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A Biological Comparison of Two Sites: An Ecological Approach using Community Ecology Metrics based on Insect Faunal Composition

Kennedy J. Martin
Portland State University

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Kennedy J. Martin

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Luis A. Ruedas

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ABSTRACT

Two natural sites in the Portland urban area managed by the City of Portland's Parks and Recreation Department, River View Natural Area (RVNA) and Powers Marine Park (PMP), were sampled to assess their insect faunal composition with the intention of determining whether the areas are sufficiently similar ecologically that they could potentially be managed as a single unit. The two areas were compared using community ecology metrics based on their respective invertebrate fauna. The results suggested that RVNA and PMP had statistically different ecological communities. The Shannon Diversity Index for PMP was 0.303, and 0.819 for RVNA. The Horn Index of Community Overlap suggested a 93.46% overlap based on these data; however, a Hutcheson's t–test for community ecology data suggested significant differences ($P <<< 0.0001$) between PMP and RVNA's insect faunal compositions.

INTRODUCTION

Natural areas are vital for the conservation of biodiversity, particularly when these areas are located in more urbanized settings. When natural areas decline we lose components of nature that are essential to maintaining agriculture and ecosystems, as well those that potentially benefit human health (Dizney and Ruedas, 2009; Schwägerl, 2016). As our cities continue to expand and push further into nature, it is important to protect, if not increase, the land that is set aside for parks, forests, and other natural areas. The question of how to best care for such areas reflects a debate that is central to the work of many ecologists and conservation biologists.

The manner in which protected areas are managed is of concern to local taxpayers as it can be much more cost–effective to manage adjacent natural areas as a single unit. The effectiveness of protection strategies is often assessed by analyzing loss of natural cover, social-ecological spillover, and population diversity of both plant and animal species (Ament & Cumming, 2016). High resolution ecological data are extremely useful in assessing the social-ecological dynamics surrounding natural areas.

For example, biomonitoring uses organisms in natural communities to gauge the impact by humans (or other) impacts on particular ecosystems. This information can then be used to develop and implement management plans for the studied areas. Insects are often used as bioindicators in these studies due to their sensitivity to environmental change. However, another advantage to using insects in biomonitoring includes their abundance and, in many instances, large population sizes (McGeogh, 1998). In addition, using plants or vertebrates for biomonitoring incurs a greater regulatory burden.

The present study, the analysis of insect population density and diversity, examination of plant species diversity, and estimated canopy cover, in a series of randomized plots, make up the

bulk of the data for a potential management assessment of two natural or semi–natural areas owned by the City of Portland: Powers Marine Park and River View Natural Area.

Powers Marine Park and River View Natural Area are two adjacent areas split in two by a single busy road. Powers Marine Park lies between the Willamette River and SW Macadam Ave (Oregon State Road 43). River View Natural Area is located on the west side of SW Macadam Ave. This road also serves as an impediment to any potential flow of organisms between sites. RVNA and PMP are also connected by culverts meant to act as wildlife corridors. However, it unclear whether there is any flow of species or movement of species through these culverts between the two sites. The assessment presented herein was undertaken in order to assess the ecological community similarity between the two sites using community ecology data.

MATERIALS AND METHODS

Site Description and Selection

River View Natural Area encompasses 146 acres, with 7 streams running through the property. It is bordered by Lewis and Clark College to the south, residential neighborhoods to the west, River View cemetery to the north, and SW Macadam Ave (OR 43) to the east. Powers Marine Park is a long and narrow property of approximately 14.25 acres wedged between OR 43 and the Willamette River. The riparian floodplain is home to hardwoods and riparian adapted herbaceous plants. Just west of this floodplain lies a mixed coniferous–hardwood forest abutting OR 43. All plots from which samples were collected were within the riparian zone or at the interface between floodplain and forest, and encompassing both habitat types.

A map of each park was divided into grids 14.14 m by 7.07 m (Brower et al. 1998) and a random number generator used to select three plots in each park. Each plot was sketched and photographed from all corners. Location of each plant within a plot was documented on the main sketch of the area. All flora contained in the plot were identified and recorded (Table 2 and Table 4).

Trees

In each plot, trees over 10 cm in diameter at breast height were identified and documented on the main sketch of the area (Tables 1 and 3). The radius of the canopy for each tree was measured by estimating the average extent of the canopy from the ground and measuring the distance from the tree to that point (Table 1 and Table 3). Tree height was calculated using distance from the base and the angle to the top of the tree using a clinometer and measuring tape.

Invertebrate Sampling

All invertebrates were captured using plastic pitfall traps. Each pitfall trap (710 mL capacity, 10 cm diameter, 15 cm deep) was filled with a small amount of ethanol to euthanize and preserve captured invertebrates, as well as being covered by an elevated plastic lid in order to prevent flooding by rainwater. Traps were arranged in a web configuration (Parmenter et al. 2003), with 5 central traps and 12 radial spokes of 11 trap stations per spoke at 1 m intervals, for a total of 137 traps. After a trap array was set, it was resampled and reset every 48 hours for a total of 3 sample collections per plot.

Sample Processing

Samples were collected three times from each web array at RVNA and PMP. Each row of an array was collected into a single labeled cup. Samples were then rinsed with ethanol and inspected under magnification. Invertebrates were identified to the lowest possible taxonomic category, sorted into one of 16 taxonomic categories (Table 5), and placed into labelled, ethanol filled storage vials. The vials were stored until the final counts could be performed.

Data Analysis

The collected invertebrate samples from both RVNA and PMP were used to calculate the indices of species diversity using the Shannon Diversity Index, H' (Shannon, 1948). The Shannon Diversity Index is an information theoretic index; that is, it takes into consideration both the presence-absence of species as well as the abundance. A Hutcheson's t-test was applied in order to calculate the significance of similarity between the diversity indices of RVNA and PMP (Hutcheson, 1970). The Horn Index of Community Overlap was used to determine the proportional overlap between the two communities (Horn, 1966).

RESULTS

Plot Characteristics/Structural Analysis—River View Natural Area

Plot 1. Geographic coordinates: 45.456301°N, 122.673820°W; Elevation: 140m (datum: WGS84)					
Plant #	Species (common name)	Diameter (m)	Canopy Radius (m)	Canopy Area (m^2)	Tree Height (m)
1	Big leaf maple	0.4386	8.5	227.0	32.6
2	Pacific red cedar	0.1705	2.4	18.1	10.9
3	Pacific red cedar	0.2879	0.6	1.1	14.9
4	Big leaf maple	0.3835	6.24	122.3	24.6

Table 1, continued

5	Big leaf maple	0.5822	4	50.3	28.9
6	Big leaf maple (snag)	0.3566	0	0	19.4
Plot 2. Geographic coordinates: 45.456471°N, 122.671792°W, Altitude: 122m (datum: WGS84)					
Plant #	Species	Diameter (m)	Canopy Radius (m)	Canopy Area (m)	Tree Height (m)
1	Big leaf maple	53.6	10.3	333.3	39.7
2	Big leaf maple	69.9	6.7	141.0	52.9
3	Western hemlock	11.9	1.9	11.3	11.0
Plot 3. Geographic coordinates: 45.454551°N, 122.673230°W, elevation: 133m (datum: WGS84)					
Plant #	Species	Diameter (m)	Canopy Radius (m)	Canopy Area (m)	Tree Height (m)
1	Big leaf maple	24.8	8.53	228.6	28.9
2	Douglas fir	14.9	4.35	59.4	12.5
3	Western hemlock	89	5	78.5	42.0
4	Pacific red cedar	25.1	4.1	52.8	6.5

Table 2: Plant species found in RVNA plots.

Scientific Name	**Common Name**
Acer circinatum	Vine Maple
Acer macrophyllum	Big Leaf Maple
Athyrium sp.	Lady Fern
Gaultheria shallon	Salal
Mahonia aquifolium	Oregon Grape
Maianthemum racemosum	False Solomon's Seal
Polypodium glycyrrhiza	Licorice Fern
Polystichum munitum	Sword Fern
Pseudotsuga menziessii	Douglas Fir
Rhamnus purshiana	Cascara Buckthorn
Rosa gymnocarpa or *R. nutkana*	Baldhip Rose or Nookta Rose
Symphoricarpos albus	Snowberry
Thuja plicata	Western Red Cedar (Oregon Cedar, Canoe cedar)

Table 2, continued.

Tusga heterophylla	Western Hemlock or (Pacific Hemlock)
Vaccinium parvifolium Sm.	Red Huckleberry
Unknown plants (4 species)	

Plot Characteristics/Structural Analysis—Powers Marine Park

Table 3: Plot location and trees in PMP.

Plot 1. Geographic coordinates: 45.45678°N, 122.66287°W, elevation: 21 m (datum: WGS 84)					
Plant #	Species	Diameter (m)	Canopy Radius (m)	Canopy Area (m)	Tree Height (m)
1	Pacific willow	0.325 (at 4.65m from base)	8.5	227.65	12.28
2	Pacific willow	0.48 (at 4.84m from base	2.4	18.09	9.00
Plot 2. Geographic coordinates: WGS84: 45.45819°N, 122.66403°W, elevation 21 m (datum: WGS 84)					
Plant #	Species	Diameter (m)	Canopy Radius (m)	Canopy Area (m)	Tree Height (m)
1	Pacific willow	0.267	8	200.96	9.25
2	Pacific willow	0.332	7.1	158.29	15.64
3	Pacific willow	0.18	3.5	38.465	6.50
Plot 3. Geographic coordinates: 45.454551°N, 122.673230°W, elevation 21 m (datum: WGS84)					
Plant #	Species	Diameter (m)	Canopy Radius (m)	Canopy Area (m)	Tree Height (m)
1	Oregon ash	0.15	5.4	91.56	11.20
2	White alder	0.339	9.3	271.58	26.64
3	White alder	0.315	8.3	216.31	36.26
4	White alder	0.314	10.4	339.62	17.92
5	Black cottonwood	0.424	9.06	257.73	39.10
6	Black cottonwood	0.175	0 (snag)	0	14.64
7	Black cottonwood	0.212	6.25	122.65	14.64

Table 4: Plant species found in PMP plots.

Scientific Name	**Common Name**
Alnus rhombifolia	White Alder
Athyrium Roth	Lady Fern
Cornus sericea	Red Twig Dogwood
Fraxinus latifolia	Oregon Ash
Geum macrophyllum	Large–leaved Geum
Hedera helix	English Ivy
Impatiens capensis	Spotted Jewel Weed
Mentha pulegium	Pennyroyal
Populus trichocarpa	Black Cottonwood
Quercus garryana	Oregon White Oak (not verified)
Rhamnus purshiana	Cascara Buckthorn
Rubus ursinus	Pacific Blackberry
Salix lucida	Pacific Willow
Solanum dulcamara	Bittersweet Nightshade
Symphyotrichum Subspicatum	Douglas' Aster
Trametes versicolor	Turkey Tails
Urtica dioica	Stinging Nettle
Viburnum ellipticum	Oregon Viburnum
Unknown A	Sedge (not verified)
Unknown B	Cone Flower–Type Plant (not verified)
Unknown C	Bush–like with Brown pods (not verified)
Unknown D	Waxy Leafed Ground Cover (not verified)

Faunal Characterics

A total of 9835 invertebrates were collected in the two sites (Table 5). Of these, arthropods were identified to order, with the exception of Coleoptera and Arachnida, which were identified to family. However, some Coleoptera had to be placed in the "other" category due to lack of taxonomic expertise. Non–arthropod invertebrates also were classified as "other," for the same reason.

In the RVNA site we collected 2957 invertebrates, while in the PMP site we collected 7010. The only group that was specific to one site only was the arachnid Order Pseudoscorpiones, which were found only at the RVNA site. All other orders and families were found at both sites, although in differing densities (Tables 6–7; Fig. 1).

Table 5: Invertebrates collected (total numbers of each taxon) at RVNA and PMP.

		RVNA	**PMP**	**TOTAL**
Coleoptera	Carabidae	635	707	1342
	Curculionidae	2	2	4
	Other	22	97	119
Diptera		66	53	119
Hymenoptera		10	15	25
Acari		252	30	282
Araneae		321	111	432
Pseudoscorpiones		9	0	9
Opiliones		3	16	19
Orthoptera		2	8	10
Collembola		921	5853	6774
Isopoda		520	23	543
Hemiptera/ Hemoptera		24	6	30
Myriapoda		55	19	74

Table 5, continued.

Unidentified Larvae		24	29	53
Other		91	41	132
TOTAL		**2957**	**7010**	**9835**
Shannon Index		**0.8185**	**0.3031**	***P* <<< 0.0001**
Horn index				**0.9346**

Table 6: Estimates of density at center of research plots, in individuals per square meter, calculated using the program "Distance" v. 7.0 (Thomas et al. 2010), for each of the taxa under consideration in either site.

		Density estimate	Standard Error	Lower 95% CI	Upper 95% CI
Carabidae	RVNA	152.39	43.10	86.58	268.24
	PMP	169.67	46.74	97.73	294.58
Curculionidae	RVNA	2.88	0.68	1.78	4.67
	PMP	2.88	0.68	1.78	4.67
Other Coleoptera	RVNA	7.04	2.96	2.99	16.58
	PMP	27.93	10.32	13.28	58.75
Diptera	RVNA	21.12	6.06	11.88	37.56
	PMP	13.88	4.88	6.87	28.02
Hymenoptera	RVNA	4.11	1.29	2.17	7.79
	PMP	7.20	2.34	3.68	14.07
Acari	RVNA	72.57	22.82	38.67	136.21
	PMP	7.85	2.85	3.80	16.23
Araneae	RVNA	77.04	21.72	43.83	135.39
	PMP	26.64	9.47	13.11	54.12
Pseudoscorpiones	RVNA	5.184	1.35	3.058	8.79
	PMP	0.00	0.00	0.00	0.00
Opiliones	RVNA	4.32	1.76	0.93	20.12
	PMP	11.52	3.39	6.30	21.06
Orthoptera	RVNA	5.76	1.36	3.55	9.34
	PMP	4.61	2.04	1.72	12.35
Collembola	RVNA	221.00	99.25	90.25	541.29
	PMP	1404.60	550.97	642.25	3072.00
Isopoda	RVNA	124.79	40.05	65.84	236.54
	PMP	8.28	2.74	4.24	16.16
Hemiptera and Homoptera	RVNA	7.68	2.68	3.80	15.54
	PMP	3.46	1.00	1.92	6.23

Table 6, continued.

Myriapoda	RVNA	13.20	3.92	7.30	23.87
	PMP	9.12	4.57	3.07	27.11
Unidentified larvae	RVNA	6.91	2.99	2.88	16.58
	PMP	10.44	3.97	4.79	22.75
Other invertebrates	RVNA	26.21	9.77	12.37	55.51
	PMP	14.76	6.04	6.36	34.25

Table 7: Estimates of total number of individuals present in the research plots (area = 124.14 m^2), in individuals, calculated using the program "Distance" v. 7.0 (Thomas et al. 2010), for each of the taxa under consideration in either site.

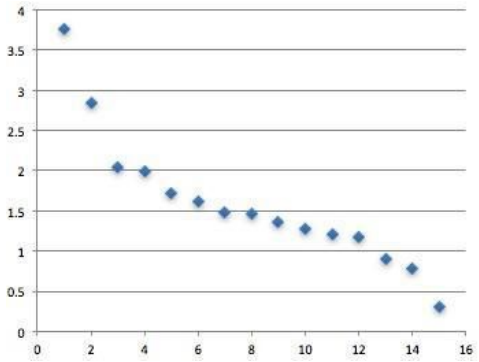
		Population estimate	Standard Error	Lower 95% CI	Upper 95% CI
Carabidae	RVNA	18,918	5,350.90	10,747	33,300
	PMP	21,063	5,802.50	1,232	36,569
Curculionidae	RVNA	358	84.31	220	580
	PMP	358	84.31	220	580
Other Coleoptera	RVNA	874	367.54	371	2,058
	PMP	3,468	1,281.20	1,649	7,293
Diptera	RVNA	2,622	752.27	1,474	4,663
	PMP	1,723	605.39	853	3,478
Hymenoptera	RVNA	511	160.61	270	967
	PMP	894	291.23	457	1,747
Acari	RVNA	9,009	2,832.30	4,800	16,909
	PMP	975	353.50	472	2,014
Araneae	RVNA	9,563	2,696.90	5,441	16,807
	PMP	3,307	1,176.10	1,628	6,719
Pseudoscorpiones	RVNA	644	167.69	380	1,091
	PMP	0	0.00	0	0
Opiliones	RVNA	536	218.76	115	2,496
	PMP	1,430	421.08	782	2,614
Orthoptera	RVNA	715	168.38	441	1,160
	PMP	572	253.29	213	1,533
Collembola	RVNA	27,439	12,321.00	11,204	67,197
	PMP	174,370	68,398.00	79,730	381,360
Isopoda	RVNA	15,492	4,972.00	8,173	29,364
	PMP	1,028	339.70	526	2,007
Hemiptera and Homoptera	RVNA	953	332.68	471	1,929
	PMP	429	123.77	238	773
Myriapoda	RVNA	1,639	486.88	906	2,964
	PMP	1,132	567.16	381	3,365
Unidentified larvae	RVNA	858	371.43	358	2,058
	PMP	1,296	493.46	595	2,824

Table 7, continued.

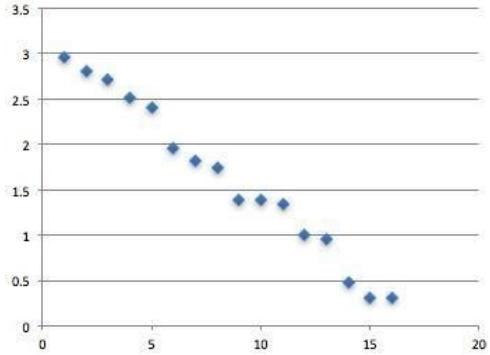
Other invertebrates	RVNA	3,253	1,213.00	1,536	6,891
	PMP	1,832	749.89	790	4,251

Figure 1: Relative abundance curves depicting number of individuals per species, showing species diversity and dominance. Horizontal axis: Species, ordered in sequence from high to low number of individuals; Vertical axis: number of individuals in species. Graph B graphically demonstrates the higher species diversity at RVNA, while graph A (PMP) shows a more typical, but also highly diverse, relative abundance curve with, however, higher dominance of a few species.

A: PMP



B: RVNA



Statistical Analyses

The Shannon Diversity Index for Powers Marine Park was 0.303, and 0.819 for River View Natural Area (Table 5). Hutcheson's t–test for community data was 51.95, corresponding to $P <<<0.0001$. This indicates a highly significant difference between the two sites based on community composition of insect species.

DISCUSSION

Differences in the insect faunal composition between sites is presumably influenced by differences in flora and substrate. Tree and plant species varied between PMP and RVNA. The PMP site is located directly next to the Willamette River in a riparian zone, and is dominated primarily by *Salix lucida*. Assorted shrubs are also present, as well as an understory cover of herbs. The RVNA site contains coniferous and deciduous forest filled with an abundance of *Acer macrophyllum*. Both RVNA and PMP contain 4 species of trees larger than 10cm in diameter.

However, these species are mutually exclusive (Table 1 and Table 3). Nineteen trees and plants species (combined) were found in RVNA and 22 were recorded in PMP, only two of which were the same species (Table 2 and Table 4). The greater diversity of invertebrates and also flora inhabiting the PMP site suggests the nutrient richness of the soil also may be different (Table 5).

A statistical analysis indicates a significant difference in community ecology metrics in species diversity between the two sites of interest. The Shannon Diversity index quantifies diversity by combining number of species present in a community with abundance and summarizing them with a numerical value between zero and one. The value found at the PMP site, H' = 0.304, indicates relatively lower diversity in comparison to the RVNA site, H' = 0.819. However, it is probable that the H' value found at the PMP site was strongly affected by a numerical dominance of Collembola, which numerically overpowered all the other taxa. The P value derived from the Hutcheson's t-test underscores the statistically significant difference between sites. The relative abundance curve (Figure 1) graphically displays a fairly even level of species dominance at RVNA, while PMP maintains a level of high diversity but displays a curve representative of a higher dominance by a fewer select species. The Horn index of community overlap gave a calculated value of 93.46% which emphasized the similarity in insect species composition between the two sites.

Given that the data collected indicates significant differences in their respective insect faunal compositions, the two sites are not ecologically identical. As a result we can conclude that they should be managed as two separate units.

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