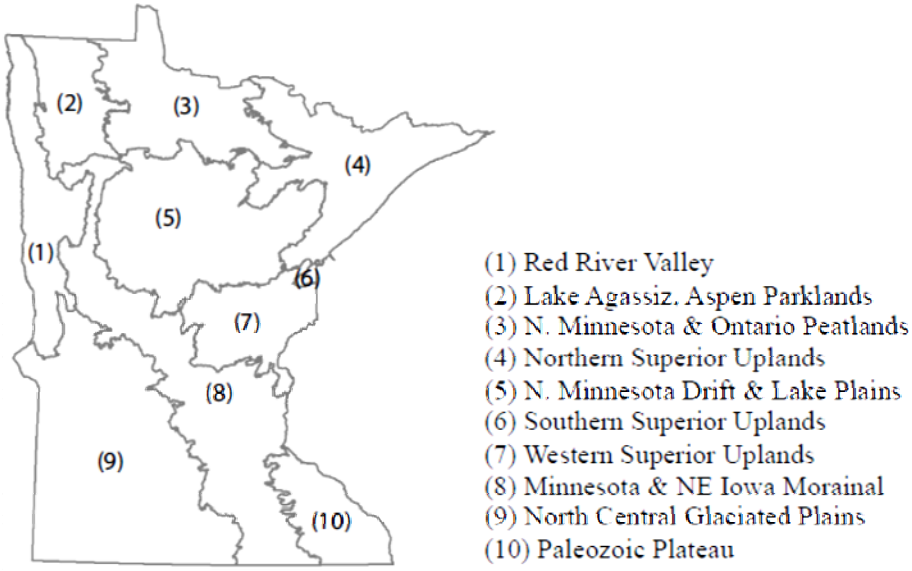


Table 2. Description of Minnesota's ecological sections (Adapted from [36]).

Ecological Section	Description
(1) Red River Valley (RRV)	This section is primarily a large, level plain partly formed by a former glacial lake (Lake Agassiz). Natural vegetation was mostly prairie and elm-ash-cottonwood cover types; now mostly agriculture.
(2) Lake Agassiz, Aspen Parklands (LAAP)	Landscape in this section is formed from a large, level lake (Glacial Lake Agassiz). Pre-European settlement vegetation was aspen-birch and prairie cover, most of which have been replaced with agricultural crops.
(3) Northern Minnesota & Ontario Peatlands (NMOP)	The topography is flat glacial lake plain with low moraines and beach ridges. Forest vegetation is aspen-birch and white-red-jack pine cover types.
(4) Northern Superior Uplands (NSU)	The physiography of this section consists of three types: a glacially scoured peneplain with lake-filled depressions in the north near Canada, highlands of drumlins on ground and end moraines, and uplands of low hills of the Mesabi Range with thin drift over iron- bearing rocks. Dominant vegetation is mostly aspen-birch, spruce-fir, white-red-jack pine, and oak-hickory cover types.
(5) Northern Minnesota Drift & Lake Plains (NMLP)	Landscape is level to gently rolling lowland characterized by glacial features. Vegetation is a mixture of aspen-birch, white-red-jack pine, and spruce-firs.
(6) Southern Superior Uplands (SSU)	This landscape consists of level to gently rolling lowlands and flat lacustrine plains with equal areas of hillier uplands and escarpments. Rock outcropings are common in upland areas. Vegetation is forests of maple-beech-birch and aspen-birch cover types
(7) Western Superior Uplands (WSU)	A relatively uniform, undulating, poorly drained, level to rolling landscape of glacial drift plains consisting of ground and end moraines, and local drumlins. Forest vegetation consists of aspen-birch, maple-beech-birch, and spruce-fir cover types.
(8) Minnesota & Northeast Iowa Morainal (MNIM)	Landscape is level plains and low, rolling hills. Existing cover type is primarily agricultural; historic vegetation was a mosaic of oak-hickory, prairie, maple-beech-birch, and elm-ash-cottonwoods.

Table 2. *Cont.*

Ecological Section	Description
(9) North Central Glaciated Plains (NCGP)	This landscape is mostly level to rolling till plain with glacial features of morainal ridges. Current cover type is mostly agricultural; historic vegetation consisted of prairie, elm-ash-cottonwood, and oak-hickory.
(10) Paleozoic Plateau (PP)	Landscape is an unglaciated upland plateau with steep-sided bedrock ridges and mounds. Current cover types are mostly urban and agricultural; historical vegetation consisted of oak-hickory and prairie cover types; the elm-ash-cottonwood cover type was along rivers.

The RLQ analysis was used to compute a standardized score to compare the supply of conservation and recreation resources across ecological sections to the state supply overall using land area and population estimates as denominators. In every analysis the state score is treated as the baseline, reported as 1.0. Ecological section scores are interpreted as the extent to which resource concentration varies from the state baseline. High scores (>1.0) indicate resources are particularly abundant and low scores (<1.0) indicate resources are particularly scarce relative to the state baseline.

4. Results

4.1. Conservation and Recreation Resources Inventory

Minnesota's publicly managed conservation and outdoor recreation resources include 60 forestland units, 1,519 nature preserve units, and 267 parkland units. In total, there are 11,316,235 acres of conservation and outdoor recreation resources in Minnesota at the federal, state and regionally significant level, accounting for 22% of the state's total land and water area (Table 3).

Statewide, Minnesotans have access to more than 11,198 miles of trails managed for summer recreation uses. Of these trail miles, 4,988 miles are maintained for non-motorized uses such as walking, hiking, inline skating, and cycling (Table 3); 4,392 miles are maintained as water trails and 1,818 miles are managed for motorized uses such as off-highway and all-terrain vehicles. In the winter, Minnesotans have access to 23,100 miles of trails including non-motorized trails (1,295 miles) and snowmobile trails (21,805 miles).

Of the 1,846 units of forestland, nature preserves, and parklands inventoried, 318 have at least one of the recreation facilities or services we selected for the resource inventory (Table 3), including picnic areas (14%), camping facilities (11%), playgrounds (7%), visitor centers (7%), equipment rental services (6%), and fishing piers (4%).

4.2. Area-Based Recreation Location Quotient Analysis

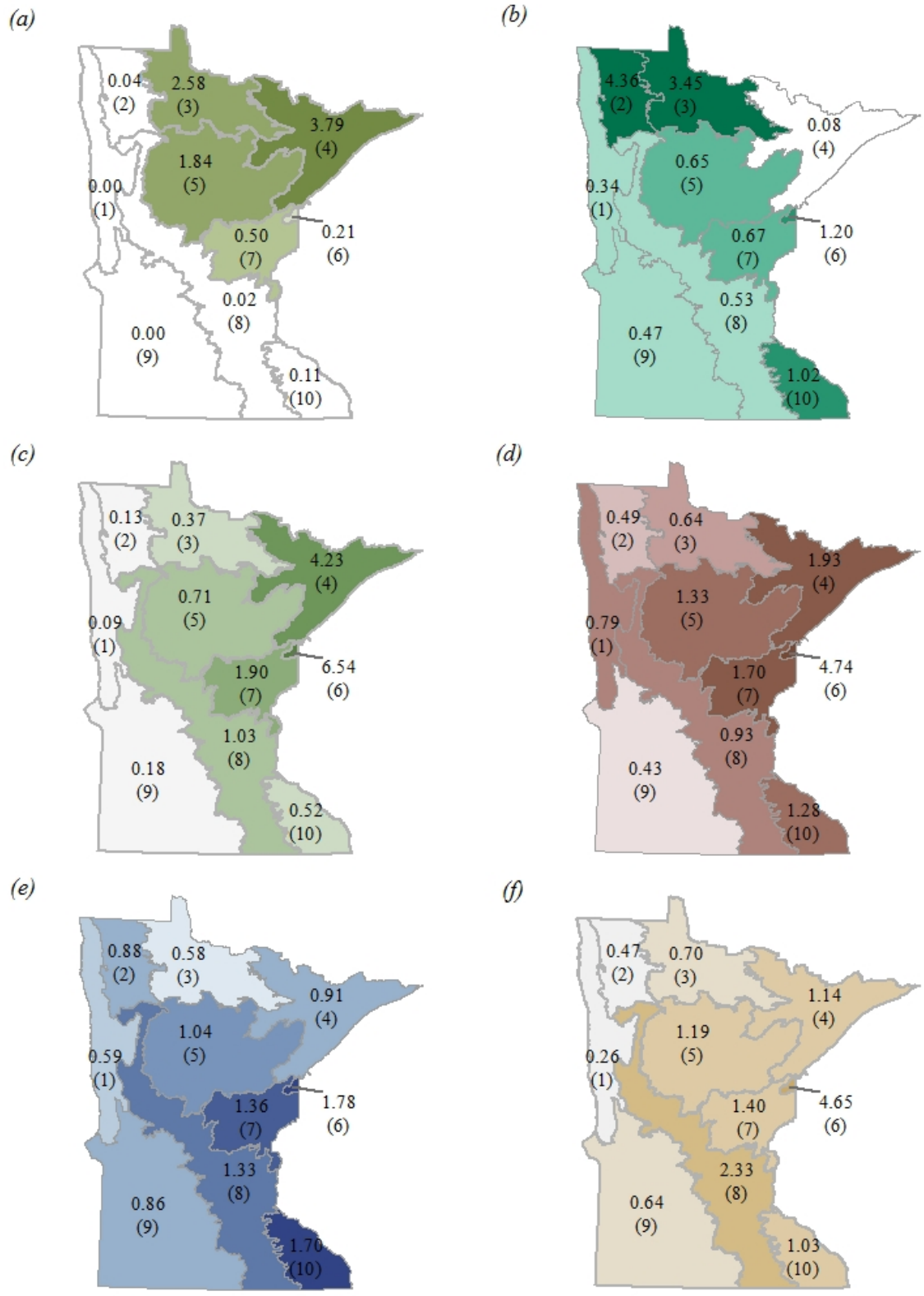
RLQ area-based analysis suggests a disproportionate distribution of conservation and outdoor recreation resources across Minnesota's 10 ecological sections (Figure 2; Table 4). Most apparent is the relative scarcity of protected areas in the southwest and west-central plains regions (e.g., North Central Glaciated Plains, Red River Valley, Lake Agassiz, Aspen Parklands ecological sections) and the relative abundance of protected areas in the northern forested lakes and Superior regions.

Table 3. Supply of conservation and outdoor recreation resources by ecological sections.

Ecological sections (acronyms correspond to Table 2)											
RECREATION TYPE	**RRV**	**LAAP**	**NMOP**	**NSU**	**NMLP**	**SSU**	**WSU**	**MNIM**	**NCGP**	**PP**	**STATE**
Acres of conservation and outdoor recreation resource areas											
Forestland [1]	0	20,035	2,442,231	4,037,105	2,744,406	4,112	299,574	28,673	0	49,580	9,625,716
Nature preserve [2]	42,346	396,322	572,695	14,514	171,130	4,119	71,405	153,473	179,987	84,528	1,690,519
Parkland [3]	3,327	3,615	18,982	247,580	58,508	7,034	63,220	93,052	21,194	13,414	529,926
Overall acreage	**42,346**	**416,357**	**3,014,926**	**4,051,619**	**2,915,536**	**8,231**	**370,978**	**182,146**	**179,987**	**134,108**	**11,316,235**
Miles of recreation resource trails											
Summer non-motorized	87	39	195	1,853	1,017	76	349	843	330	198	4,988
Summer motorized	37	144	173	159	637	24	535	36	24	48	1,818
Water trails	525	110	336	375	665	8	309	892	718	455	4,392
Overall summer trail miles	**649**	**293**	**704**	**2,388**	**2,319**	**108**	**1,193**	**1,772**	**1,072**	**701**	**11,198**
Winter non-motorized	5	15	25	581	81	27	88	262	82	129	1,295
Snowmobile	993	1,074	1,279	1,754	3,642	57	1,884	4,951	4,380	1,790	21,805
Overall winter trail miles	**998**	**1,089**	**1,304**	**2,335**	**3,724**	**84**	**1,973**	**5,213**	**4,462**	**1,919**	**23,100**
Number of conservation and outdoor recreation resource areas with presence of recreation resource facilities											
Camping facilities	4	6	20	28	51	3	23	51	37	9	201
Developed camping	4	4	10	16	22	1	15	43	37	7	145
RV/camper	2	4	7	12	16	1	9	27	33	6	108
ADA camp	2	0	5	9	11	1	5	14	8	4	51
Group camping	3	3	7	8	12	1	8	16	10	7	75
Primitive camping	1	6	17	24	42	3	16	22	12	5	121
Picnic area	5	6	13	23	39	3	19	116	44	13	256
Fishing pier	2	3	11	7	13	0	5	39	10	1	79
Play ground	3	3	2	6	14	0	6	62	29	5	127
Visitor center	1	5	15	26	39	3	15	32	10	6	126
Equipment rental	0	3	16	21	36	3	16	30	10	5	117
Overall facilities	**6**	**8**	**22**	**40**	**59**	**3**	**28**	**126**	**46**	**16**	**318**

Notes: 1 = State & national forests; 2 = National wildlife refuges, state scientific & natural areas, state wildlife management areas; 3 = Regionally significant parks, state parks, state recreation areas, state waysides, national monuments, national parks, national recreation areas, and national scenic rivers.

Figure 2. Area based RLQs for (**a**) forestland, (**b**) nature preserve, (**c**) parkland, (**d**) summer trails, (**e**) winter trails, and (**d**) facilities.



(1) Red River Valley (2) Lake Agassiz, Aspen Parklands (3) Northern Minnesota & Ontario Peatlands (4) Northern Superior Uplands (5) Northern Minnesota Drift & Lake Plains (6) Southern Superior Uplands (7) Western Superior Uplands (8) Minnesota & Northeast Iowa Morainal (9) North Central Glaciated Plains (10) Paleozoic Plateau

Table 4. Area-based recreation location quotients by ecological section.

Ecological sections (acronyms correspond to Table 2)										
RECREATION TYPE	**RRV**	**LAAP**	**NMOP**	**NSU**	**NMLP**	**SSU**	**WSU**	**MNIM**	**NCGP**	**PP**
Acres of conservation and outdoor recreation resource areas										
Forestland [1]	-	0.039	2.582	3.793	1.835	0.210	0.495	0.017	-	0.105
Nature preserve [2]	0.343	4.355	3.448	0.078	0.651	1.200	0.672	0.533	0.473	1.020
Parkland [3]	0.086	0.127	0.365	4.225	0.711	6.535	1.899	1.031	0.178	0.516
Overall acreage	**0.053**	**0.659**	**2.607**	**3.282**	**1.616**	**0.634**	**0.583**	**0.136**	**0.076**	**0.254**
Miles of recreation resource trails										
Summer non-motorized	0.240	0.147	0.398	3.360	1.313	7.456	1.114	0.993	0.294	0.808
Summer motorized	0.277	1.471	0.969	0.793	2.254	6.594	4.686	0.118	0.059	0.540
Water trails	1.638	0.464	0.778	0.773	0.974	0.878	1.118	1.193	0.727	2.113
Overall summer trail miles	**0.794**	**0.486**	**0.640**	**1.928**	**1.333**	**4.736**	**1.695**	**0.930**	**0.426**	**1.276**
Winter non-motorized	0.052	0.215	0.196	4.058	0.404	10.100	1.086	1.188	0.281	2.034
Snowmobile	0.624	0.915	0.597	0.727	1.075	1.286	1.376	1.334	0.893	1.675
Overall winter trail miles	**0.592**	**0.876**	**0.575**	**0.914**	**1.037**	**1.780**	**1.360**	**1.326**	**0.859**	**1.695**
Number of conservation and outdoor recreation resource areas with presence of recreation resource facilities										
Camping facilities	0.273	0.555	1.013	1.260	1.633	7.348	1.822	1.490	0.818	0.913
Developed camping	0.378	0.513	0.702	0.998	0.976	3.395	1.647	1.742	1.135	0.985
RV/camper	0.254	0.688	0.660	1.005	0.953	4.559	1.327	1.469	1.359	1.133
ADA camp	0.538	-	0.998	1.596	1.388	9.653	1.561	1.612	0.697	1.600
Group camping	0.548	0.743	0.950	0.965	1.030	6.564	1.698	1.253	0.593	1.904
Primitive camping	0.113	0.921	1.430	1.794	2.234	12.206	2.105	1.068	0.441	0.843
Picnic area	0.268	0.435	0.517	0.812	0.980	5.769	1.182	2.662	0.764	1.036
Fishing pier	0.347	0.706	1.417	0.801	1.059	-	1.008	2.900	0.563	0.258
Play ground	0.324	0.439	0.160	0.427	0.709	-	0.752	2.868	1.015	0.803
Visitor center	0.109	0.737	1.212	1.866	1.992	11.722	1.895	1.492	0.353	0.971
Equipment rental	-	0.476	1.392	1.623	1.980	12.624	2.177	1.506	0.380	0.872
Overall facilities	**0.259**	**0.467**	**0.704**	**1.138**	**1.194**	**4.645**	**1.402**	**2.327**	**0.643**	**1.026**

Notes: 1 = State & national forests; 2 = National wildlife refuges, state scientific & natural areas, state wildlife management areas; 3 = Regionally significant parks, state parks, state recreation areas, state waysides, national monuments, national parks, national recreation areas, and national scenic rivers.

The majority (81%) of resource acres protected in Minnesota are in the form of state or national forests. These forestlands are concentrated in the north central and northeastern regions (Northern Minnesota and Ontario Peatlands, Northern Minnesota Drift and Lake Plains, and Northern Superior Uplands). Nature preserves for wildlife habitat protection and scientific study are predominately located in northwestern Minnesota (Lake Agassiz, Aspen Parklands and Northern Minnesota and Ontario Peatlands). Parklands (*i.e.*, areas designed primarily for recreation and cultural resources) are concentrated in Lake Superior's uplands. The RLQ scores for parklands in the three Superior Upland sections range from approximately two to more than six times that of the state baseline (Southern Superior Uplands = 6.54, Northern Superior Uplands = 4.23, Western Superior Uplands = 1.90). While the Superior Uplands sections are well represented by parklands, other ecological sections appear to be lacking representation in these systems. For example, the Red River Valley section, Lake Agassiz, Aspen Parklands section, North Central Glaciated Plains section, and Northern Minnesota and Ontario Peatlands section each have RLQ scores for parklands under 0.4.

Both recreation trails and facilities are more evenly distributed across ecological sections than resource areas, but disparities still exist. Interestingly, the supply of resource trails appears to vary by seasons of use. For example, the Northern Minnesota and Northeast Iowa Morainal (RLQ = 1.33) and Paleozoic Plateau (RLQ = 1.68) sections are relatively rich in snowmobile trail miles but somewhat deprived of summer-motorized trails (0.12 and 0.54, respectively). Resource trail scores indicate a relative abundance of winter and summer trail miles in the Northern Minnesota Drift and Lake Plains, Paleozoic Plateau, Southern Superior Uplands, and Western Superior Uplands sections. At the same time, resource trail scores indicate a relative scarcity of trail miles in the southwestern prairies and northwestern prairies/marshland sections (e.g., Lake Agassiz, Aspen Parklands, Northern Minnesota and Ontario Peatlands, North Central Glaciated Plains, and Red River Valley).

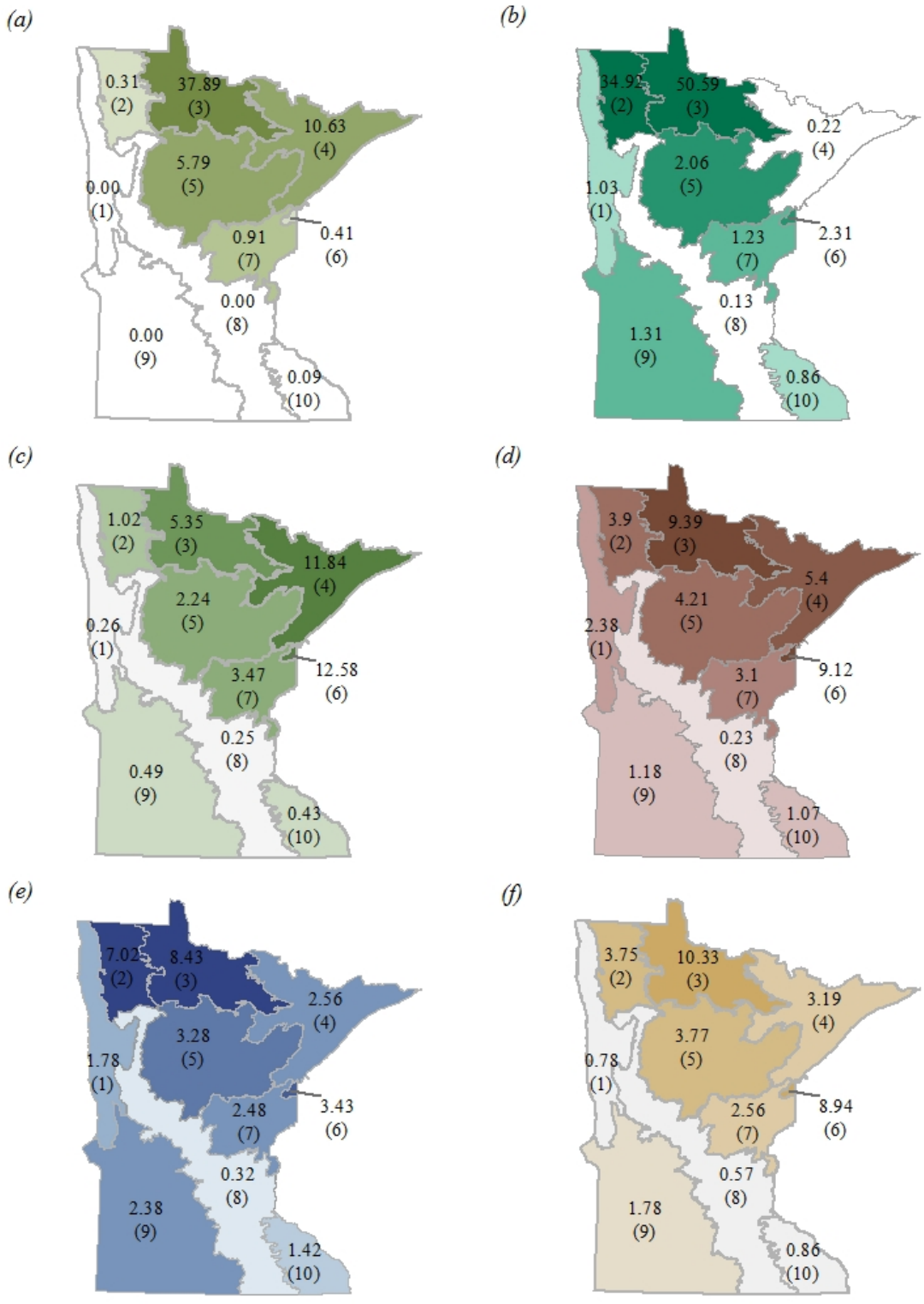
The distribution of resource facilities across ecological sections parallels the distribution of trails. The Lake Agassiz, Aspen Parklands, Northern Minnesota and Ontario Peatlands, North Central Glaciated Plains, and Red River Valley have relatively few sites with resource facilities. RLQ analysis of the Minnesota and Northeast Iowa Morainal section shows a relative abundance of resource facilities (RLQ = 2.33) despite its relatively low overall resource area score (RLQ = 0.14). This section encompasses the Twin Cities metropolitan area where parklands, though relative low in overall concentration, tend to be highly developed.

4.3. Population-Based Recreation Location Quotient Analysis

The population-based RLQ identifies ecological sections with a relative abundance or deficit of resource area acreage, trail miles, and facilities given each section's population (Figure 3; Table 5). Scores for overall acreage show the Northern Minnesota and Ontario Peatlands with almost 40 times the state baseline of resource areas per capita. Sections such as Minnesota and Northeast Iowa Morainal, which includes the Twin Cities metropolitan area, and Red River Valley have less than 20% of the resource area acreage per capita that the state has overall. While these statistics seem to be largely consistent across recreation resource area types, a smaller disparity exists in the distribution of parklands across ecological sections. The Southern Superior Uplands (RLQ = 12.58) and Northern Superior Uplands (RLQ = 11.84) have the highest scores, or the most parkland per resident, of any

section. The Minnesota and Northeast Iowa Morainal (RLQ = 0.25) and Red River Valley (RLQ = 0.25) have the lowest scores.

Figure 3. Population based RLQs for (**a**) forestland, (**b**) nature preserve, (**c**) parkland, (**d**) summer trails, (**e**) winter trails, and (**d**) facilities.



(1) Red River Valley (2) Lake Agassiz, Aspen Parklands (3) Northern Minnesota & Ontario Peatlands (4) Northern Superior Uplands (5) Northern Minnesota Drift & Lake Plains (6) Southern Superior Uplands (7) Western Superior Uplands (8) Minnesota & Northeast Iowa Morainal (9) North Central Glaciated Plains (10) Paleozoic Plateau

Table 5. Population-based recreation location quotients by ecological section.

Ecological sections (acronyms correspond to Table 2)										
RECREATION TYPE	**RRV**	**LAAP**	**NMOP**	**NSU**	**NMLP**	**SSU**	**WSU**	**MNIM**	**NCGP**	**PP**
Acres of conservation and outdoor recreation resource areas										
Forestland [1]	-	0.310	37.887	10.630	5.794	0.405	0.905	0.004	-	0.088
Nature preserve [2]	1.030	34.922	50.587	0.218	2.057	2.310	1.228	0.130	1.310	0.857
Parkland [3]	0.258	1.016	5.349	11.842	2.243	12.583	3.470	0.251	0.492	0.434
Overall acreage	**0.159**	**5.281**	**38.243**	**9.199**	**5.101**	**1.222**	**1.066**	**0.033**	**0.209**	**0.213**
Miles of recreation resource trails										
Summer non-motorized	0.720	1.177	5.844	9.418	4.145	14.358	2.035	0.242	0.814	0.679
Summer motorized	0.829	11.791	14.217	2.222	7.118	12.697	8.561	0.029	0.163	0.454
Water trails	4.911	3.719	11.421	2.165	3.077	1.692	2.043	0.291	2.012	1.775
Overall summer trail miles	**2.382**	**3.897**	**9.391**	**5.405**	**4.209**	**9.120**	**3.098**	**0.227**	**1.178**	**1.072**
Winter non-motorized	0.155	1.721	2.879	11.374	1.276	19.450	1.984	0.290	0.777	1.709
Snowmobile	1.872	7.339	8.760	2.039	3.394	2.476	2.513	0.325	2.472	1.407
Overall winter trail miles	**1.776**	**7.024**	**8.430**	**2.562**	**3.275**	**3.428**	**2.484**	**0.323**	**2.377**	**1.424**
Number of conservation and outdoor recreation resource areas with presence of recreation resource facilities										
Camping facilities	0.818	4.447	14.858	3.531	5.156	14.150	3.328	0.363	2.266	0.767
Developed camping	1.134	4.109	10.298	2.797	3.083	6.538	3.009	0.425	3.141	0.827
RV/camper	0.762	5.517	9.678	2.816	3.010	8.778	2.424	0.358	3.761	0.952
ADA camp	1.613	-	14.640	4.473	4.383	18.589	2.851	0.393	1.931	1.344
Group camping	1.645	5.958	13.937	2.704	3.251	12.641	3.102	0.305	1.641	1.599
Primitive camping	0.340	7.387	20.980	5.027	7.053	23.505	3.846	0.260	1.221	0.708
Picnic area	0.803	3.491	7.583	2.277	3.096	11.110	2.159	0.649	2.115	0.870
Fishing pier	1.041	5.657	20.792	2.246	3.344	-	1.841	0.707	1.558	0.217
Play ground	0.971	3.519	2.352	1.197	2.240	-	1.374	0.699	2.811	0.675
Visitor center	0.326	5.911	17.777	5.230	6.290	22.573	3.462	0.364	0.977	0.816
Equipment rental	-	3.820	20.420	4.549	6.252	24.309	3.977	0.367	1.052	0.732
Overall facilities	**0.776**	**3.747**	**10.331**	**3.188**	**3.770**	**8.944**	**2.561**	**0.567**	**1.780**	**0.862**

Notes: 1 = State & national forests; 2 = National wildlife refuges, state scientific & natural areas, state wildlife management areas; 3 = Regionally significant parks, state parks, state recreation areas, state waysides, national monuments, national parks, national recreation areas, and national scenic rivers.

With respect to trails, the Northern Minnesota and Ontario Peatlands has the most summer (RLQ = 9.39) and winter (RLQ = 8.43) trail miles per capita of any section, while Minnesota and Northeast Iowa Morainal has the fewest summer (RLQ = 0.32) and winter (RLQ = 0.32) trail miles per capita. RLQ analysis of facilities paints a similar picture. The Northern Minnesota and Ontario Peatlands (RLQ = 10.33) and Southern Superior Uplands (RLQ = 8.94) have the most sites with the selected facilities per capita, while Minnesota and Northeast Iowa Morainal (RLQ = 0.57) and Red River Valley (RLQ = 0.78) have the fewest facilities per capita.

5. Discussion and Conclusions

This paper presents a new RLQ application that assesses the supply of publicly protected conservation and recreation resources across ecological sections in the state of Minnesota by land area and by population. The study combined a comprehensive inventory of publically protected areas, an ecological classification system, US Census Bureau population data, and RLQ analysis to evaluate the distribution and abundance of conservation and outdoor recreation resources across ecological sections. The study takes an ecosystem management approach by focusing on ecological protection and operating at ecological rather than political or administrative boundaries [3]. Further, the system enables local planning decisions be made within the context of regionally defined landscapes and ecological sections.

RLQ analysis is not without limitations, however. Importantly, RLQ analysis is associated with a baseline metric, which is often misinterpreted as a standard. Though RLQ scores suggest relative abundance and deficits of resources across ecological sections and the scores can bring to the forefront issues of parity, they do not speak to the quality of the resources or the adequacy of the overall supply of resources in the state given current population demands or ecosystem service needs. Heeding Clawson and Knetsch's [5] warning, the state average, 1.0, should be viewed as the baseline or status quo and not a standard or target. Another limitation is inherent in our population-based RLQ analysis. While our findings speak to the relative distribution of recreation resources given each section's population, it does not account for true recreation demand (*i.e.*, visitation statistics) nor does it represent interregional demand between sections (*i.e.*, tourism). For example, the Northern Superior Uplands has the majority of forestland in the state and includes the Superior National Forest and the Boundary Waters Wilderness Area. Both of these recreation resource areas serve as major recreation destinations for tourists statewide. Thus, the population-based RLQs must be interpreted with this caveat. To date, comprehensive recreation visitation and tourism data are not available at the ecological section level. Recognizably, using only area and population metrics to estimate recreational demands fails to consider the diversity of socio-demographic characteristics researchers have identified as important influences affecting recreation patterns. By this omission we do not intend to imply socio-demographics are unimportant; they are simply beyond the scope of the current study. In addition to the ecological considerations our findings highlight, comprehensive planning efforts ought to account for recreationalists' age [37], gender [38], social class [39], and ethnicity [40-42], all issues pertinent to researchers internationally.

Despite the limitations, our results underscore the utility of RLQ analysis as a planning tool on three accounts.

First, RLQ scores assist decision-makers in prioritizing future conservation and recreation area acquisition, protection and development. In Minnesota, for example, given the RLQ scores, resource planners may direct future land acquisition projects on the western prairie and marshland ecological sections (e.g., Red River Valley, North Central Glaciated Plains, and Minnesota and NE Iowa Morainal) where relatively few recreation and conservation resources are currently protected. Such findings provide land use planners with objective data to support and guide decision-making processes related to park expansion and development.

Second, results provide a new lens to assess a region's nature-based recreation and learning opportunities. Recreation resource systems should represent a full array of ecosystem types to increase awareness of, build appreciation for, and promote stewardship of landscapes across the ecological spectrum. Such considerations are especially important areas like Minnesota with a historical legacy of converting land into agricultural production (e.g., Red River Valley and North Central Glaciated Plains) and urban uses (e.g., Minnesota and NE Iowa Morainal and Paleozoic Plateau). Given a region's history of competing land uses, developing representative outdoor recreation and conservation systems will pose multiple challenges. In Minnesota, for example, much of the ecological sections currently underrepresented by the state's outdoor recreation system is under private ownership [43], is economically productive [44], and the landscapes themselves don't always meet the traditional standards of "scenic beauty" [45-50]. In light of deeply rooted, historical, economic, and emotional challenges, tools such as the RLQ can provide a systematic and objective assessment to help planners incorporate ecological priorities into recreation decisions.

Third, the ecological RLQ provides information to planners interested in cross-jurisdictional management and planning. Inherent to our ecological approach is the idea that traditional, geo-political boundaries can produce gaps in environmental management [51,52]. Our results confirm this hypothesis: traditional recreation planning methods in Minnesota have resulted in an outdoor recreation system that provides disproportional opportunities across the state's ecological landscapes. Future recreation planners, then, need to be mindful of what opportunities are available not only across levels of government and geo-political boundaries, but also across different land types. The ecological RLQ can help in these efforts.

While our results are specific to the US state of Minnesota, our conclusions and the applicability of the RLQ are not. Using Minnesota only as an example, we hope to have demonstrated adapting the RLQ to landscape/ecological scales is valuable in prioritizing acquisition decisions, highlighting ecological disparities in park and trail systems, and informing cross-jurisdictional planning. These concerns are not unique to Minnesota or to the United States and have been acknowledged internationally. Outlined in the founding document of The International Union for Conservation of Nature and Natural Resources, for example, is an objective to strengthen capacity to conserve biological and ecological diversity across global, regional, national, and local levels of governance [53]. Providing opportunities for recreationalists to develop deep aesthetic, symbolic, and spiritual relationships [54,55] with landscapes across the ecological spectrum is vital to this mission. The RLQ may be especially applicable in working toward this goal in Europe, where the value of outdoor recreation is widely recognized in legislation but measurement and monitoring of recreation uses is sometimes suspended from legislative goals [56]. Thus, for recreation managers who are both conscious of "ecological

aesthetics" [47,55] and charged with a mandate to develop and sustain representative outdoor recreation systems, the RLQ is a valuable tool.

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Conflict of Interest

The authors declare no conflict of interest.

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