ROI analysis of North America Region 'big deal' pipeline

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With capital always scarce, management needs to be able to compare the return on investment (ROI) of major "deals" or "transactions" that are significant enough to require Board approval. To meet this need, we introduce here metrics that can be rapidly and inexpensively applied to projects across broad geographies and that encompass a range of potential benefits to nature and people. The chosen metrics use datasets with, at a minimum, coverage of the United States. Rather than lumping everything into one "return," we propose a dashboard approach, and present ROI metrics for different dimensions of the conservation return. We believe that this information is more likely to be used if presented via an intuitive user interface. We developed a ROI Dashboard (beta version), which can be viewed here: http://nascience.us/roi/public. Note that to protect confidential information, this version of the dashboard uses hypothetical project names and locations; there exists a password-protected version that contains actual project names and locations. Metrics can best aid decision-making when placed in context. Therefore, we examine previously implemented projects using these same metrics and provide these results as benchmarks for evaluating future projects. In this way one can ask "are we at least doing as well or better than in the past?"

Use and Abuse of the ROI Dashboard: Ultimately, we hope that applying these metrics will help TNC staff identify the highest ROI projects to invest their energies in, resulting in continued improvement in the ROI of projects that make it to the Board for approval. This would occur simply if staff working on large projects use this tool to assess the potential ROI of deals early in their scoping process. It is important to note that this tool has important limitations that render its use inappropriate in several situations: 1) Our approach is meant for comparison across large geographies. It is not appropriate for comparison of projects within a state or ecoregion where higher resolution data on potential conservation benefits are available; 2) Our approach does not assess all potential benefits, such as benefits to aquatic species, or specific species of conservation concern, or ecosystem services such as coastal defense 3) It cannot be used for prospecting, because there is no accurate nationwide data on land costs. 4) Because it is difficult to capture all potential benefits and each large conservation projects is unique, it would be inappropriate to apply a 'threshold' for identifying projects that should move forward.

Current Status: Based on the above design principles, we present here a first draft of such an effort for review. These metrics were designed in response to requests from Peter Kareiva and Board scientists and have received input from a small group of TNC scientists. However, they are very much still in draft stage. The plan is to revise them in response to Board and TNC staff comments until we have a product that meets approval (no hard deadline has yet been set for completion of this process). Before providing complete methods and discussion, we first present an outline overview of the metrics, which fall into four categories: 1) Bucks and acres, 2) Biodiversity and ecosystem service benefits, 3) Climate resilience, and 4) Avertable Threats, and 5) Mineral Development Risk. We seek projects that have the greatest biodiversity and ecosystem service benefits, greatest resilience to climate change, and the lowest costs. Further, we identify two types of risk from development: 1) avertable risk – this is development that would be prevented by owning or easing surface rights; 2) mineral development risk – since we rarely control mineral rights, even protected properties may be developed for mineral rights. We should seek to protect lands where we can avert development and seek to avoid lands where mineral development is likely to degrade our investment.

Dashboard Overview

Bucks and Acres

1. Acres
2. Fee value
3. Dollars per acre
4. TNC dollars at risk per acre

Biodiversity and Ecosystem Service Benefits

5. Total species (# of species saved, from the species area curve)
6. Critical habitat (acres of designated and proposed critical habitat)
7. Species (various taxa, from the species area curve)
8. % of area within TNC's ecoregional portfolio
9. Interior protected habitat (new interior acres protected)
10. Connectivity corridors (acres protected)
11. Carbon storage (metric tons CO_2; 100% of aboveground carbon + 40% of carbon in top 30 cm of soil for projects at risk of conversion to cropland)
12. Water provision (drinking water importance index, from USFS Forests to Faucets report)

Climate Resilience

13. Intactness (% project in intact area)
14. Biome change (probability of change: Very High, High, Med, Low, Very Low)
15. Climate velocity (maximum value of the normalized change over past 30 years in min temperature, evapotranspiration, and moisture deficit change over past 30 years)

Avertable Threats

16. General development risk (% of natural habitat within 3 mile buffer of project area projected to convert to developed land use by 2100, as modeled by neural net development model)
17. Cropland conversion (% of natural habitat in a county converted to cropland 2008-2012)
18. Wind development suitability (% project in suitable wind area)
19. Solar development suitability (% project in suitable solar area)

Mineral Development Risk (un-avertable threats)

20. Oil and gas suitability (% project area in tight gas plays or shale plays, or near existing wells)
21. Coal suitability (% project in coal fields)

Methods and Discussion

Bucks and Acres

'Bucks and acres' has historically been used as a measure of success – the more acres per dollar the better the deal. Our dashboard considers both the total cost of the project and the TNC dollars at risk. TNC dollars at risk will depend on the deal structure. For example, for a deal where costs are partially covered by an impact investor, but TNC covers 10% upfront and must repay an additional 10% if costs are not recouped over time, this cost would be 20%. A more rigorous estimation of costs to TNC would account for the probability of recovering funds (e.g. based on project risk characteristics and data on past delays and write-downs from LPF) and the time value of the money invested in this project (e.g. the opportunity cost of not loaning it out through the LPF). We are looking into a research project with an academic partner to rigorously develop such a metric.

Biodiversity

We provide estimates of the number of species saved by each project. These estimates account for both 1) geographic variation in diversity and 2) the diminishing returns of habitat protection. To assess whether a project is appropriately targeted within an ecoregion, we consider its overlap with our ecoregional portfolio and report the percent overlap. In addition, some projects are also designed to 1) protect migration corridors that are essential for biodiversity, or 2) leverage existing protected areas by buffering them with additional protection, providing the 'interior' habitat that many of our most sensitive conservation targets require. Neither of these benefits is adequately captured by 'number of species saved' approach, so we include separate metrics to quantify these benefits.

Species area curve and diminishing returns: the number of species that can persist in a protected area increases with the size of the protected area. However, the relationship between the number of species protected and acres protected is not linear; there are diminishing per acre returns as more and more habitat is secured. We obtained data for the number of species in each ecoregion. We believe that the ecoregion is the appropriate scale at which to conduct this analysis. Species do not need a certain proportion of their habitat protected everyplace that their habitat exists; rather, species within an ecoregion can be preserved with a large enough network of protected areas even as other areas are developed. Within an ecoregion, we assume that unprotected areas have or may eventually have compromised habitat value. Based on this assumption, the incremental benefit from new protection is based on the species area curve, starting at the area that is currently protected, and increasing by the amount of the proposed project area (see Figure 1). We assume that all public land is under some form of protection. This has the reasonable effect of not favoring additional land protection in areas that are already dominated by public lands. This is reasonable even if these public lands are poorly managed – in which case the highest ROI conservation strategy in that ecoregion would be likely be working to improve management of existing public lands rather than acquiring more land for protection. We parameterized the species area curve $S=cA^z$ with z =0.2 and solved for the constant c based on the known total number of species in each ecoregion of known area (Kareiva and Marvier 2011). Although there is debate in the literature about what the value of the z parameter should be (He and Hubbell 2011), we expect that for our purposes of characterizing the relative ranking of projects, this approach is robust to variation in the z parameter. We quantify the species benefits separately for all species, terrestrial vertebrates, and plants.

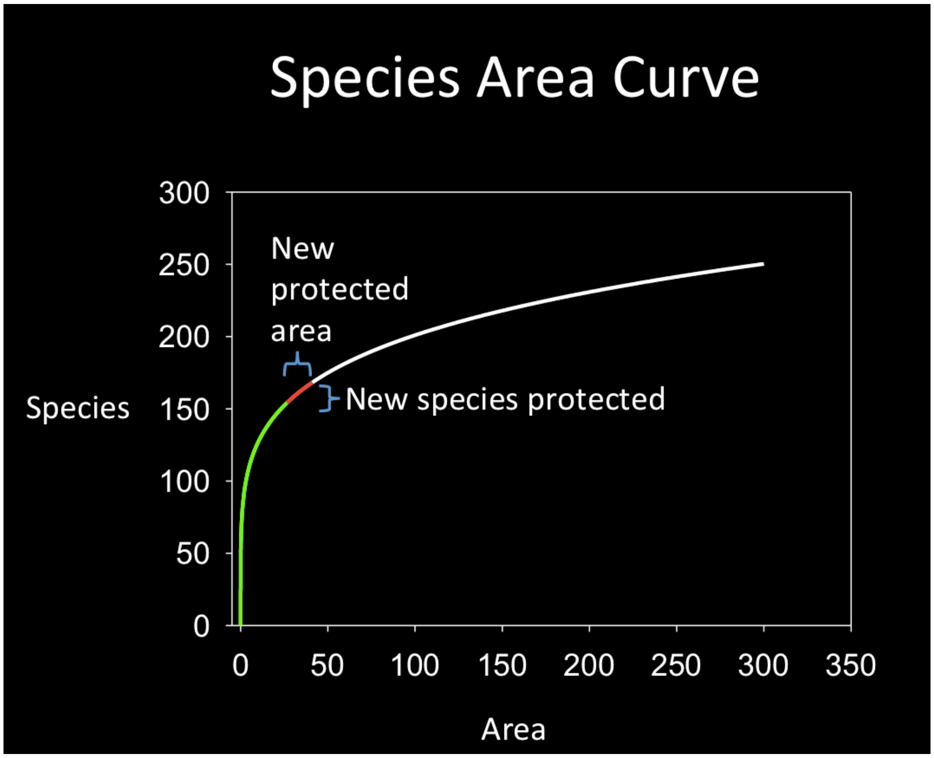

Figure 1. Hypothetical species area curve showing the diminishing returns of species with area. The benefits of a new protected area depends on how high the curve saturates (how diverse the ecoregion), the amount of land already protected (shown in green), and the amount of new area protected (shown in red).

Critical Habitat: Acres of US Fish & Wildlife Service designated and proposed Critical Habitat for Threatened and Endangered species. The Critical Habitat footprint does not capture all important habitat for T&E species, and in some cases may omit habitat on private lands.

Ecoregional Portfolio: The Nature Conservancy has identified priority conservation areas within each ecoregion. In any given ecoregion, projects that protect more ecoregion acres are likely to have greater conservation benefit.

New acres of interior protected habitat: There are well-known edge effects on protected areas that abut roads and development. Edges of protected areas often have more invasive species, unnaturally high rates of predation and parasitism, and other activities that result in habitat degradation and avoidance (e.g. Forman et al. 1997; Fahrig 2003). When protected lands occur in small patches, their benefit for conservation can be compromised. This is particularly problematic where lands have been 'checkerboarded', as when many public lands were granted to railroads over 100 years ago. Projects that consolidate ownership in checkerboarded or otherwise fragmented lands have the benefit of reducing edge effects, increasing interior habitat, and creating the enabling conditions for consistent and efficient management of timber, fire, and invasive species. To quantify this benefit we calculate the number of new interior protected acres that will be created by the project. Interior areas are defined as being greater than 400 meters from an 'edge' (e.g. Forman et al. 1997; Fahrig 2003). For the purposes of this exercise, an edge is defined by a boundary between protected and unprotected areas. This accounts for future disturbances likely to occur on unprotected lands, which would not be accounted for if current land cover were used to identify edges.

Corridors: 'Connectivity' is essential to biodiversity conservation, both to permit seasonal migration, colonization, and gene flow among extant habitat and populations and to allow migration in response to climate change (Crooks and Sanjayan 2006, Heller and Zavaleta 2009). As one national approach that identifies corridors that can support a variety of these functions, we used preliminary results from a new climate corridor modeling effort by McGuire et al (in prep). This analysis connects large natural areas that differ in temperature following climatic gradients (Nunez et al. 2013). Using Climate Linkage Mapper software (Kavanagh et al. 2013) corridors were identified that connect large natural areas (> 1000 ha) that differ in temperature from one another by at least 1 C while avoiding developed areas and following gentle climatic gradients. Natural areas and resistance values were based upon the human modification index (Theobald 2009). We quantify the acres of corridors that a project would protect.

Ecosystem Services

Although land protection projects have a myriad of ecosystem services, here we focus on two that we were able to consistently quantify across the whole United States: carbon sequestration and water provision.

Carbon sequestration: We assume that aboveground carbon is at risk of loss if lands are not conserved. Aboveground carbon could be at risk from development. Aboveground carbon could also be at risk or loss from pest outbreak, catastrophic fire, or unsustainable logging, the risk from all of which are increased if lands are unprotected and poorly managed. We use biomass estimated in a nationwide 240 m pixel grid, developed from satellite data by Woods Hole researchers (Kellendorfer et al. 2000).

In addition to aboveground carbon, soil carbon may also be lost, but this only a significant threat if the area is converted to cropland. Therefore, in those counties where conversion to cropland is a threat, we added soil carbon losses to aboveground carbon losses. Soil carbon losses were calculated as 40% of the carbon in the top 30 cm (1 foot) of soil, reflecting average losses of soil carbon following conversion to agriculture. Carbon at risk is expressed in metric tons of CO2, which are the common units for measuring greenhouse gas emissions, using this formula:

CO2 protected by project = (100% of aboveground carbon + 40% of soil carbon in top 30 cm of soil in counties where % cropland conversion >1%)*44/12 to convert from C to CO2.

Water Provision: We used an index of drinking water importance from the "Forests to Faucets" report (Weidner and Todd 2011). This report uses an EPA dataset of the location of drinking water intakes for municipal water use. To calculate the index, each watershed is weighted based on the number of people to which it provides drinking water. Watersheds are given credit for the people for whom they provide dinking water, weighted by how far upstream the watershed is from the drinking water intake. If the intake is in the watershed, 100% of the people are counted, if the intake is in the adjacent downstream watershed 78% of the people are counted, if the intake is two watersheds downstream 60% of the people are counted, etc. The formula used to generate the weight is 0.99^{25w} where w is the number of watersheds downstream to the intake. The resulting index was rescaled from 0 to 100. We multiply this index by the acres protected to quantify the benefit of a project for drinking water provision.

Climate Resilience

Areas that are more intact, have a lower modeled probability of biome change, and that are experiencing less rapid climate change are more likely to be relatively resilient to climate change, and thus have greater conservation value (or return). While there are a variety of ways in which to assess climate resilience, these approaches capture different aspects of resilience in readily available, relatively high-resolution datasets with national coverage. This information should be supplemented by the Conserving the Stage resilient sites analyses where these have been conducted https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/terrestrial/resilience/Pages/default.aspx. For coastal projects, sea level rise should also be considered.

Intactness: Relatively intact areas are more likely to, under future climate change: contain suitable microsites, lack barriers to migration, have large enough populations to withstand climate variability, and to contain the genetic diversity that will be the basis of evolutionary adaptation. We use Dave Theobald's human modification index (Theobald, personal communication), representing a refined version of data presented in Theobald (2010), to identify intact lands. This model includes proximity to roads, land use, housing density, and other factors, and estimates the degree of human impact on a scale of 0 (no impact) to 1 (high impact). We selected a threshold of 0.4 based on spatial variability across the country. Specifically, if the threshold is higher, almost everything in the Western US would be considered intact and if it is lower almost nothing in the eastern US would be considered intact. The selected threshold allows us to identify the relatively intact places in every part of the country.

Biome change: Climate change may pose particular threats when ecological thresholds are crossed. For example, we might chose to avoid investing in forest restoration in areas that may no longer support forests. We use the probability of biome change as modeled by Gonalez et al. (2010). Gozalez et al. estimate this risk based on two datasets: a coupled global climate and vegetation model, and recent climate change patterns. This data is at a relatively coarse resolution (50 x 50 km pixels). We are seeking to obtain the results of other analyses that are at a finer resolution and would update our analysis with this new data if further evaluation deemed it to be better suited for our analysis.

Climate velocity: Climate velocity is the distance that a species has to move to stay in the same climate. For example, under a warming climate, a species could find an area with the same temperature that it currently experiences by moving to a higher latitude or a higher altitude. In general, in areas with large topographic gradients (e.g. mountains), the distance species need to travel to find a cooler climate is shorter. Thus, climate velocity integrates changes in climate with topography variation. Places with rapid climate change and little topography are expected to be the most stressful, as species would have to rapidly migrate long distances to stay in the same climate. Different areas are expected to experience different amounts of climate change. For example, models predict greater temperature changes at higher latitudes and that some areas will receive less rainfall while others receive more. However, climate models make relatively uncertain predictions for any particular area and therefore cannot be accurately 'downscaled' to make predictions at spatial scales relevant for prioritizing land protection actions. However, ongoing climate change is generally consistent with climate model predictions and therefore provides a good leading indicator of likely future stress due to climate change. Species ranges are particularly sensitive to changes in minimum temperature, actual evapotranspiration and moisture deficit. We obtained data on the climate velocity for each of these variables from 1976-2005 as modeled by Dobrowski et al. (2012). Because rapid change in any of these variables is expected to be stressful for species, we integrated these variables into one index by taking the maximum value at each location. All three variables are expressed in the same units: km/year, indicating how far a species would have to travel in order to stay in the same climate. Areas with a lower climate velocity were considered more resilient.

Avertable Threats

If an area is not at risk of some form of development, then protection will not change the course of species loss and hence offers a lower ROI. The primary development risks that can be averted with a purchase of or easement on surface rights are from residential/urban development, agricultural development and wind and solar energy development. We assess each of these independently. Because we are making investments in long-term conservation, we are interested in long-term development risks. If one looks at recent patterns of development, particularly for energy development, a notable feature is how unpredictable this development has been. Therefore, we avoid short-term predictions about imminent risk of development that are likely to underestimate the full extent of areas at long-term risk of development. We focus instead on suitability for development, expecting that many of these places will eventually be at risk of development even if they are not at immediate risk. This is a good strategy for conservation – if we wait until areas are under imminent threat of development their cost of protection is likely to dramatically increase.

Urban/residential development: We used the Land Transformation model forecasts changes in urbanization by 2100 (Tayyebi et al. 2012). Given the uncertainty with long-term development projections, we report the percent of existing undeveloped area that is projected to be converted within a 3 mile radius of a project area.

Cropland conversion: Some areas of the country have dramatic amounts of ongoing conversion to cropland. These are lands that were previously considered marginal for agriculture, are often currently grazed, and for which high commodity prices and improved agricultural varieties have led to high rates of conversion to cropland. For each county in the United States, we quantified the percent of remaining natural habitat that was converted to cropland between 2008 and 2012. To identify remaining natural habitat, we used the National Land Cover Dataset 2006. For change in cropland, we used the USDA's Cropland Data Layer (http://nassgeodata.gmu.edu/CropScape/). We assumed that the entire net expansion of cropland in a county came at the expense of existing natural habitat, since existing development is hardly ever converted back to cropland. This was conducted as a tabular analysis using data aggregated at the county level. Our estimate could be an underestimate if net cropland expansion is lower than gross cropland expansion, for example if urban expansion consumes cropland in one area, causing expansion elsewhere in the county. Our estimate could be an overestimate if cropland expansion does not come at the expense of natural habitat, for example if fallow lands are returned to cropland. 2008 is the earliest year that national coverage was available for this dataset. 2012 is the most recent year for which this dataset is available.

Wind development suitability: Areas with a wind power class 3 or higher are suitable for wind development. We report the percent of a project area that has a wind power class 3 or higher. We used the National Renewable Energy Lab's wind power class data set, which reports wind power class at 50 meter height, with a resolution of 200m (http://www.nrel.gov/gis/data_wind.html). This is the best freely available data at this resolution.

Solar development suitability: Areas that are relatively flat (<3% slope) and sunny (>6.0 Kw/km2/day) are considered suitable for solar development. We report the percent of the project area that is suitable for solar development based on data from the National Renewable Energy Laboratory (NREL; http://www.nrel.gov/gis/data_solar.html).

Mineral Rights Development Risk

Oil and Gas suitability: areas that were near existing wells or within shale gas plays or tight gas plays were considered suitable for development. Because of emerging technology, the current distribution of wells does not reflect the likely expansion of oil and gas development into previously unrecoverable formations. We address this by including shale gas plays and tight gas plays (Ventyx Corporation, 2013) as suitable for development. Areas near existing wells were defined as areas within 10km of an existing well, using a national dataset containing 576,000 well locations (Biewick 2008). We report the percent of a project area that is suitable for oil and gas development.

Coal Fields: We report the percent of a project area that is within identified coal fields based on data from Ventyx corporation.

Reference Projects

A single ROI result for a single project is hard to interpret without context. For example, one cannot identify a good stock investment without knowing how it compares to alternative possible investments. To provide appropriate context to ROI we developed some baseline comparisons. Specifically, we obtained parcel data for the Montana Legacy Project and the International Paper deal. Since the IP deal spanned several regions and we were able to obtain separate dollar values for each of two regions, we report the project as two separate deals, one in the southeast and one in the midewest.

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