Assessing the benefits of ENRTF funded conservation easements

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Our Approach

Overview

After researching the methods used to prioritize acquisitions in the state[1], we designed a tool to complement existing approaches in two ways. First, we observed that existing systems all use a rubric to score proposed acquisitions on a parcel-by-parcel basis. Detailed local knowledge gathered in site visits is important for decision making, however, it is impossible to gather site-level data for the entire state. Valuable parcels will be missed without a statewide, landscape-level perspective. To complement existing rubrics, our approach scored over 426,000 privately held, undeveloped, and unprotected parcels (hereafter referred to as 'viable parcels') to provide the context of how a proposed acquisition compares to all other parcels in the state that could be considered for a conservation easement.

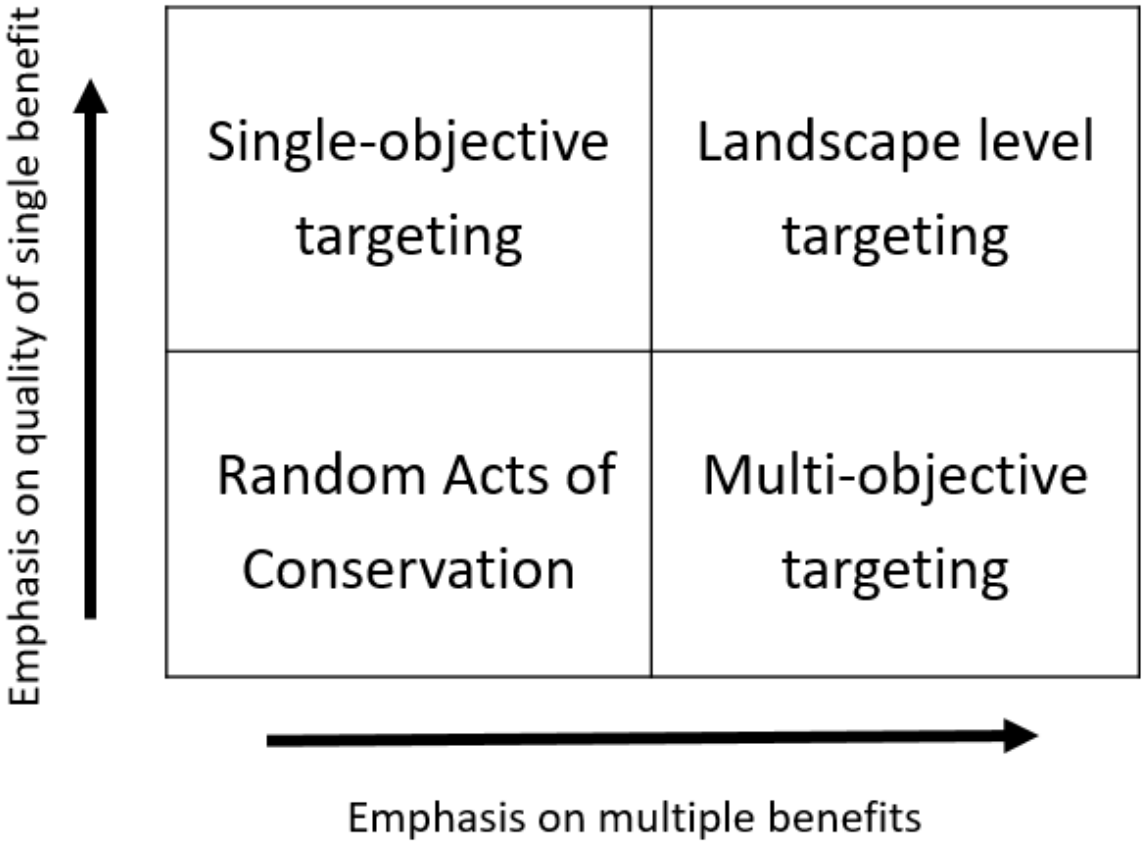
Second, our approach created 11 environmental benefit metrics, designed to complement those used in existing prioritization systems. Our metrics combine spatial data to map not just where high quality natural resources are, but also where the public would benefit the most from conservation. For example, our bird watching metric considers where experts have identified as important bird habitat, and also where the public goes to engage in bird watching. The resulting metric recognizes both important habitat, and where bird watchers go, but gives the highest scores to locations where both occur.

The information used in our approach is designed to be used in conjunction with local expertise; disagreement between the tool's scores and local expertise is an opportunity to better understand how benefits are perceived, measured, and valued.

Maximizing benefits by avoiding random acts of conservation

Our analysis compares past LCCMR funded easement acquisitions to all other viable parcels in the state. This provides insight into what services are being prioritized and which are being randomly targeted. Parcels that receive scores lower than or similar to the average scores of all other viable parcels for all of the metrics may be a sign of 'random acts of conservation'. While all conservation activities have value, the limited resources available necessitate targeting activities with strong public benefits.

[1] Noe, R. R., B. L. Keeler, M. A. Kilgore, S. J. Taff, and S. Polasky. 2017. Mainstreaming ecosystem services in state-level conservation planning: progress and future needs. *Ecology and Society* 22(4):4. https://doi.org/10.5751/ES-09581-220404



More targeted conservation strategies can take multiple forms, ranging from emphasis on the quality of a single benefit to emphasis on the number of benefits an acquisition provides. Both approaches are useful for producing targeting acquisitions with strong public benefits. When a landscape level approach is used, it is possible to combine elements from both single and multi-objective targeting to identify all parcels that score highly on a single objective, and further target among them those with the most other benefits. Our approach and tool help practitioners identify whether or not other parcels exist that meet their objectives and also provide other previously unconsidered benefits.

Factors to consider when interpreting results

Environmental benefits are diverse and numerous

Our metrics are designed to complement those used in existing prioritization systems. Our research indicated that habitat and biodiversity related metrics are already emphasized by existing prioritization systems, therefore we opted to focus on metrics in terms of human wellbeing. Other benefits derived from the environment, such as spiritual and cultural, are not well suited to a quantitative prioritization framework, but

can be immensely valuable. A parcel may have value that we were not able to consider in our landscape level approach because statewide data are not available. For example, high quality duck habitat supports the environmental benefit of duck hunting, however outputs from the most appropriate duck habitat model are not available statewide, and could not be included as a landscape level metric.

A statewide tool is best used to gain perspective and identify potentially valuable, previously unconsidered parcels; not to reject parcels for not obtaining an arbitrary score threshold. These metrics provide a valuable tool for quickly quantifying, visualizing, and considering multiple benefits, but consider what benefits are not captured by this approach before rejecting a parcel.

Combining multiple benefits is a values question

Any acquisition has tradeoffs between benefits. We can illuminate benefits, provide a framework to think about tradeoffs, and visualize portfolios of benefits. However, considering which benefits to prioritize requires that policymakers decide which values best represent the interests of the public. We encourage agencies and policymakers to use this tool and metrics as a framework for communicating priorities, and to continue to consider the interests of the public.

Comparison parcel definitions are approximate

To define parcels we used the statewide map of 40 acre public land survey parcels. These boundaries conform well to the shape of major features, and offer a good approximation of the scale at which land management and ownership operates. We defined ‘viable’ parcels as >50% privately held, >50% undeveloped, and <75% water. These 426,000 parcels are not necessary an exact representation of land management or ownership, and they do not indicate the land owner is willing to sell, but they do represent a realistic set of parcels for comparison and targeting purposes. Note that a parcel can be any shape and does not need to conform to the public land survey parcels in order to be considered with this approach.

Consider factors that influence cost

Land prices vary drastically around the state and expensive land does not mean that it doesn’t provide valuable benefits. High prices can indicate that land is likely to be developed without protection or that there is a large population of beneficiaries nearby. The ROI in our reports is a benchmark to visualize where parcels excel when their cost is considered. An expensive parcel may still be more valuable than a parcel with a

higher ROI if it provides great benefits and it is very likely to be developed. For example, shoreline property on Lake Superior would likely have a lower ROI compared to past acquisitions because its price is much higher than land in the rest of the state. This does not indicate it is a worse investment, but rather that it has value that isn't captured in our metrics. These are factors which must be considered on a case by case basis, but in many cases can be informed by reviewing past acquisition scores and prices.

Compare parcels, not metrics

Due to differences in the distribution of benefits, scores of different metrics are not comparable, and should not be combined. For example, high scores for the groundwater nitrate metric are much rarer than high scores for the wild rice metric. Because of these differences, it is best to only make comparisons between different sets of parcels within individual metrics (e.g., groundwater nitrate score for a proposed acquisition vs. average groundwater nitrate score of all viable parcels in the state).

Environmental benefit metrics

We created 11 statewide metric maps that depict where individual environmental benefits are produced, and how their quality compares to the rest of the state. For example, to contribute to lake recreation, an acquisition must be in the catchment of a publicly accessible lake. Among these, land that contributes to lakes with higher visitation and that are more sensitive to increased runoff pollution have higher scores. The metrics focus on ways in which human wellbeing is influenced by the environment, such as providing recreation opportunities or protecting drinking water. We also include two non-environmental metrics, nearby population and risk of conversion, to help users consider the impact and efficiency of a proposed acquisition.

We designed the metrics for prioritizing protection of undeveloped land without public access, such as with a conservation easement. Benefits must be provided to the public without access to the parcel, such as by controlling runoff into a public lake or by sequestering carbon from the atmosphere. The metrics all range from zero to one, where zero indicates the benefit is not produced there, and one indicates it is the best place for that benefit in the state. However, due to differences in the distribution of benefits, scores of different metrics are not comparable, and should not be combined. See the expanded documentation (z.umn.edu/pebat-documentation) for more information on how the metrics were constructed.

Past Acquisitions Analysis

Single-objective performance

One approach to targeted conservation is to acquire a portfolio of parcels that each excel at different benefits. With this approach, each acquisition only needs to be strong in one area, so you would expect to have a relatively small proportion of past acquisitions two standard deviations above the average of viable parcels, and many below average. Having a high proportion of acquisitions below average for a metric can also be explained by the limited endpoints that contribute to certain services. For example, acquisitions outside of the catchments of trout streams receive a trout angling score of 0. Since it is impossible for a single acquisition to be in all of the endpoints at once, it is normal for these metrics to have many 0 scores.

Figure 1-a. In figures 1 a-k, the green bars represent the average scores, and the average scores plus one and two standard deviations (SD) of all viable parcels in the state. The orange bar represents the average of past LCCMR funded easement acquisitions and the blue dots represent the scores of individual acquisitions. Metrics with all acquisitions (blue dots) near the average of all viable parcels (evenly dashed dark green line) indicate that metric is being randomly targeted. However, even a relatively small proportion of high scoring acquisitions can indicate successful targeting of a portfolio approach.

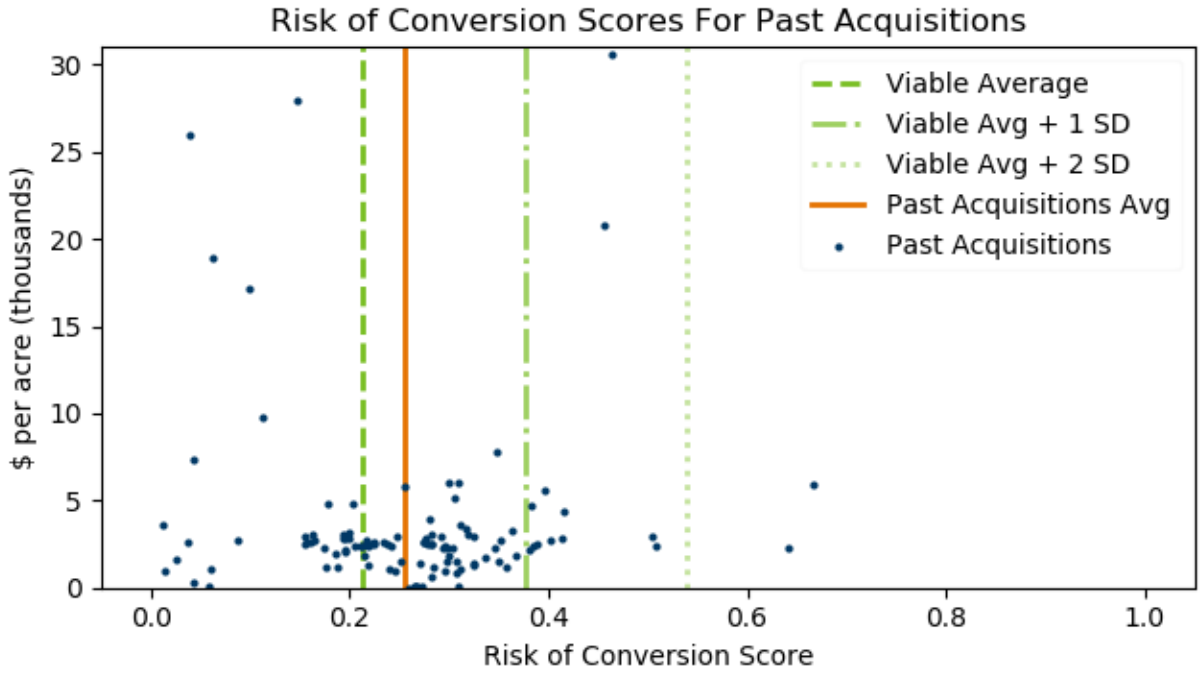
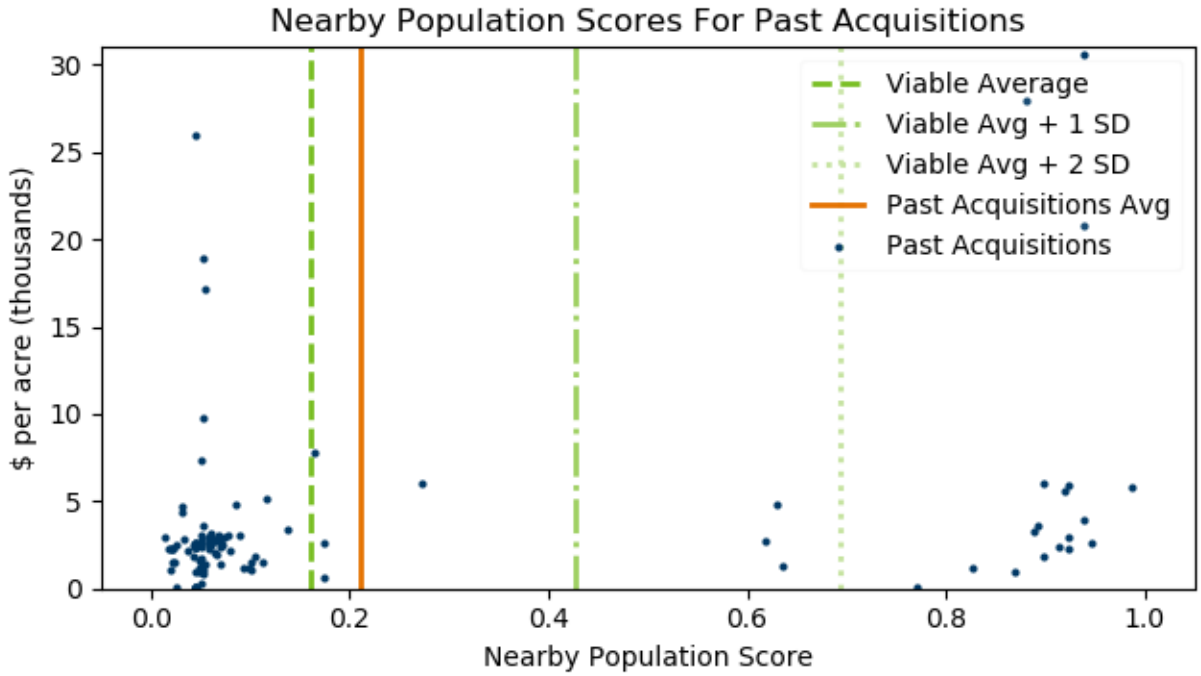


Figure 1-b.



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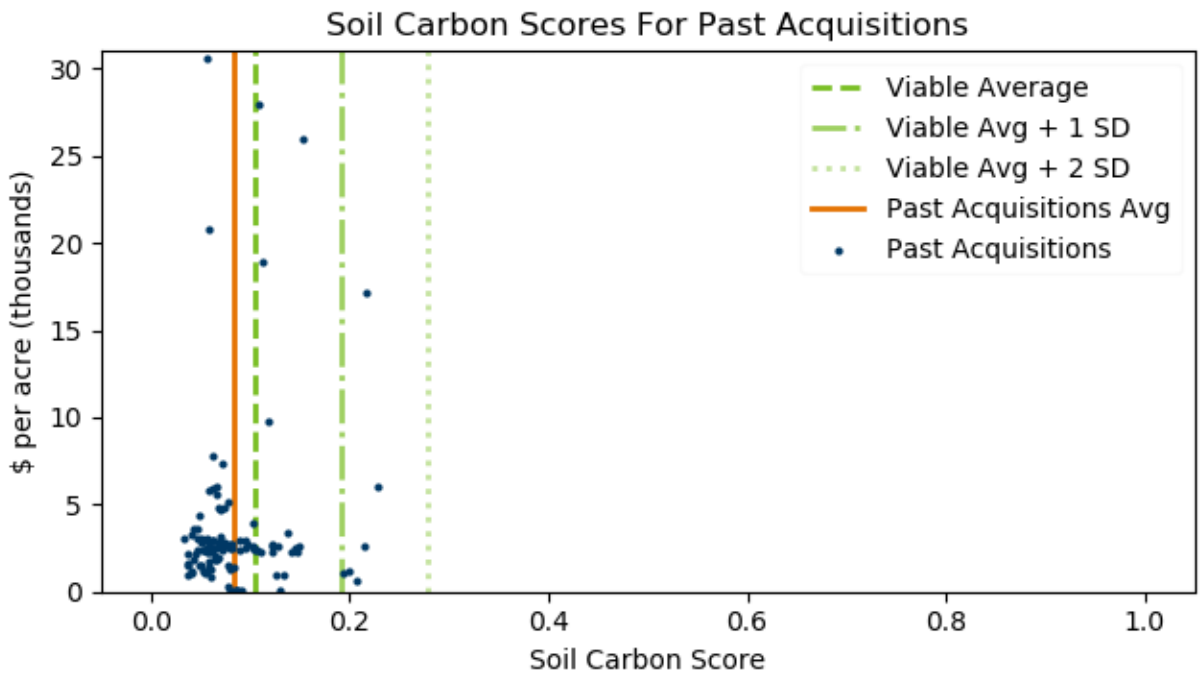

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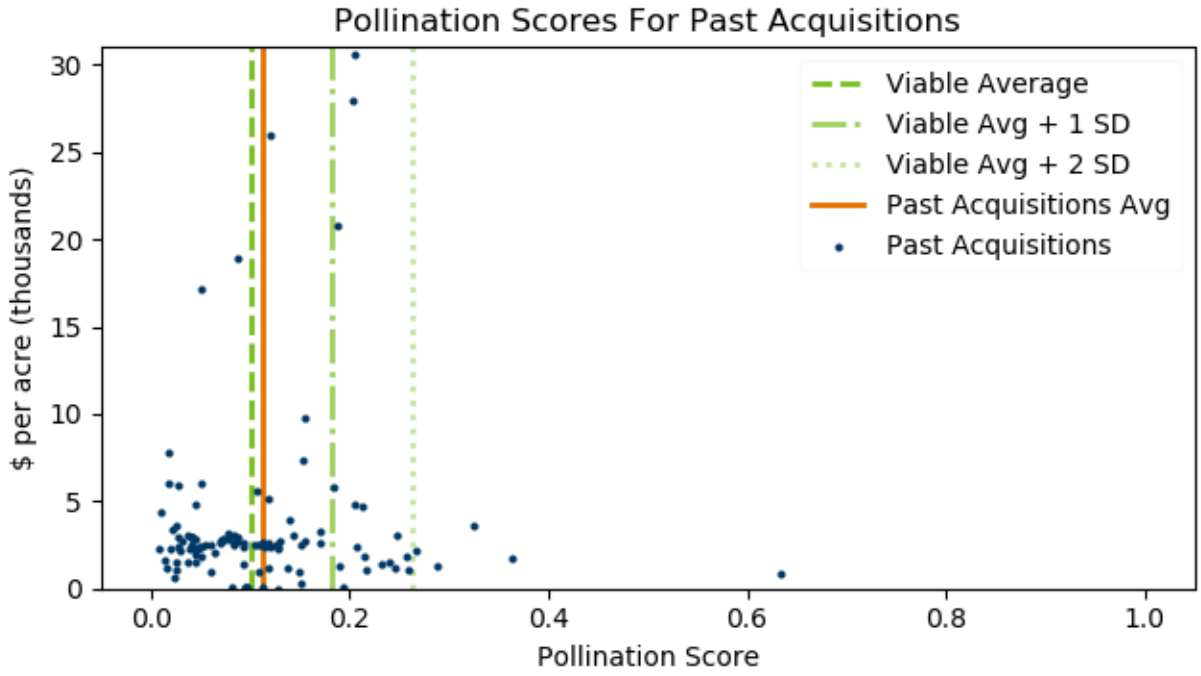

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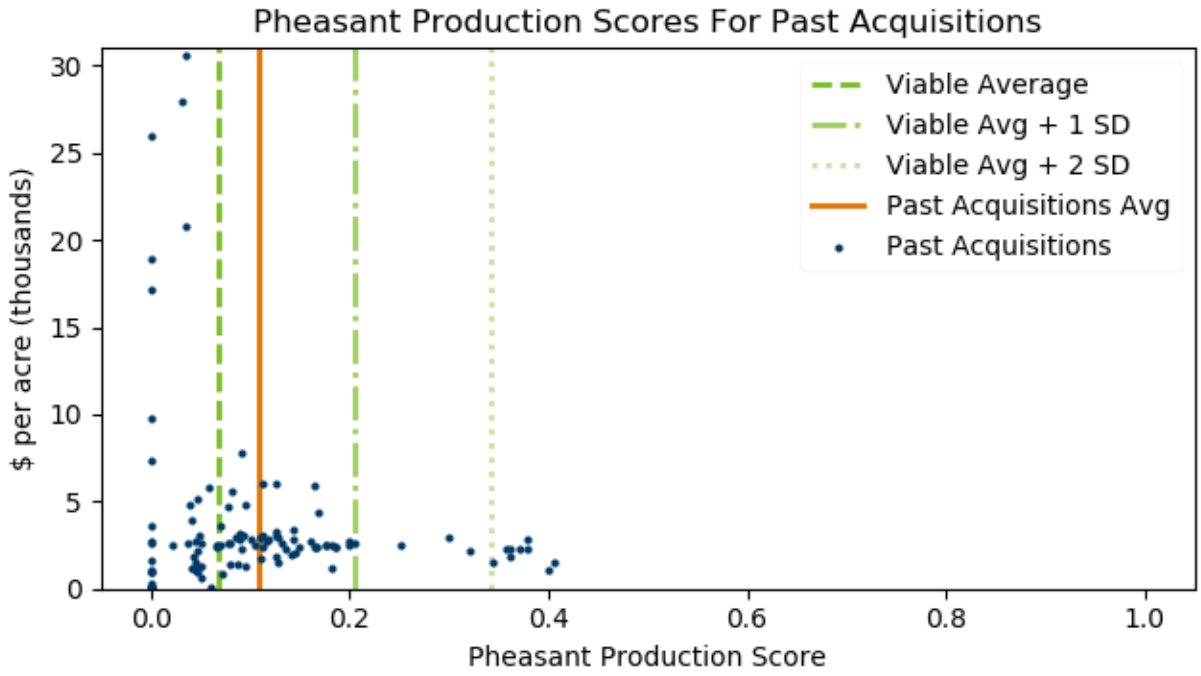

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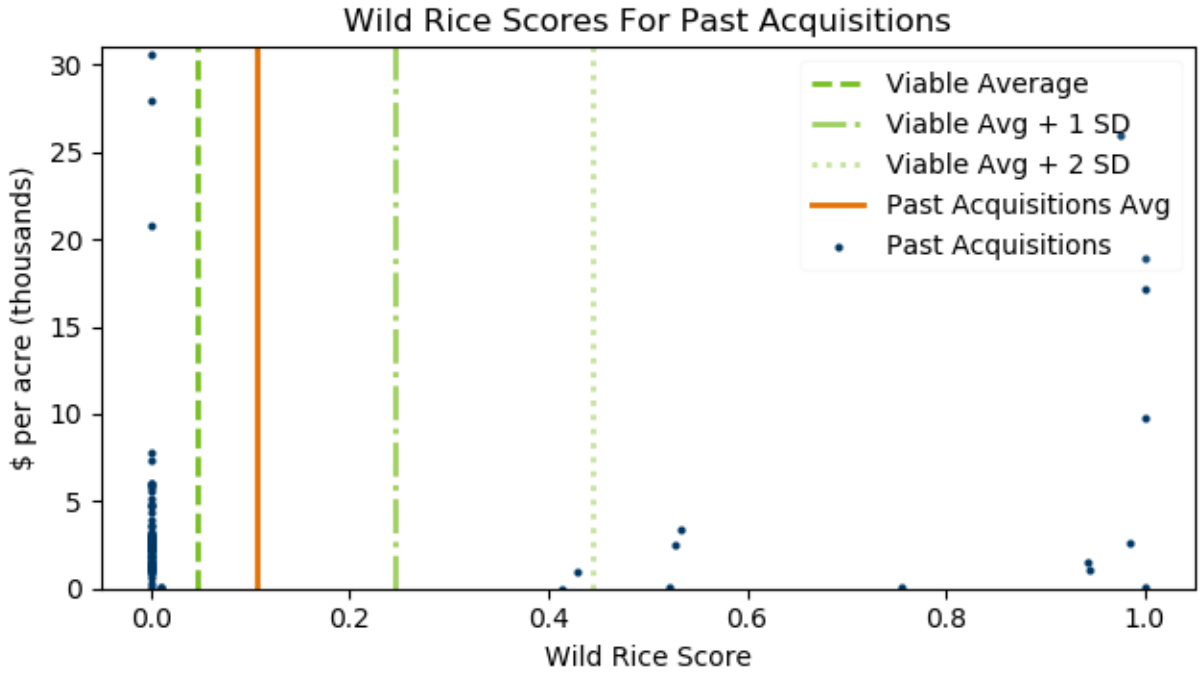

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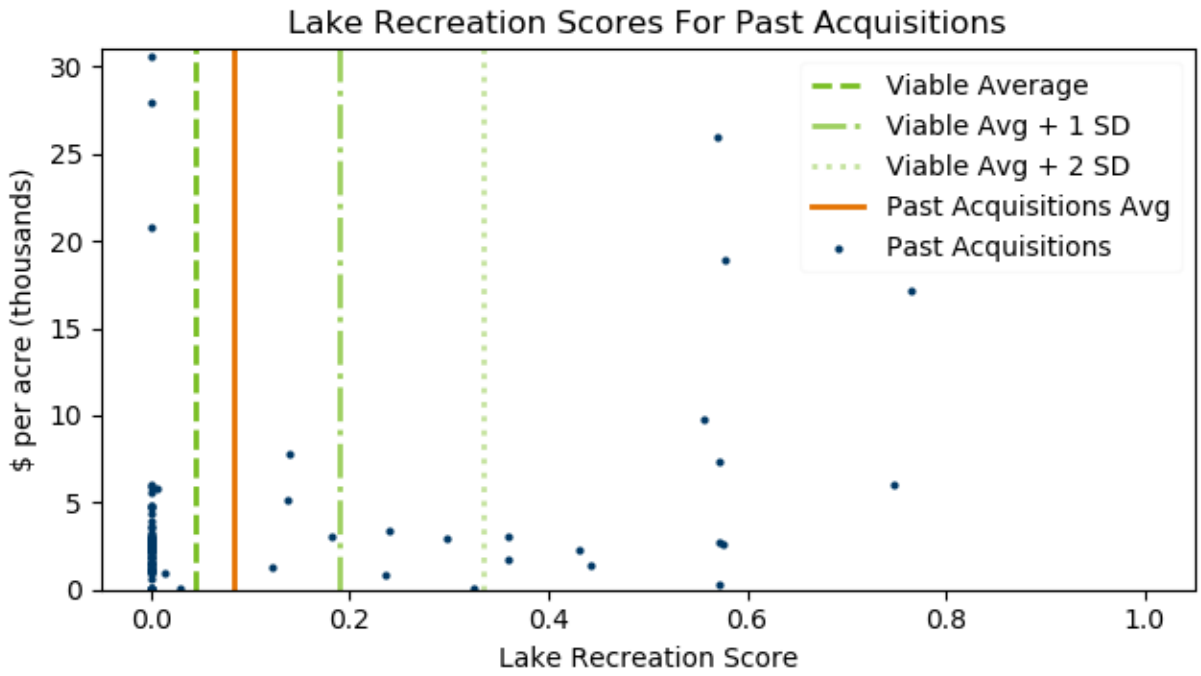

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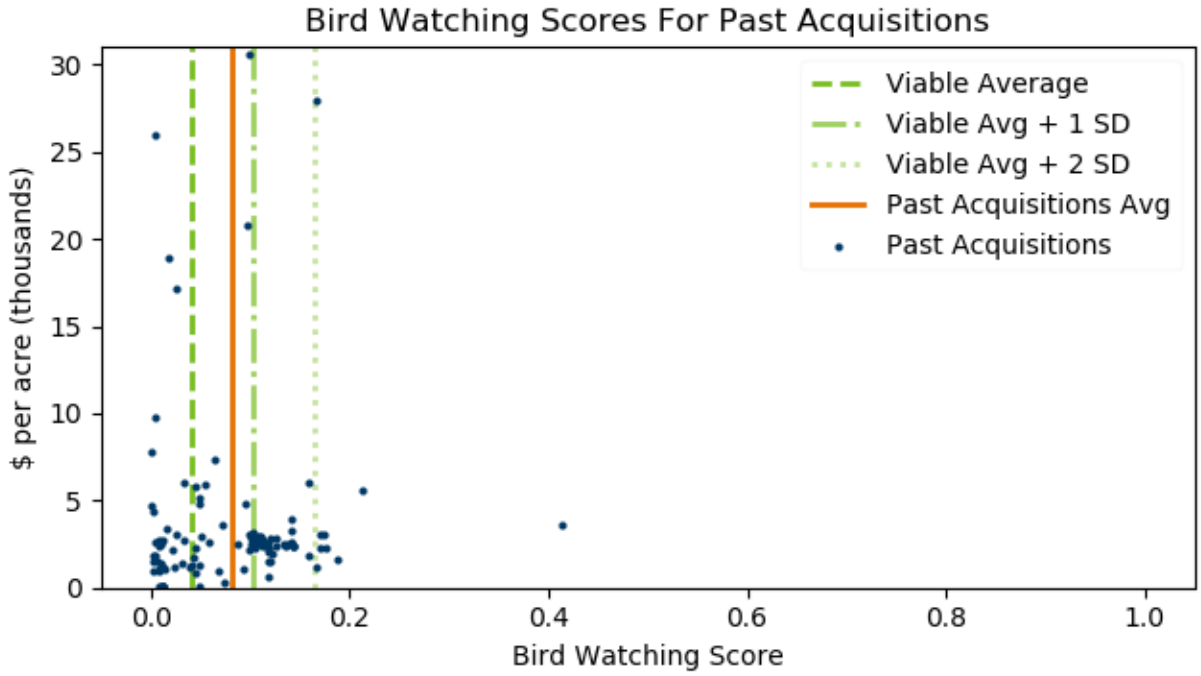
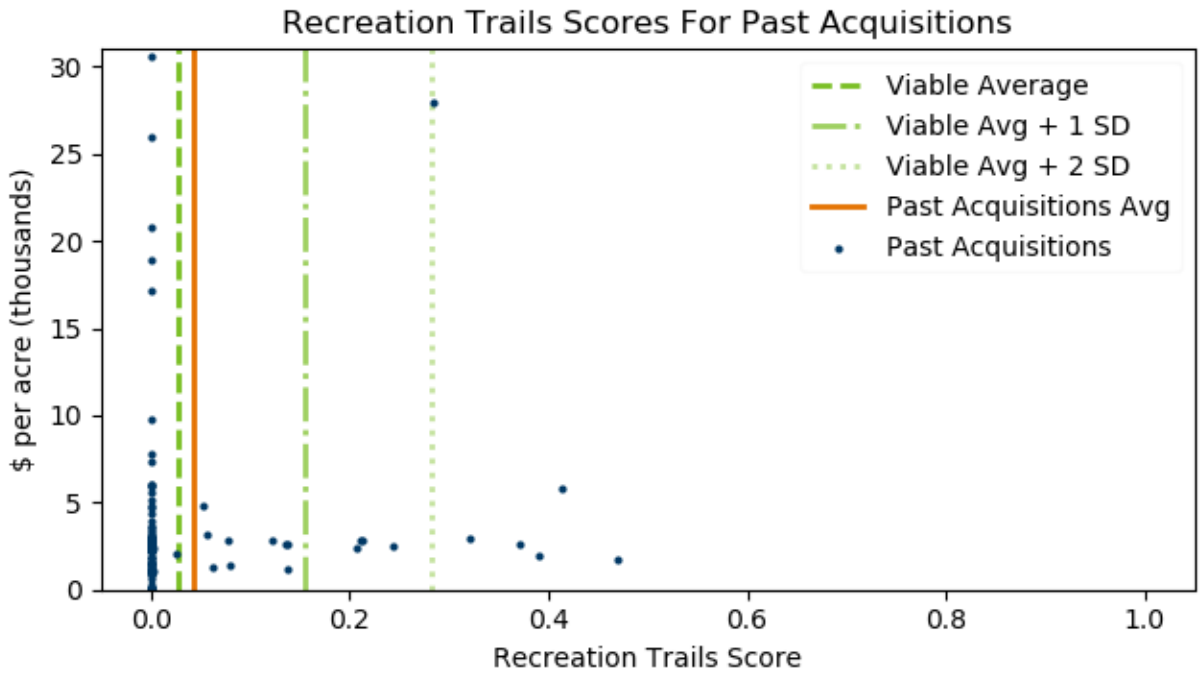


Figure 1-i.



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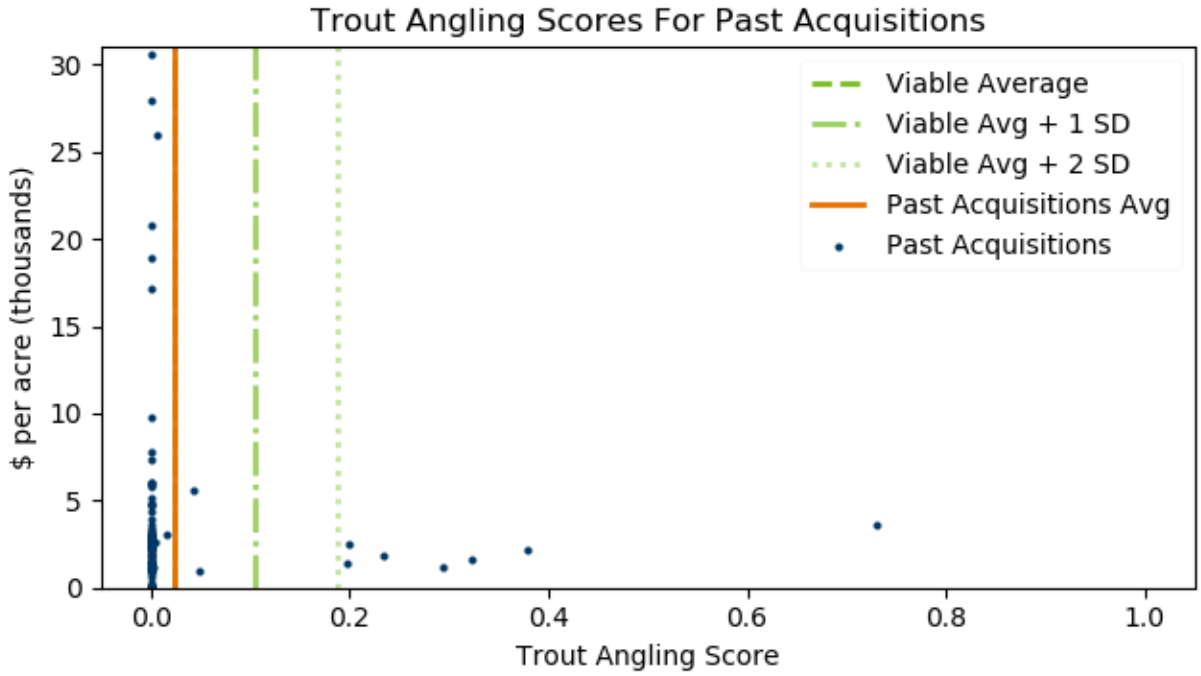


Figure 1-k.

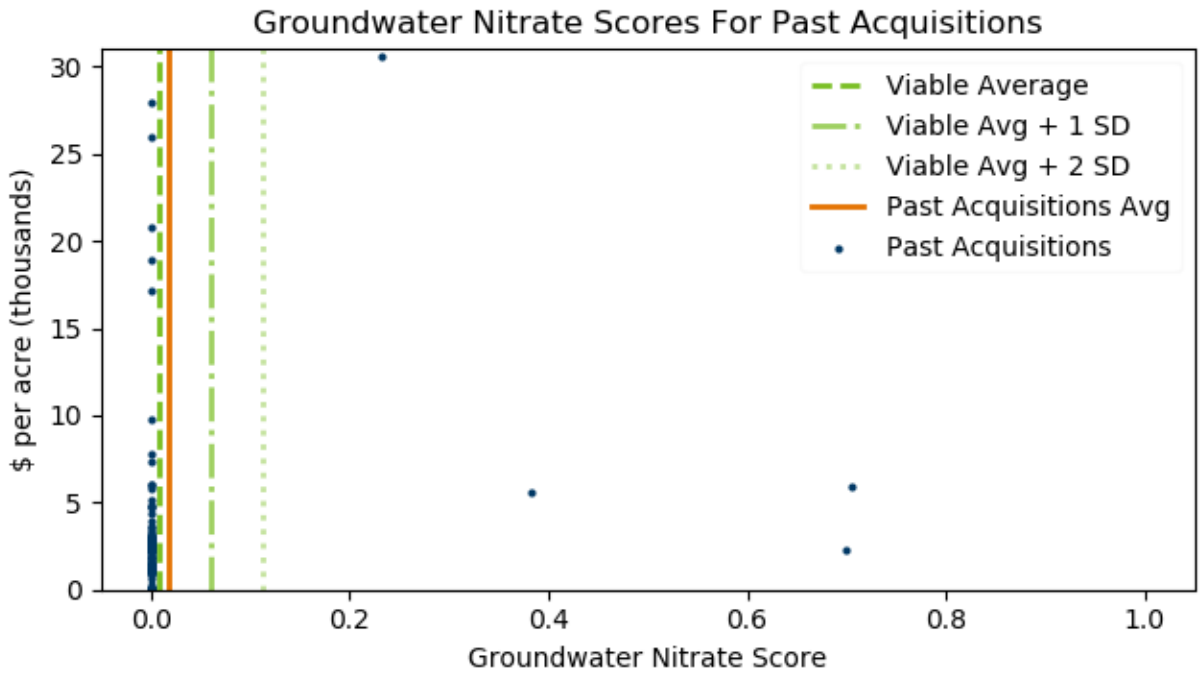


Table 1. Break down of proportion of past acquisitions that had scores above the average of all viable parcels in the state. The proportion of past acquisitions is also broken down by number of standard deviations (SD) above average.

	Groundwater Nitrate	Trout Angling	Trails	Bird Watching	Lake Recreation	Wild Rice	Pheasant Production	Pollination	Soil Carbon	Nearby Population	Risk of Conversion
Above Average	4%	9%	18%	67%	19%	13%	59%	47%	23%	22%	66%
Below Average	96%	91%	82%	33%	81%	87%	41%	53%	77%	78%	34%
Average to < 1 SD Above Average	0%	3%	8%	23%	4%	0%	49%	27%	18%	4%	54%
1 SD to < 2 SD Above Average	0%	0%	4%	36%	4%	2%	3%	15%	5%	3%	11%
> 2 SD Above Average	4%	6%	6%	8%	12%	12%	8%	4%	0%	16%	2%

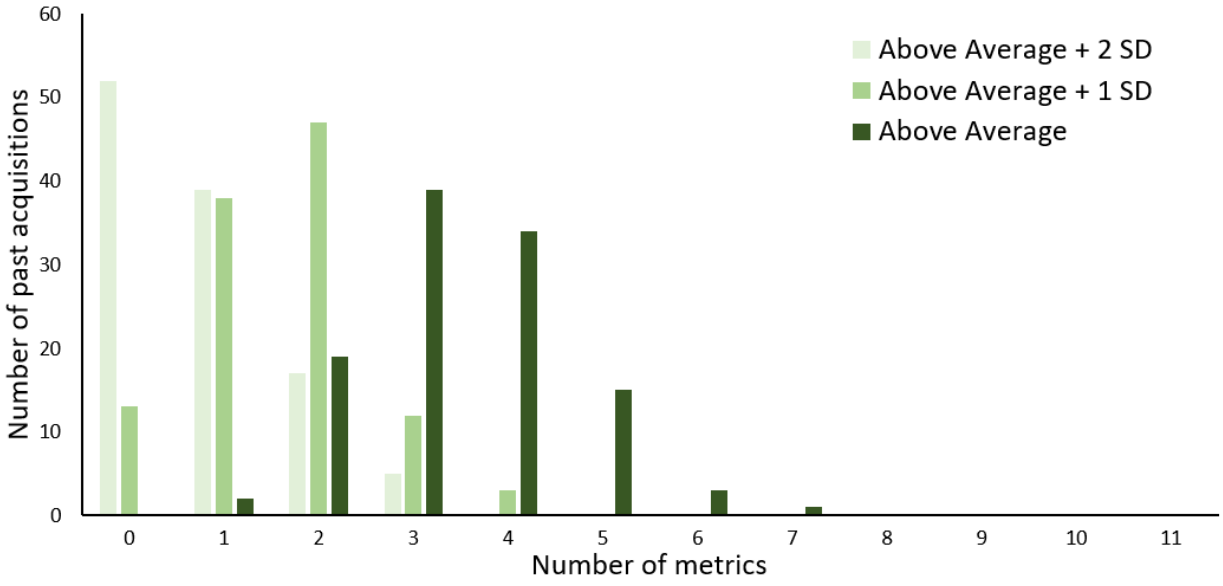
Table 2. Highest performing easement acquisition per metric. Metric scores are created such that the highest scoring viable parcel in the state receives a 1. The closer to 1, the closer a given acquisition is the highest scoring in the state for that metric. All dollar values are adjusted for inflation and presented in 2016 dollars.

Metric	Metric score	LCCMR ID	Original Purchaser	Acres	Year	Total $/Acre	ENRTF $/Acre
Risk of Conversion	0.666	11-037-009	Dakota County	193.2	2011	5,918	2,817
Nearby Population	0.987	11-053-001	Minnesota Land Trust	44.7	2011	5,801	4,119
Soil Carbon	0.228	14-093-001	Ducks Unlimited	33.6	2012	5,996	4,923
Pollination	0.634	06-041-001	MN DNR	555.6	2006	864	104
Pheasant Production	0.405	11-011-004	MN DNR	178.8	2010	1,466	537
Wild Rice	1.000	14-005-005	Minnesota Land Trust	37.4	2013	32	32
Lake Recreation	0.765	08-035-002	MN DNR	61.3	2007	17,197	1,273
Bird Watching	0.414	11-075-001	MN DNR	2.8	2008	3,620	3,620
Trails	0.750	11-075-004	Minnesota Land Trust	11.5	2011	61,869	22,273
Trout Angling	0.729	11-075-001	MN DNR	2.8	2008	3,620	3,620
Groundwater Nitrate	0.706	11-037-009	Dakota County	193.2	2011	5,918	2,817

Multi-objective performance

Another approach to maximizing returns of public benefits from an acquisition is to target acquisitions that are positioned to provide multiple benefits. In figure 2, past acquisitions are broken down by the number of metrics where they scored above the average of all viable parcels in the state. The break down is repeated in the lighter green bars for the number of metrics where they were above the average plus one and two standard deviations. This figure demonstrates one of the trade-offs commonly associated with a multi-objective approach. Parcels that perform better on individual metrics (i.e., more standard deviations above average), often do not perform as well on multiple objectives.

Figure 2. Number of past acquisitions that scored better than average of all viable parcels on a given number of metrics.



While trade-offs exist, the figure also shows acquisitions that were both far above average and contributing to multiple objectives (Table 3). These parcels excel at both single and multiple objectives, but this does not imply that other acquisitions are not valuable. There may not be alternatives to a parcel that performs well on a single objective that also has co-benefits. Furthermore, simply counting the number of above average metrics does not indicate you are maximizing public benefits. If the public views one metric as a much higher priority than the others, having good performance on several lower priority metrics could be equivalent to good performance on a single metric. Policy makers and practitioners must weigh public needs and priorities when determining what portfolio of benefits to prioritize and protect.

Table 3. Past acquisitions that had above average or greater performance on the most metrics. Counting the number of above average metrics does not account for variation in preferences in the public. This analysis provides a framework to identify what benefits a parcel provides, and how the benefit's quality compares to the rest of the state. Policy makers and practitioners should consider the values and priorities of the public when deciding which benefits to emphasize. All dollar values are adjusted for inflation and presented in 2016 dollars. For detailed information on all past acquisitions see the parcel score appendix.

LCCMR ID	Original Purchaser	Acres	Year	Total $ / Acre	ENRTF $ / Acre	Above Average Count
10-037-001	Dakota County	42.3	2008	5,548	1,054	7
15-037-003	Dakota County	27.4	2015	2,279	1,071	6
09-041-004	Ducks Unlimited	180	2009	1,328	181	6
09-041-005	Ducks Unlimited	23	2009	1,717	498	6
						Above Average + 1 SD Count
15-037-002	Dakota County	103.1	2012	30,633	1,532	4
10-037-001	Dakota County	42.3	2008	5,548	1,054	4
08-163-005	MN DNR	42.5	2006	27,951	4,808	4
						Above Average + 2 SD Count
11-037-009	Dakota County	193.2	2011	5,918	2,817	3
15-037-003	Dakota County	27.4	2015	2,279	1,071	3
10-037-001	Dakota County	42.3	2008	5,548	1,054	3
08-163-005	MN DNR	42.5	2006	27,951	4,808	3
09-041-005	Ducks Unlimited	23	2009	1,717	498	3

Targeting with a landscape level approach

Our framework is designed to leverage the benefits of both single and multi-objective approaches by using a landscape level approach. For any parcel we can assess how many, if any, viable parcels exist that perform better than it on every metric. This does not guarantee that those land owners are interested in selling development rights, but it does provide leads on potentially more desirable acquisitions. The number of parcels that score better than a given parcel on all metrics is an indicator of how well a parcel performs at both single and multi-objective targeting. Parcels that score very highly on a single attribute or those that have strong performance on several will have few parcels that can match either their single objective strength or unique combination of benefits across multiple objectives, respectively.

The high proportion (40%) of acquisitions with fewer than 10 parcels that scored better on all metrics indicates that past acquisitions have successfully targeted parcels with high quality benefits and/or co-benefits. Despite these successes, some parcels had hundreds of alternatives that were better on all metrics assessed here. These acquisitions still may have been well targeted if they were acquired to support a benefit not included in our metrics. Identifying parcels that scored better on all metrics is a high standard. Relaxing this requirement would reveal many parcels that scored better than past acquisitions most, but not all metrics. Practitioners could identify promising parcels by querying our dataset for parcels that perform well on their metric of interest and also have strong co-benefits.

Table 4. Count of viable parcels that had higher scores on all metrics than a given past acquisition. Parcels with a high number of parcels better on all metrics could have benefited from a landscape level approach. Note that a parcel may excel at a benefit we did not produce a metric for. For example, there was not sufficient data to construct a statewide duck production metric.

LCCMR ID	Original Purchaser	Acres	Year	Total $ / Acre	ENRTF $ / Acre	Better On All Metrics Count
11-075-004	Minnesota Land Trust	11.5	2011	22,273	61,869	0
13-073-001	BWSR	45.1	2011	2,329	2,329	0
11-039-001	BWSR	39.7	2011	2,656	2,656	0
11-173-004	BWSR	67.9	2011	2,442	2,442	0
14-111-001	Minnesota Land Trust	48.6	2012	114	1,444	0
13-073-003	BWSR	30	2011	2,229	2,229	0
06-041-001	MN DNR	555.6	2006	104	864	0
09-041-005	Ducks Unlimited	23	2009	498	1,717	0

11-055-002	BWSR	190.1	2008	148	2,466	0
11-037-009	Dakota County	193.2	2011	2,817	5,918	0
09-041-004	Ducks Unlimited	180	2009	181	1,328	0
08-157-001	The Nature Conservancy	33	2007	3,083	3,083	0
11-173-010	BWSR	43.6	2011	2,432	2,432	0
10-037-001	Dakota County	42.3	2008	1,054	5,548	0
13-023-002	BWSR	35.1	2012	2,592	2,592	0
11-053-001	Minnesota Land Trust	44.7	2011	4,119	5,801	0
14-093-001	Ducks Unlimited	33.6	2012	4,923	5,996	0
15-037-003	Dakota County	27.4	2015	1,071	2,279	0
11-127-004	BWSR	46.4	2010	2,621	2,621	1
08-035-002	MN DNR	61.3	2007	1,273	17,197	1
09-041-003	Ducks Unlimited	78	2008	184	3,072	1
14-021-006	Cass County	38.6	2011	399	2,610	1
08-047-002	Ducks Unlimited	39	2007	2,933	3,372	2
11-127-007	BWSR	53.9	2011	2,855	2,855	2
12-003-001	Minnesota Land Trust	80	2012	1,125	2,616	2
11-157-003	MN DNR	284.6	2010	1,188	1,212	2
08-129-002	BWSR	70.6	2008	2,820	2,820	2
14-005-004	Minnesota Land Trust	198.9	2013	953	953	3
08-127-001	BWSR	46.6	2008	2,329	2,329	3
14-021-002	Cass County	5.8	2012	1,427	25,950	3
08-129-001	BWSR	15.9	2008	2,701	2,701	4
11-037-010	Dakota County	39.3	2011	1,086	3,621	4
11-127-009	BWSR	13	2011	2,007	2,007	5
08-127-002	BWSR	79.3	2008	2,920	2,920	5
11-127-003	BWSR	50	2010	2,054	2,054	5
16-155-001	MN DNR	150.8	2014	1,792	2,891	5
11-127-008	BWSR	20	2011	2,564	2,564	5
14-005-005	Minnesota Land Trust	37.4	2013	32	32	6
11-157-004	MN DNR	30	2010	1,719	1,848	6
14-151-001	MN DNR	19.34	2013	1,007	2,798	6
11-129-001	BWSR	15.8	2010	3,178	3,178	7
08-163-005	MN DNR	42.5	2006	4,808	27,951	7
13-073-002	BWSR	28	2011	2,314	2,314	7
11-127-001	BWSR	21.6	2010	2,546	2,546	8
11-127-006	BWSR	79.9	2011	2,539	2,539	8
11-045-002	MN DNR	40.5	2010	2,164	2,172	10
11-157-005	MN DNR	1220.3	2010	1,116	1,139	10
14-021-007	Cass County	21.7	2011	480	9,791	11
11-129-007	BWSR	30.7	2011	2,874	2,874	12
15-037-001	Dakota County	34.3	2015	1,133	2,361	12

16-037-004	Dakota County	20.6	2016	2,932	6,008	12
15-037-004	Dakota County	26.1	2015	925	1,814	12
15-037-002	Dakota County	103.1	2012	1,532	30,633	13
14-067-001	Minnesota Land Trust	30.7	2011	97	5,105	15
11-173-002	BWSR	26.3	2010	2,523	2,523	15
11-173-009	BWSR	18.5	2011	2,506	2,506	16
15-025-001	Minnesota Land Trust	79	2014	30	30	17
11-129-009	BWSR	27.6	2011	2,882	2,882	17
11-173-001	BWSR	43	2010	2,503	2,503	20
14-021-009	Minnesota Land Trust	31	2013	313	313	23
12-127-001	MN DNR	19.6	2012	2,861	2,895	23
15-059-001	Minnesota Land Trust	158.5	2014	1,057	1,140	23
11-173-006	BWSR	44.5	2011	2,449	2,449	25
11-011-004	MN DNR	178.8	2010	537	1,466	25
11-129-005	BWSR	16.6	2010	2,976	2,976	26
09-025-002	Minnesota Land Trust	140	2007	446	4,852	27
11-173-003	BWSR	40.4	2010	2,518	2,518	27
11-049-002	MN DNR	33.4	2010	3,301	3,317	27
14-021-005	Cass County	4.5	2011	2,344	54,892	27
11-173-007	BWSR	35.4	2011	2,434	2,434	28
12-173-001	BWSR	61	2011	2,438	2,438	28
11-173-005	BWSR	13.5	2011	2,442	2,442	29
11-173-008	BWSR	40.9	2011	2,433	2,433	30
16-011-001	MN DNR	125.5	2015	1,139	2,316	32
11-145-003	Ducks Unlimited	75.7	2011	1,459	1,520	35
14-021-008	Cass County	6.8	2013	1,693	7,398	39
11-037-011	Dakota County	16.8	2011	8,258	20,802	40
14-021-003	Cass County	9.4	2010	520	18,925	40
11-075-001	MN DNR	2.8	2008	3,620	3,620	47
10-003-001	Minnesota Land Trust	45	2010	3,985	3,985	53
11-117-001	MN DNR	160.2	2009	810	1,060	57
11-145-005	Minnesota Land Trust	56.5	2011	586	681	64
14-021-001	Cass County	2.7	2012	1,989	2,673	67
14-121-001	MN DNR	65.7	2014	1,435	1,435	70
11-157-001	MN DNR	262.4	2009	1,011	1,032	74
16-167-001	MN DNR	53.4	2014	1,478	1,795	82
11-011-003	MN DNR	63.2	2010	1,482	1,527	84
14-015-001	MN DNR	26.99	2014	4,759	4,856	87
14-005-002	Minnesota Land Trust	108.7	2013	14	14	88
16-037-003	Dakota County	17.2	2016	1,480	2,953	94
11-129-004	BWSR	3.7	2010	3,044	3,044	96
14-041-002	BWSR	39.5	2013	1,062	2,722	98
11-149-004	BWSR	122.8	2010	1,509	4,717	105

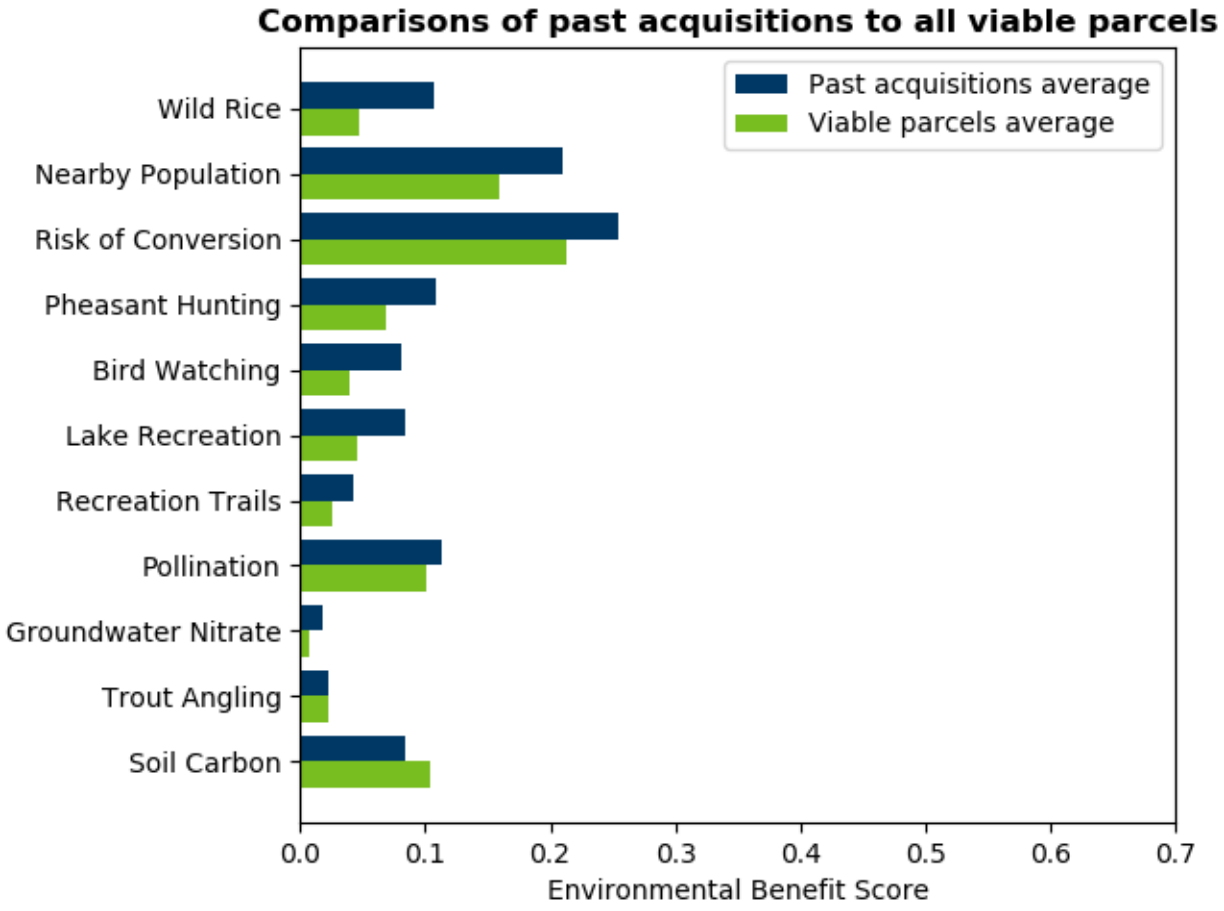
15-143-001	Minnesota Land Trust	79.6	2014	752	1,331	105
12-163-001	Minnesota Land Trust	294	2012	10	988	110
11-127-002	BWSR	136.8	2010	3,080	3,080	115
14-005-006	Minnesota Land Trust	58	2013	25	25	152
11-025-001	Minnesota Land Trust	39.7	2010	416	2,771	167
11-035-002	Ducks Unlimited	150	2011	1,049	1,093	168
14-041-001	BWSR	343.9	2012	891	2,345	184
14-007-001	Minnesota Land Trust	145.5	2014	30	30	190
14-005-003	Minnesota Land Trust	71	2013	75	75	236
13-111-002	Minnesota Land Trust	71	2013	38	38	236
14-041-003	BWSR	192.2	2014	1,139	2,530	247
11-145-004	Minnesota Land Trust	43.9	2011	2,331	2,649	354
09-051-003	Ducks Unlimited	28.62	2008	428	2,139	409
14-041-005	BWSR	55.1	2014	1,200	2,728	411
09-161-001	Ducks Unlimited	12.42	2008	6,481	7,809	503
11-075-005	Minnesota Land Trust	88	2010	188	1,631	707
08-041-001	Ducks Unlimited	111	2007	987	1,131	754
11-157-002	MN DNR	114.4	2009	1,429	1,489	1034
11-149-003	BWSR	155.8	2010	398	4,417	5288
12-035-001	Minnesota Land Trust	88	2011	259	926	9804

Portfolio Statistics

Targeting a suite of benefits with a portfolio of acquisitions is a necessary tool because all of the benefits of interest cannot be found in a single area. When protecting a portfolio of parcels practitioners must decide how to prioritize benefits relative to one another. Our tool is useful for identifying strengths and weaknesses within a portfolio. In figure 3, the average scores of past acquisitions is compared to the average scores of all viable parcels, sorted from the metric where past acquisitions are most above the other viable parcels to the metric where they are the most below. Randomly acquiring parcels would produce benefit scores near the average of all viable parcels in the state. Being near or below the average of viable parcels indicates that that benefit is under represented in your portfolio.

However, other factors are also relevant in portfolio allocation. For example, the highest soil carbon concentrations in the state are in areas with some of the lowest risk of conversion. It would not be efficient to acquire land unlikely to be convert solely to increase the soil carbon benefits in the ENRTF portfolio. Acquisition decisions require weighing trade-offs and priorities across both benefits and geographies. Our tool provides data and a framework for organizing information to improve conservation targeting.

Figure 3. Analysis of ENRTF portfolio in comparison to all viable parcels in the state. The further the blue bar is past its adjacent green bar, the more that metric is represented in past acquisitions relative to all privately held undeveloped parcels.



Recommendations

Target acquisitions for a portfolio of benefits

The ENRTF has a broad constitutional mandate to protect Minnesota's “air, water, land, fish, wildlife, and other natural resources.” Addressing these environmental benefits equitably for all Minnesotans will require a portfolio of diverse benefits from acquisitions throughout the state. Having a clear picture of the strengths and weaknesses of a portfolio will allow for better targeting of specific benefits. Our analysis and tools are a useful framework for assessing a portfolio conservation activities, however, continued work with conservation practitioners and the public are vital for identifying benefits not included in this analysis, and prioritizing among those benefits.

Survey the public to better understand conservation values and priorities

The ENRTF plays a vital role in foundational data collection; many of the metrics in our tool were built on data not available in other states. However, a recurring question in acquisition decisions is how to prioritize among multiple metrics. Funding foundational social data acquisition (e.g., surveys) would provide more information on what the public's priorities and preferences for environmental benefits are, and would ensure that all Minnesotans are equitably represented. This information would help policymakers and practitioners make decisions that maximize returns of the wellbeing of Minnesotans.

Use a landscape level approach to target multiple benefits

Acquiring parcels that excel at a single benefit is a useful strategy when acquiring a portfolio of benefits. However, once promising parcels have been identified, test to see if there are other parcels that perform as well or better on all metrics. Conversations with practitioners indicated that often a parcel isn't considered until after the land owner comes forward. By querying our data, practitioners can identify parcels that meet their objectives and also have co-benefits. Broadening land owner outreach efforts to these parcels would help protect valuable parcels that might have been missed without a landscape level approach.

Improve risk of conversion estimates

Many past acquisitions scored highly on our risk of conversion metric, indicating that practitioners are efficiently using resources to protect the benefits most in danger of being lost. However, our metric, and those used by practitioners, could be refined to provide more reliable, higher resolution, and specific predictions of conversion. For example, our metric is ill-suited for identifying small-scale recreation-oriented development, such as lakeshore cabins. Land use change models and data are advancing rapidly, and improving estimates of risk of conversion would maximize the efficacy of any organization acquiring land for the public benefit.

Appendix I - Parcel Score Appendix

See included file "parcel_score_appendix.xlsx".

Also available at https://z.umn.edu/pebat-report-appendix

Appendix II - Past Acquisitions Analysis: Comparison to publicly held land

Overview

Our primary analysis focused on how past and proposed acquisitions compare to all privately held, undeveloped, and unprotected parcels in the state because this is the most relevant set of alternatives when targeting conservation easements. Another useful comparison set for assessing how outstanding a parcel's benefits are is all publicly held, undeveloped, and often protected parcels. This appendix presents the same analysis as in the main section of the report, but uses publicly held undeveloped land as the comparison set. The definition for public land used in this analysis differs slightly from the main analysis in that it uses a single, slightly older data set to define public land, the 2008 GAP stewardship layer. Note that the order of the metrics in the figures and tables of this analysis differs from the main analysis because metrics are typically sorted by the mean score of the comparison set.

Single-objective performance: public land comparison

Figure 1-a. In figures 1 a-k, the green bars represent the average scores, and the average scores plus one and two standard deviations (SD) of all *publicly held undeveloped* parcels. The orange bar represents the average of past LCCMR funded easement acquisitions and the blue dots represent the scores of individual acquisitions.

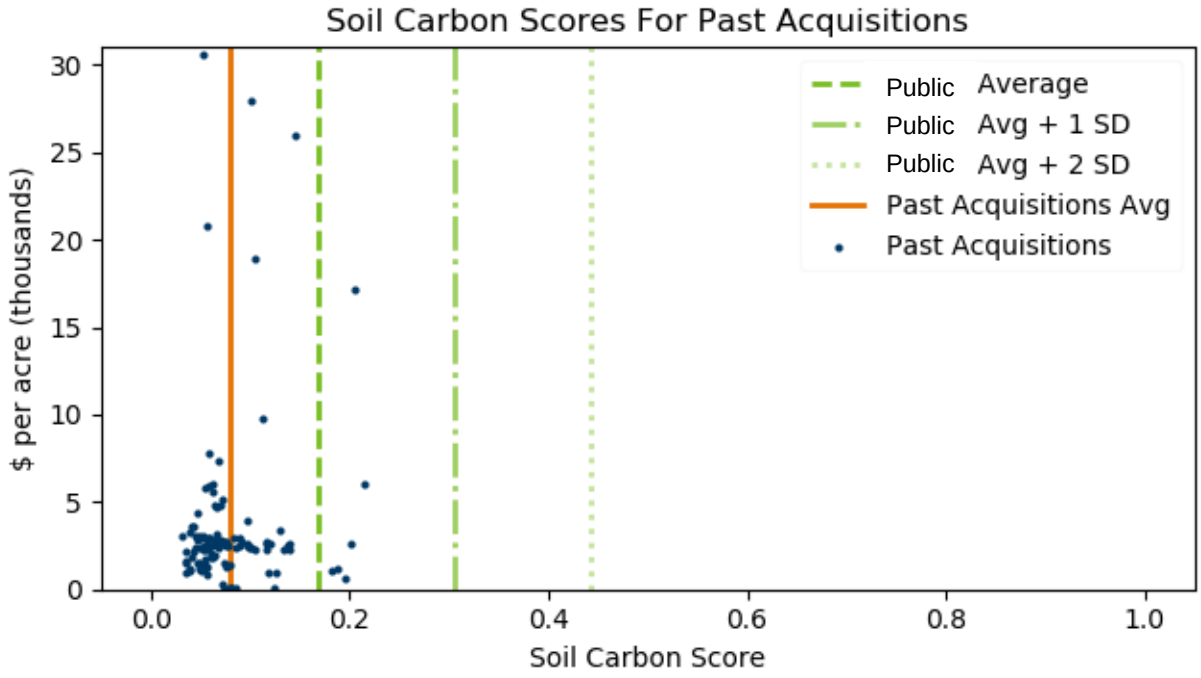


Figure 1-b.

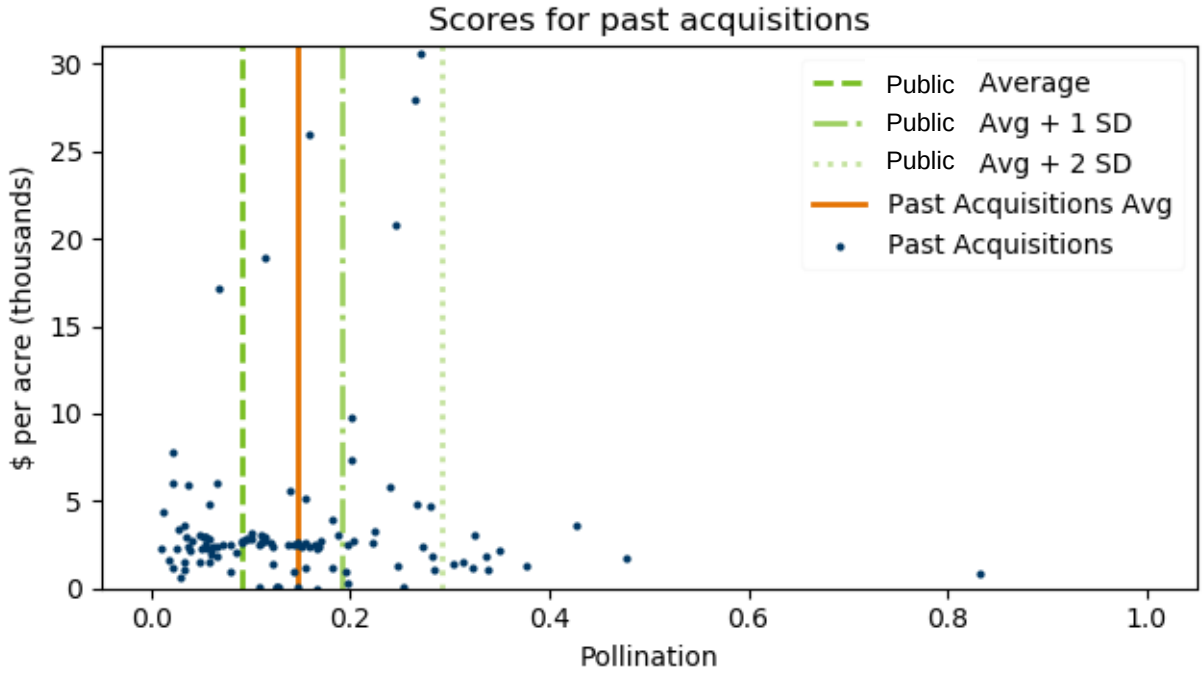


Figure 1-c.

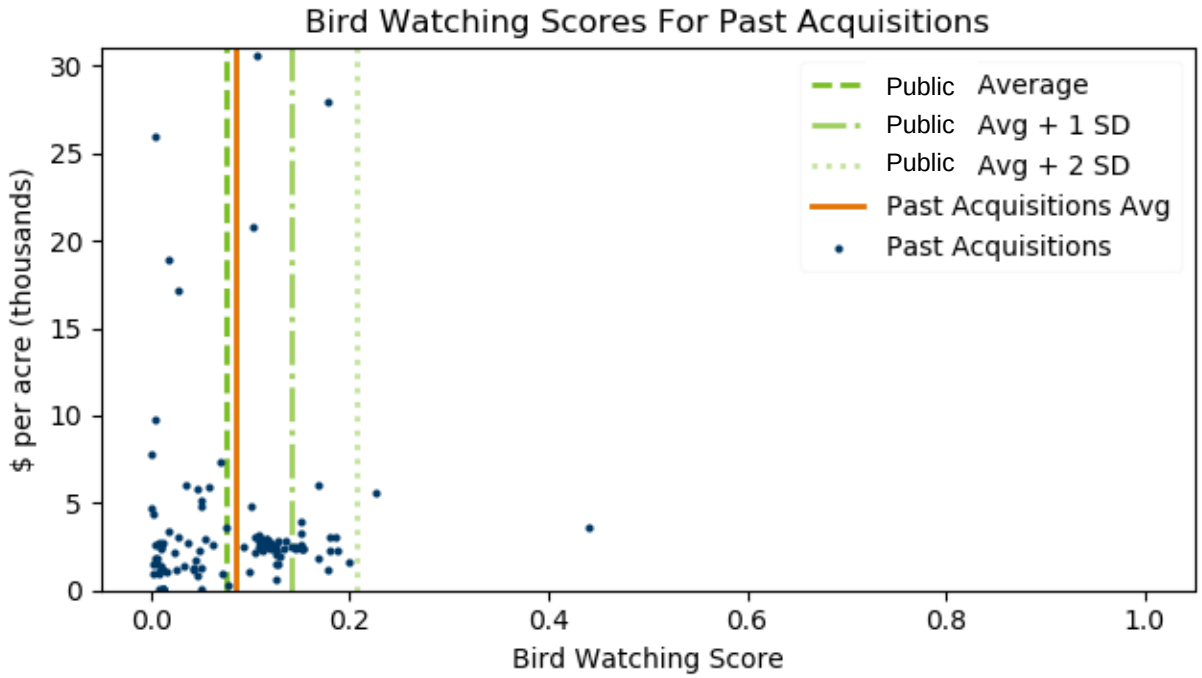


Figure 1-d.

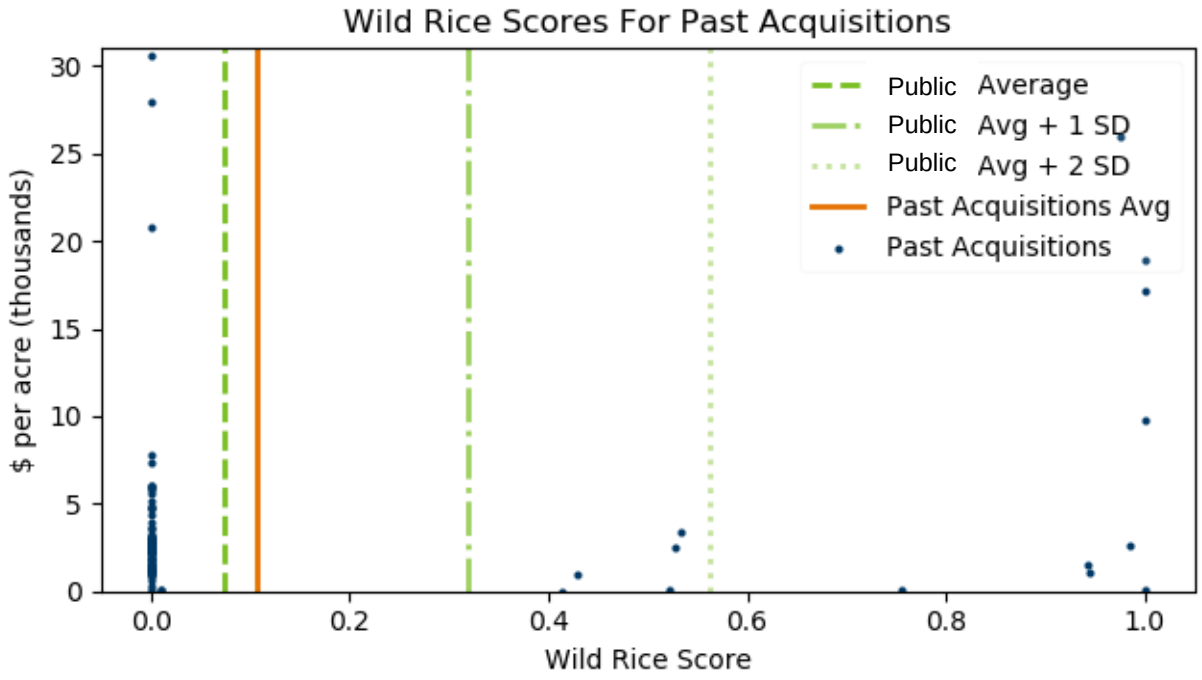


Figure 1-e.

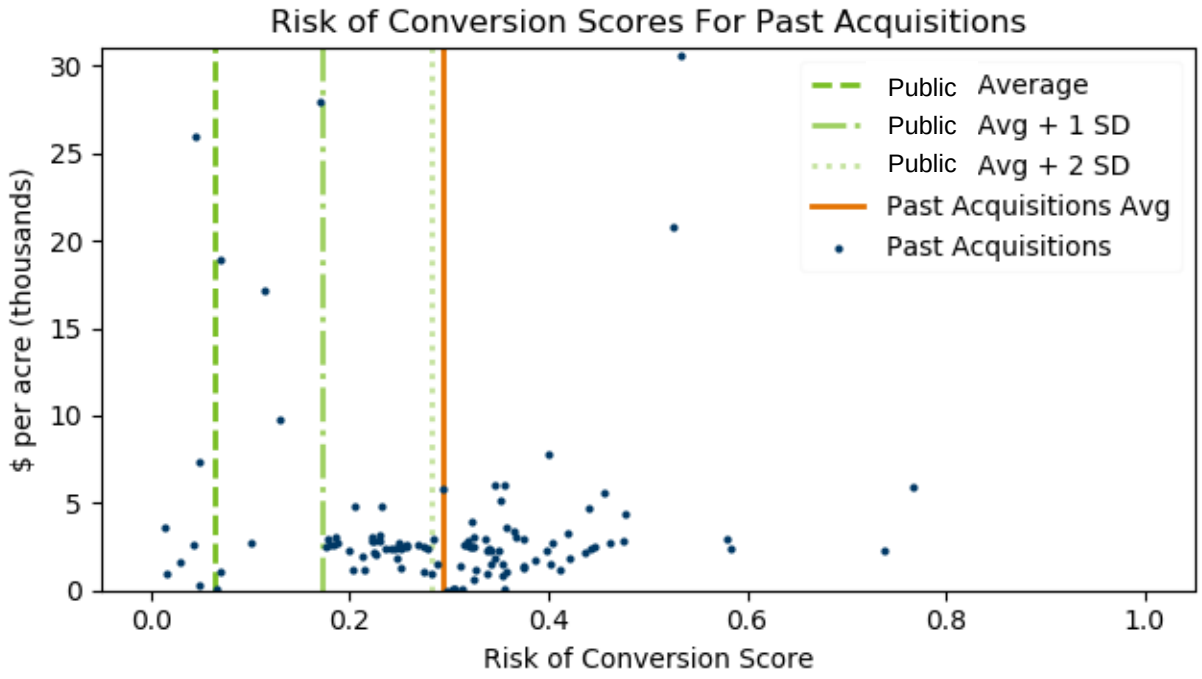


Figure 1-f.

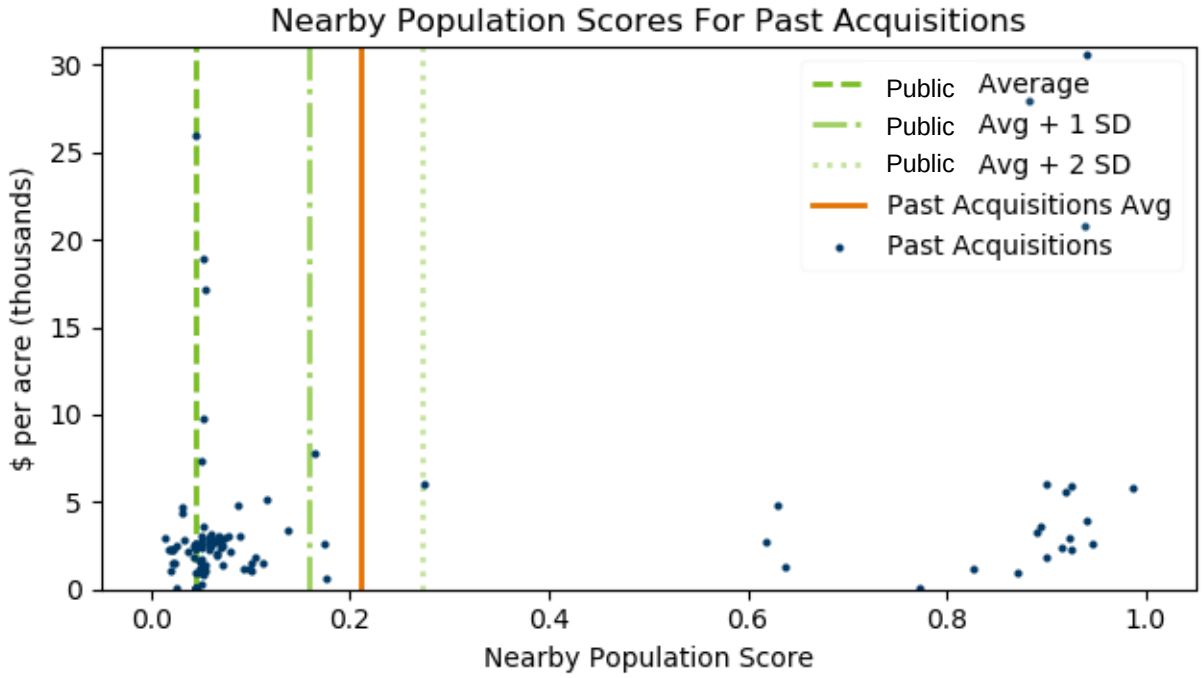


Figure 1-g.

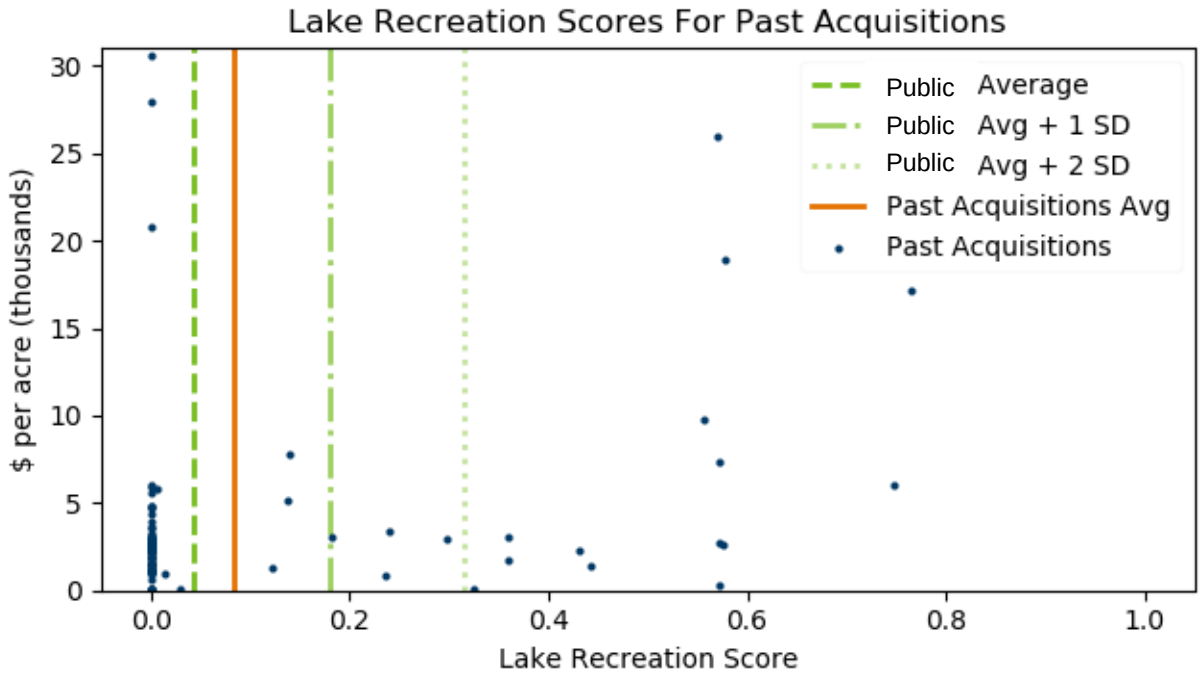


Figure 1-h.

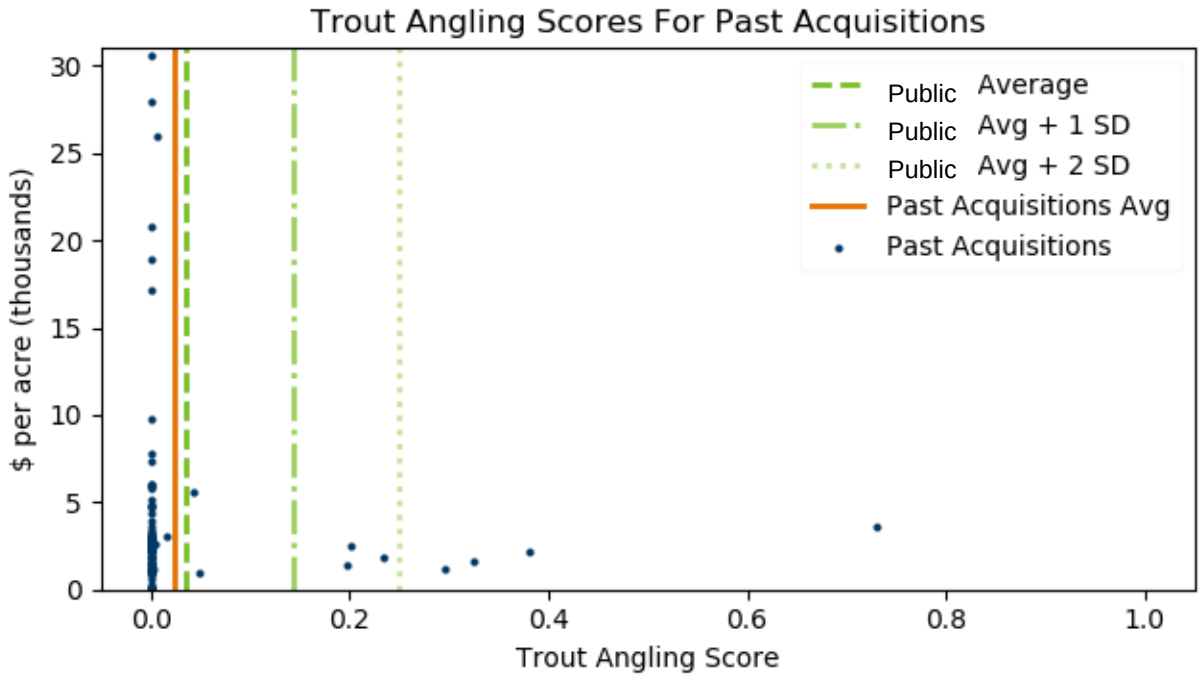


Figure 1-i.

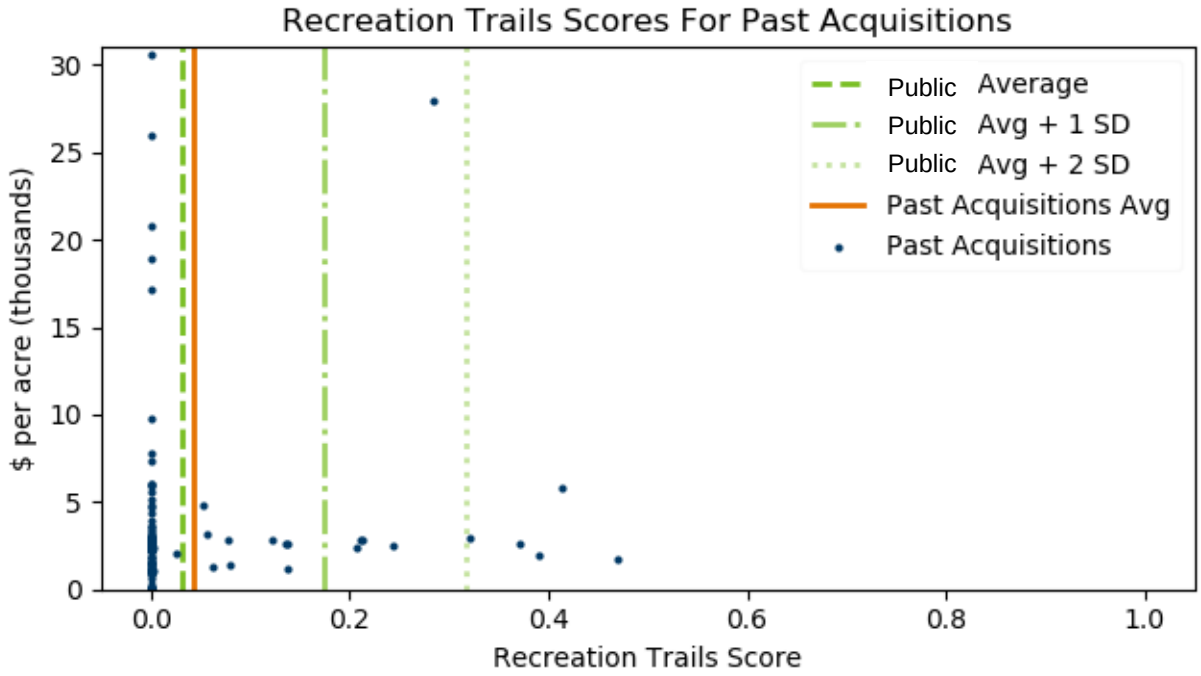


Figure 1-j.

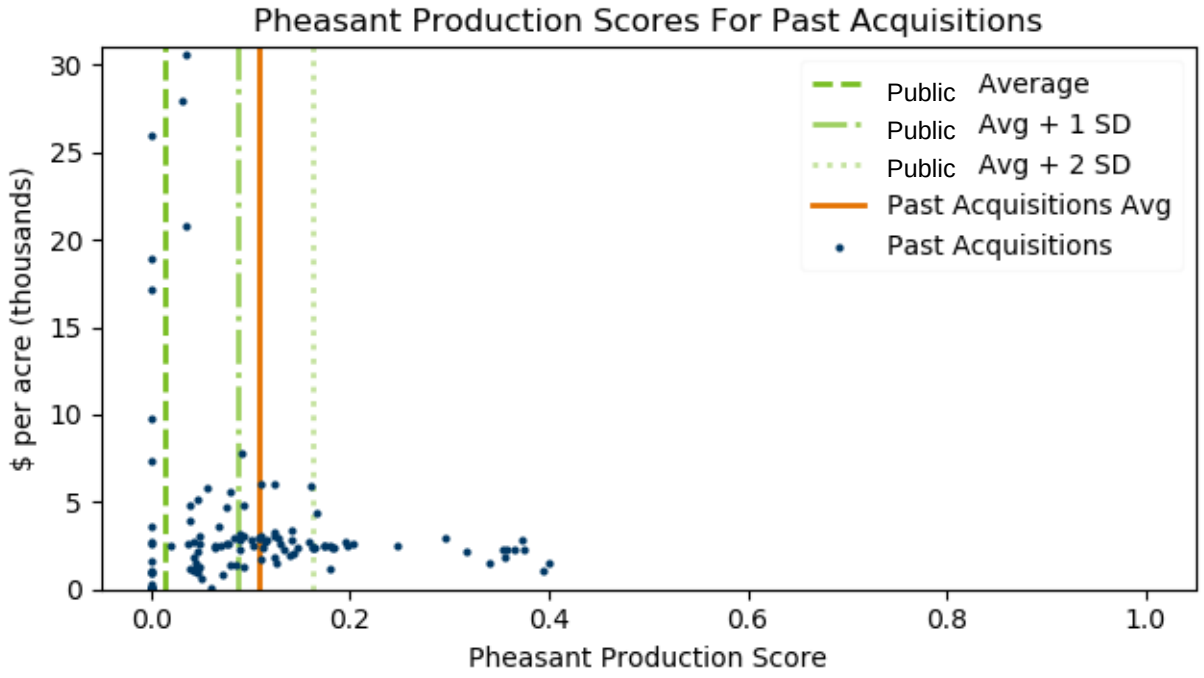


Figure 1-k.

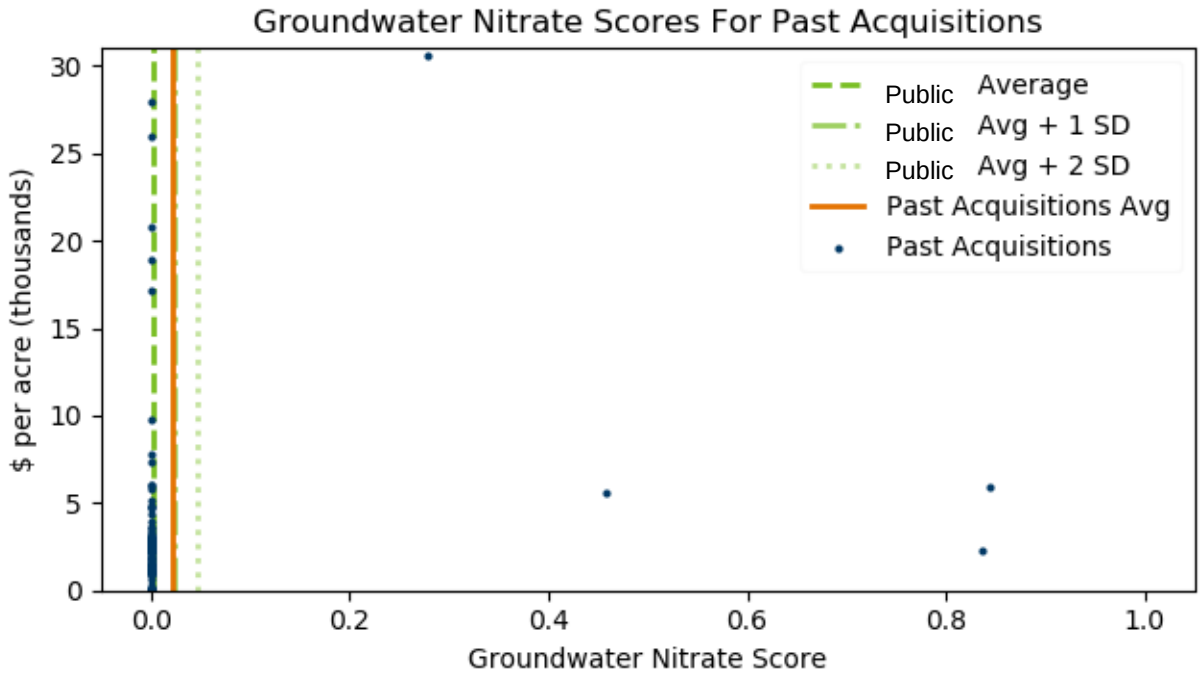


Table 1. Break down of proportion of past acquisitions that had scores above the average of all *publicly held undeveloped* parcels in the state. The proportion of past acquisitions is also broken down by number of standard deviations (SD) above average.

	Groundwater Nitrate	Pheasant Production	Trails	Trout Angling	Lake Recreation	Nearby Population	Risk of Conversion	Wild Rice	Bird Watching	Pollination	Soil Carbon
Above Average	4%	81%	18%	9%	19%	75%	94%	13%	55%	64%	5%
Below Average	96%	19%	82%	91%	81%	25%	6%	87%	45%	36%	95%
Average to < 1 SD Above Average	0%	31%	8%	3%	3%	53%	8%	0%	36%	37%	5%
1 SD to < 2 SD Above Average	0%	28%	4%	3%	4%	3%	30%	4%	17%	17%	0%
> 2 SD Above Average	4%	22%	5%	4%	13%	19%	56%	9%	2%	10%	0%

Table 2. Highest performing easement acquisition per metric relative to all *publicly held undeveloped* land. Metric scores are created such that the highest scoring viable parcel in the state receives a 1. The closer to 1, the closer a given acquisition is the highest scoring in the state for that metric. All dollar values are adjusted for inflation and presented in 2016 dollars.

Metric	Metric score	LCCMR ID	Original Purchaser	Acres	Year	Total $/Acre	ENRTF $/Acre
Soil Carbon	0.215	14-093-001	Ducks Unlimited	33.6	2012	5,996	4,923
Pollination	0.832	06-041-001	MN DNR	555.6	2006	864	104
Bird Watching	0.441	11-075-001	MN DNR	2.8	2008	3,620	3,620
Wild Rice	1.000	14-005-005	Minnesota Land Trust	37.4	2013	32	32
Risk of Conversion	0.766	11-037-009	Dakota County	193.2	2011	5,918	2,817
Nearby Population	0.988	11-053-001	Minnesota Land Trust	44.7	2011	5,801	4,119
Lake Recreation	0.765	08-035-002	MN DNR	61.3	2007	17,197	1,273
Trout Angling	0.731	11-075-001	MN DNR	2.8	2008	3,620	3,620
Trails	0.750	11-075-004	Minnesota Land Trust	11.5	2011	61,869	22,273
Pheasant Production	0.400	11-011-004	MN DNR	178.8	2010	1,466	537
Groundwater Nitrate	0.844	11-037-009	Dakota County	193.2	2011	5,918	2,817

Multi-objective performance: public land comparison

Figure 2. Number of past acquisitions that scored better than average of all *publicly held undeveloped* parcels on a given number of metrics.

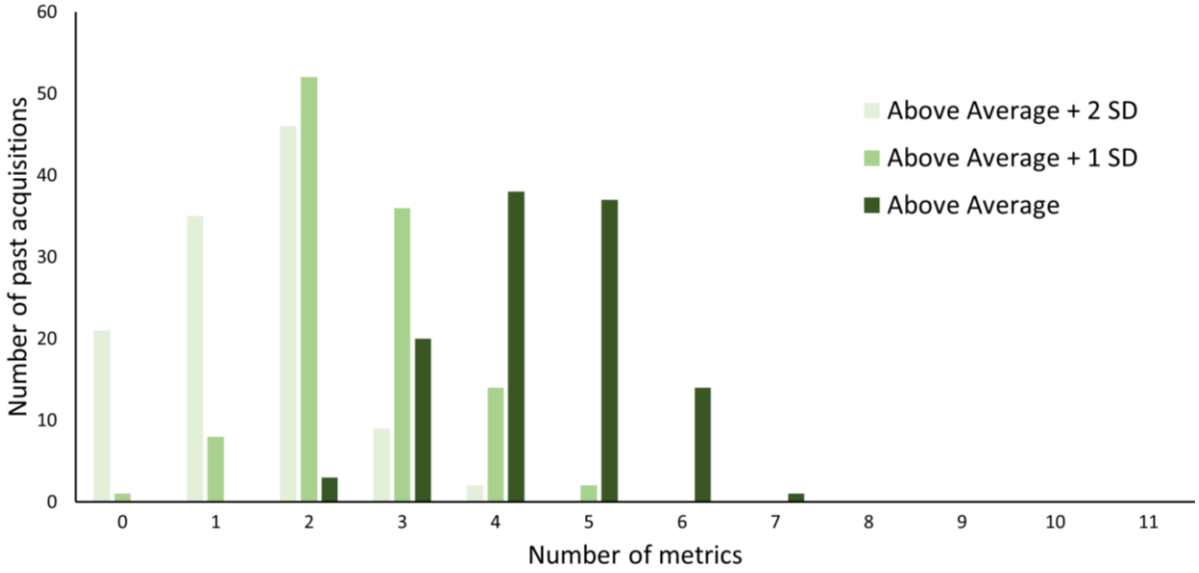


Table 3. Past acquisitions that had above average or greater performance relative to *publicly held undeveloped* land on the most metrics. Counting the number of above average metrics does not account for variation in preferences in the public. This analysis provides a framework to identify what benefits a parcel provides, and how the benefit's quality compares to the rest of the state. Policy makers and practitioners should consider the values and priorities of the public when deciding which benefits to emphasize. All dollar values are adjusted for inflation and presented in 2016 dollars.

LCCMR ID	Original Purchaser	Acres	Year	Total $ / Acre	ENRTF $ / Acre	Above Average Count
10-037-001	Dakota County	42.3	2008	5,548	1,054	7
11-127-004	BWSR	46.4	2010	2,620	2,620	6
11-045-002	MN DNR	40.5	2010	2,172	2,163	6
14-111-001	Minnesota Land Trust	48.6	2012	1,444	114	6
11-127-007	BWSR	53.9	2011	2,855	2,855	6
09-041-005	Ducks Unlimited	23	2009	1,716	497	6
11-055-002	BWSR	190.1	2008	2,465	147	6
09-041-004	Ducks Unlimited	180	2009	1,328	180	6
15-037-002	Dakota County	103.1	2012	30,632	1,531	6
11-157-003	MN DNR	284.6	2010	1,211	1,187	6
08-157-001	The Nature Conservancy	33	2007	3,083	3,083	6
11-129-001	BWSR	15.8	2010	3,178	3,178	6
08-163-005	MN DNR	42.5	2006	27,950	4,807	6

11-129-009	BWSR	27.6	2011	2,882	2,882	6
08-129-002	BWSR	70.6	2008	2,819	2,819	6
						Above Average + 1 SD Count
09-041-005	Ducks Unlimited	23	2009	1,716	497	5
11-049-002	MN DNR	33.4	2010	3,317	3,300	5
						Above Average + 2 SD Count
10-037-001	Dakota County	42.3	2008	5,548	1,054	4
09-041-005	Ducks Unlimited	23	2009	1,716	497	4

Targeting with a landscape level approach: public land comparison

Table 4. Count of *publicly held undeveloped* parcels that had higher scores on all metrics than a given past acquisition. Parcels with a high number of parcels better on all metrics could have benefited from a landscape level approach. Note that a parcel may excel at a benefit we did not produce a metric for. For example, there was not sufficient data to construct a statewide duck production metric.

LCCMR ID	Original Purchaser	Acres	Year	Total $ / Acre	ENRTF $ / Acre	Better On All Metrics Count
11-127-009	BWSR	13	2011	2,007	2,007	**0**
11-075-004	Minnesota Land Trust	11.5	2011	61,869	22,273	**0**
08-047-002	Ducks Unlimited	39	2007	3,372	2,933	**0**
13-073-001	BWSR	45.1	2011	2,329	2,329	**0**
11-039-001	BWSR	39.7	2011	2,656	2,656	**0**
11-173-004	BWSR	67.9	2011	2,442	2,442	**0**
13-073-003	BWSR	30	2011	2,229	2,229	**0**
06-041-001	MN DNR	555.6	2006	864	104	**0**
11-127-007	BWSR	53.9	2011	2,855	2,855	**0**
11-055-002	BWSR	190.1	2008	2,466	148	**0**
11-037-009	Dakota County	193.2	2011	5,918	2,817	**0**
12-003-001	Minnesota Land Trust	80	2012	2,616	1,125	**0**
16-037-003	Dakota County	17.2	2016	2,953	1,480	**0**
11-157-003	MN DNR	284.6	2010	1,212	1,188	**0**
08-157-001	The Nature Conservancy	33	2007	3,083	3,083	**0**
10-037-001	Dakota County	42.3	2008	5,548	1,054	**0**
08-035-002	MN DNR	61.3	2007	17,197	1,273	**0**
08-129-001	BWSR	15.9	2008	2,701	2,701	**0**
08-163-005	MN DNR	42.5	2006	27,951	4,808	**0**

13-023-002	BWSR	35.1	2012	2,592	2,592	**0**
11-049-002	MN DNR	33.4	2010	3,317	3,301	**0**
11-127-003	BWSR	50	2010	2,054	2,054	**0**
11-053-001	Minnesota Land Trust	44.7	2011	5,801	4,119	**0**
16-037-004	Dakota County	20.6	2016	6,008	2,932	**0**
13-073-002	BWSR	28	2011	2,314	2,314	**0**
14-093-001	Ducks Unlimited	33.6	2012	5,996	4,923	**0**
15-037-003	Dakota County	27.4	2015	2,279	1,071	**0**
11-037-010	Dakota County	39.3	2011	3,621	1,086	**0**
08-127-001	BWSR	46.6	2008	2,329	2,329	**0**
08-129-002	BWSR	70.6	2008	2,820	2,820	**0**
15-037-004	Dakota County	26.1	2015	1,814	925	**0**
14-021-007	Cass County	21.7	2011	9,791	480	**0**
14-021-006	Cass County	38.6	2011	2,610	399	**0**
11-127-004	BWSR	46.4	2010	2,621	2,621	**1**
11-157-004	MN DNR	30	2010	1,848	1,719	**1**
11-129-007	BWSR	30.7	2011	2,874	2,874	**1**
11-127-006	BWSR	79.9	2011	2,539	2,539	**1**
14-151-001	MN DNR	19.34	2013	2,798	1,007	**1**
15-037-001	Dakota County	34.3	2015	2,361	1,133	**1**
14-021-002	Cass County	5.8	2012	25,950	1,427	**1**
14-111-001	Minnesota Land Trust	48.6	2012	1,444	114	**2**
09-041-004	Ducks Unlimited	180	2009	1,328	181	**2**
11-157-005	MN DNR	1220.3	2010	1,139	1,116	**2**
11-173-010	BWSR	43.6	2011	2,432	2,432	**2**
11-129-001	BWSR	15.8	2010	3,178	3,178	**2**
11-127-008	BWSR	20	2011	2,564	2,564	**2**
14-021-003	Cass County	9.4	2010	18,925	520	**2**
14-005-005	Minnesota Land Trust	37.4	2013	32	32	**3**
11-127-001	BWSR	21.6	2010	2,546	2,546	**3**
11-145-003	Ducks Unlimited	75.7	2011	1,520	1,459	**3**
14-021-005	Cass County	4.5	2011	54,892	2,344	**3**
09-041-005	Ducks Unlimited	23	2009	1,717	498	**4**
08-127-002	BWSR	79.3	2008	2,920	2,920	**4**
11-129-004	BWSR	3.7	2010	3,044	3,044	**4**
14-005-004	Minnesota Land Trust	198.9	2013	953	953	**4**
12-163-001	Minnesota Land Trust	294	2012	988	10	**5**
11-145-005	Minnesota Land Trust	56.5	2011	681	586	**5**
11-045-002	MN DNR	40.5	2010	2,172	2,164	**5**
11-173-008	BWSR	40.9	2011	2,433	2,433	**5**
11-173-005	BWSR	13.5	2011	2,442	2,442	**5**
15-025-001	Minnesota Land Trust	79	2014	30	30	**5**
12-173-001	BWSR	61	2011	2,438	2,438	**5**

15-059-001	Minnesota Land Trust	158.5	2014	1,140	1,057	**5**
11-173-003	BWSR	40.4	2010	2,518	2,518	**6**
11-173-002	BWSR	26.3	2010	2,523	2,523	**6**
11-129-009	BWSR	27.6	2011	2,882	2,882	**6**
11-173-009	BWSR	18.5	2011	2,506	2,506	**7**
09-025-002	Minnesota Land Trust	140	2007	4,852	446	**8**
14-021-009	Minnesota Land Trust	31	2013	313	313	**8**
14-067-001	Minnesota Land Trust	30.7	2011	5,105	97	**8**
11-173-006	BWSR	44.5	2011	2,449	2,449	**8**
14-121-001	MN DNR	65.7	2014	1,435	1,435	**9**
11-173-001	BWSR	43	2010	2,503	2,503	**10**
11-075-001	MN DNR	2.8	2008	3,620	3,620	**10**
15-037-002	Dakota County	103.1	2012	30,633	1,532	**10**
16-155-001	MN DNR	150.8	2014	2,891	1,792	**10**
11-173-007	BWSR	35.4	2011	2,434	2,434	**11**
09-041-003	Ducks Unlimited	78	2008	3,072	184	**12**
11-157-001	MN DNR	262.4	2009	1,032	1,011	**14**
14-021-008	Cass County	6.8	2013	7,398	1,693	**14**
11-011-004	MN DNR	178.8	2010	1,466	537	**15**
11-127-002	BWSR	136.8	2010	3,080	3,080	**17**
16-011-001	MN DNR	125.5	2015	2,316	1,139	**18**
15-143-001	Minnesota Land Trust	79.6	2014	1,331	752	**22**
11-129-005	BWSR	16.6	2010	2,976	2,976	**23**
14-005-002	Minnesota Land Trust	108.7	2013	14	14	**28**
10-003-001	Minnesota Land Trust	45	2010	3,985	3,985	**28**
14-021-001	Cass County	2.7	2012	2,673	1,989	**28**
11-117-001	MN DNR	160.2	2009	1,060	810	**29**
16-167-001	MN DNR	53.4	2014	1,795	1,478	**31**
11-037-011	Dakota County	16.8	2011	20,802	8,258	**33**
11-011-003	MN DNR	63.2	2010	1,527	1,482	**34**
09-161-001	Ducks Unlimited	12.42	2008	7,809	6,481	**42**
11-149-004	BWSR	122.8	2010	4,717	1,509	**43**
12-127-001	MN DNR	19.6	2012	2,895	2,861	**44**
14-041-002	BWSR	39.5	2013	2,722	1,062	**45**
14-005-006	Minnesota Land Trust	58	2013	25	25	**50**
14-041-001	BWSR	343.9	2012	2,345	891	**51**
14-041-005	BWSR	55.1	2014	2,728	1,200	**51**
14-041-003	BWSR	192.2	2014	2,530	1,139	**53**
14-015-001	MN DNR	26.99	2014	4,856	4,759	**66**
11-025-001	Minnesota Land Trust	39.7	2010	2,771	416	**67**
14-005-003	Minnesota Land Trust	71	2013	75	75	**72**
13-111-002	Minnesota Land Trust	71	2013	38	38	**72**
11-145-004	Minnesota Land Trust	43.9	2011	2,649	2,331	**85**

08-041-001	Ducks Unlimited	111	2007	1,131	987	**88**
14-007-001	Minnesota Land Trust	145.5	2014	30	30	**110**
11-157-002	MN DNR	114.4	2009	1,489	1,429	**113**
11-035-002	Ducks Unlimited	150	2011	1,093	1,049	**120**
09-051-003	Ducks Unlimited	28.62	2008	2,139	428	**121**
11-075-005	Minnesota Land Trust	88	2010	1,631	188	**182**
11-149-003	BWSR	155.8	2010	4,417	398	**696**
12-035-001	Minnesota Land Trust	88	2011	926	259	**2120**

Portfolio Statistics: public land comparison

Figure 3. Analysis of ENRTF portfolio in comparison to all publicly held parcels in the state. The further the blue bar is past its adjacent green bar, the more that metric is represented in past acquisitions relative to all *publicly held undeveloped* parcels.