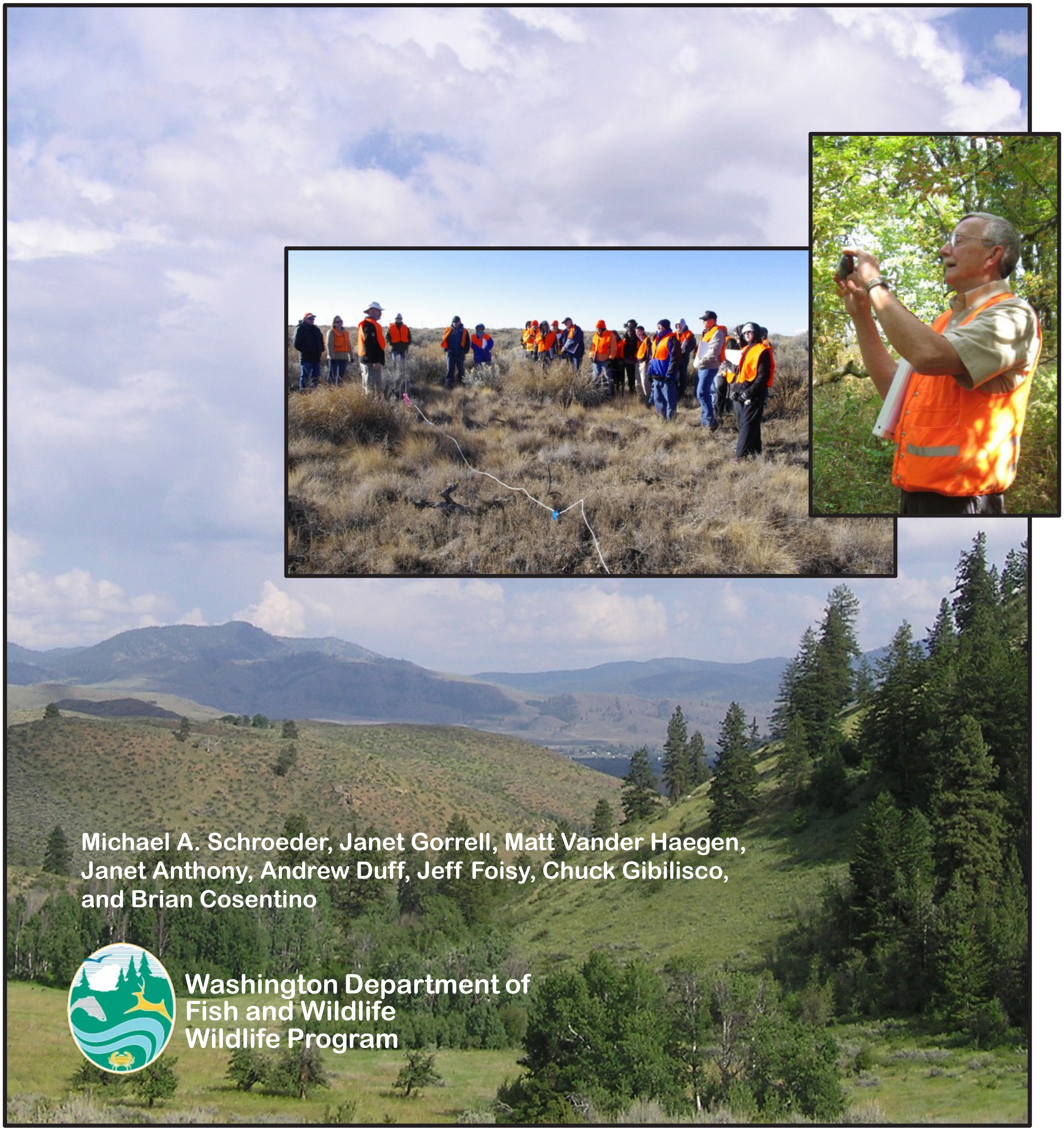
Ecological Integrity Monitoring of Wildlife Areas in Washington State

Pilot Study Report for the 2011-2013 Biennium **November 2013**



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Executive Summary

Ecological integrity can be defined as the ability of an ecosystem to support and maintain a community of organisms comparable to those of natural and/or undisturbed habitats. The Washington Department of Fish and Wildlife (WDFW) initiated a project to monitor ecological integrity on wildlife areas in Washington State. The Ecological Integrity Monitoring project (EIM) has been designed to be implemented on three levels: Level 1 (remote, using existing GIS data layers), Level 2 (rapid, field-based), and Level 3 (intensive, field-based). Metrics used in each of these 3 levels are designed to be useful at multiple spatial scales, relevant across ecosystems, grounded in natural history, and applicable to management.

During the 2011-13 biennium we completed a Level 1 assessment of a pilot project area (Kittitas County) and used these data to generate a simple comparison table of ecological integrity for each wildlife area unit in the project area. We also initiated field-base (Level 2) EIM work, focusing on 3 pilot wildlife areas: Swanson Lakes, Sinlahekin, and Scatter Creek. This effort involved refining ecosystem maps and developing Level 2 protocols for a set of common ecosystems on each wildlife area. We also developed protocols for collection of photo point data (repeat photography from standard locations and aspects) that will be an important component of ecosystem monitoring. We established 652 Level 2 sampling points and 148 permanent photo points on the 3 pilot wildlife areas. We also developed a spatial database (ArcGIS Geodatabase), web services, and web maps to capture EIM project data and photos and to support mission planning and site identification for EIM volunteers and teachers.

Due to the lack of capacity within WDFW to collect monitoring data, WDFW engaged volunteers and teachers under a citizen science model in the collection of Level 2 EIM data by conducting photo-point monitoring and collecting measurements at randomized vegetation plots. Substantial effort was employed to recruit, train, and retain citizen volunteers to collect data in the field and upload it to the project website. We trained 59 volunteers during 5 separate training sessions in eastern and in western Washington. The overall effort for all aspects of the EIM project included the equivalent of approximately 2 WDFW Biennium-FTEs.

Plans for the 2013-15 biennium include: a state-wide Level 1 assessment, including depiction of current ecological integrity and a tool that will allow the Lands Division to evaluate relative contributions of each stressor to integrity ranks; initiation or continuation of EIM monitoring on 8 wildlife areas; incorporation of ecological integrity goals and objectives in 4-6 wildlife area management plans; additional training of volunteers and volunteer mentors; and development of a structured communication plan to keep volunteers and educators engaged and active along with site-specific outreach plans for wildlife areas where EIM has been implemented.

Summary of primary activities and staff hours spent during the 2011-2013 Biennium.

Activity	Key Divisions	Hours
Level 1 Pilot Study	Science	200
Project management	Science, Lands, Outreach	997
Map development	Science	216
EIM Design and implementation	Science	1306
Data management and evaluation	Science	1092
Citizen Science Network	Outreach, Science	4365

1.0 Introduction

The mission of the WDFW is to preserve, protect and perpetuate fish, wildlife and ecosystems while providing sustainable fish and wildlife recreational and commercial opportunities. To this end, WDFW manages approximately 1 million acres of land across the state, as “wildlife areas,” to provide fish and wildlife habitat and maintain recreational opportunities for the citizens of Washington. To make informed management decisions, it is essential that current ecological condition be understood so that management efforts are appropriately implemented.

The WDFW strategic plan (WDFW 2013-15, Goal 1, Objective A) requires that ecological integrity of critical habitat and ecological systems be protected and restored. Ecological integrity is defined as the ability of an ecological system to support and maintain a community of organisms that has species composition, diversity, and functional organization comparable to those of natural habitats within a region (adapted from Karr and Dudley 1981 and Parrish et al. 2003). To have ecological integrity, an ecosystem should be relatively unimpaired across a range of ecological attributes and spatial and temporal scales (De Leo and Levin 1997, Karr 1994).

The WDFW Lands Division has adopted the Ecological Integrity Assessment (EIA) method as a tool to measure ecological integrity on wildlife areas. EIA (Schroeder et al. 2011) is a valuable technique for evaluating ecological condition by comparing current condition with reference ecosystems operating within the bounds of natural or historic disturbance regimes. The EIA method is a standardized and repeatable assessment of current condition associated with the structure, composition, and ecological processes of a particular ecological system (Schroeder et al. 2011). The method can also be sued at multiple spatial scales or ‘levels’ and is designed to be used with ‘scorecards’ specifically designed for each ecosystem (summarized in Schroeder et al. 2011). The concept of ecological integrity, as used within the context of the EIA method, builds on the related concepts of biological integrity and ecological health, and is a broad and useful endpoint for ecological assessment and reporting (Harwell et al. 1999).

In 2011 the WDFW initiated a pilot project to implement Ecological Integrity Monitoring (EIM) on selected wildlife areas and in selected ecosystems in Washington. The wildlife areas included Swanson Lakes, Sinlahekin, Scatter Creek, and Johns River. The purpose of the pilot project was to use citizen science to measure the current ecological integrity of a site through a standardized and repeatable assessment of the current structure, composition, and ecological processes of a particular ecological system.

1.1 Ecological integrity

Ecological integrity can be defined as the natural range of variability associated with the structure, composition, and function of an ecosystem exposed to minimal human-induced impacts (Schroeder et al. 2011). Regardless of which metric is being measured, a standard ecological integrity ranking scale is used to score each measurement. A report-card style scale is used and metrics, cutoff points for measurements, key ecological attributes, or overall ecological integrity is ranked from ‘excellent’ to ‘degraded’ or ‘A’, ‘B’, ‘C’ or ‘D’ (Appendix 1). In order to make such rankings operational, the general ranking definitions are specifically described. These descriptions provide guidance when developing specific metric rankings and help ensure that all metrics, regardless of the actual unit of measurement, are ranked on a comparable scale.

1.2 Assessment levels

The selection of metrics to assess ecological integrity was done at three levels of intensity depending on the purpose and design of the data collection effort. These levels are detailed below and further summarized in Appendix 2.

Level 1 assessments are a comprehensive and generic approach to measuring ecological integrity that are applicable to all natural ecological systems and based primarily on metrics derived from remotely sensed imagery. Existing GIS layers are used as indicators of landscape integrity (e.g., road density), forming the basis for various stressor-based metrics. These metrics are then weighted according to their perceived impact on ecological integrity and used to produce a rasterized map (all stressor-based metrics are combined) that ranks areas according to their ecological 'integrity.'

Level 2 assessments are relatively rapid field-based assessments of ecological integrity that combine qualitative and narrative-based ratings of metrics with quantitative or semi-quantitative ratings. Field observations are required for most metrics. Within the hierarchical monitoring framework, Level 2 assessments balance efficiency of application and assessment accuracy. The outcome is an indication of a particular ecological system's functioning relative to desired ecological conditions.

Level 3 assessments are intensive, field-based assessments that provide higher resolution information on the integrity of ecological systems within a site. They generally use quantitative, plot-based protocols coupled with a sampling design to provide data for detailed metrics. Level 3 assessments can be used to verify the results of rapid (Level 2) assessments.

The pilot project designed here was focused on rapid assessments (level 2). These metrics were selected to be informative while at the same time being relatively simple and quick to collect.

1.3 Putting it together

Due to the lack of capacity within WDFW to collect monitoring data, WDFW has engaged volunteers and teachers under a citizen science model in the collection of Level 2 EIA data by conducting photo point monitoring and collecting measurements at randomized vegetation plots. Developing a citizen science component to the project that involves NGOs, educators, and interested members of the public will be critical to the success of monitoring our wildlife areas.

The purpose of this document is to report on the EIM efforts made and outcomes during the 2011-2013 biennium and anticipated approaches for the 2013-2015 biennium. In the next biennium, WDFW will be working to more fully integrate EIM development into the wildlife area planning process being conducted within the Lands Division. Adoption of EIM and application of the tiered assessments will allow WDFW to more effectively manage wildlife areas to meet stated goals and objectives. By monitoring ecological integrity, the Lands Division will be able to make informed decisions on where to 1) implement active habitat management and restoration to maintain or improve ecological integrity and 2) focus development for the purpose of meeting recreation access needs.

2.0 Level 1 Assessment

As stated above, a Level 1 assessment is a comprehensive and generic approach to measuring ecological integrity that is applicable to all natural ecological systems, and is based primarily on metrics derived from remotely sensed imagery. In the 2011-2013 biennium, WDFW conducted a pilot Level 1 assessment as a coarse measure of ecological health using entirely remotely sensed or previously modeled datasets. The Level 1 results may act as a way to stratify more detailed on the ground rapid assessments conducted by volunteers and schools (i.e., Level 2) and finely detailed monitoring conducted by professional staff (i.e., Level 3). Likewise, results from the higher level assessments can feed back into the Level 1 indicator datasets, refining the Level 1 results.

2.1 Study Area

The Kittitas Valley was chosen as the Level 1 Pilot Study Area. This study area includes wildlife area Units (WLAUs) associated with the L.T. Murray, Wenas, and Colockum Wildlife Areas. The boundaries of eleven level 10 Hydrologic Unit Codes (HUC 10s) that overlapped the WLAUs and three urban centers of Ellensburg, Yakima and Wenatchee, were merged to form the analysis area. The area encompasses representative ecosystems from across the state.

2.2 Scorecard Development

To support the Level 1 pilot analysis, WDFW created a 'scorecard' (based on readily available statewide datasets, Table 1) that was a modified version of the Ecological Integrity Assessment ranking (Faber-Langendoen et al., 2009). The initial scorecard defined the indicators, how they were scored, and the datasets used. Selected indicators were limited to largely abiotic, landscape and hydrologic context indicators including: 1) unnatural neighbor length/perimeter; 2) area/unnatural buffer intersect; 3) landscape conditions; 4) connectivity (intactness); 5) absolute patch size; and 6) riparian ecosystem (measured as the potential impact of stream blockages on hydrological condition). Aside from absolute patch size, the selected indicators are ecosystem independent.

2.3 Indicator Processing

Of the five Level 1 landscape context indicators (Table 1), three were generated from the Regional Gap Analysis Project (ReGAP) dataset. ReGAP has generated land cover maps of dominant ecological systems. At the time that the Level 1 pilot assessment was conducted the National and Regional GAP programs utilized the NatureServe three-tiered ecological classification system. The indicators are described below.

Unnatural neighbor length captured the percentage of 'natural' ecosystem perimeter that borders that of an 'unnatural' system. This required reclassifying ecosystems as 'natural' or 'unnatural.' Contiguous ecosystems were individually examined out to 20 miles from the analysis area edge; thereafter the amount of unknown edge was removed from the ratio calculation. A polygon neighbor's tool was used to calculate the amount of shared edge between the focal ecosystem features and neighboring features. The total sum of the edge lengths were used as the denominator in the ratio calculation, which means that portions of ecosystems that border on undefined ecosystems nothing (e.g., outside of the analysis area) are not included in the calculation. Ratios were converted to scores (via percentage calculations) as integer value grids.

Area/unnatural buffer intersect captured the percent-area intersection with an unnatural buffer of 200 meters. The purpose of this indicator was to provide a crude estimate of relative extent of potential 'contamination' of natural ecosystems from nearby modified (unnatural) ecosystems. The classification of ecosystems as 'natural' and 'unnatural' (described above) was applied to this indicator. Ecosystems labeled as unnatural were buffered 200 meters. The area of each discrete, contiguous ecosystem inside the buffer was used as the numerator while the area of the entire ecosystem was used as the denominator in a ratio calculation. The calculated ration was later converted to integer percentage ranges then to scorecard scores.

Landscape condition and *connectivity (intactness)* were taken directly from the Western Governors Association's (WGA) Critical Assessment Tool's (CHAT) Landscape Condition Model and Landscape Integrity Composite Model datasets.

Absolute patch size scored ecosystem integrity based on absolute ecological patch size based on scorecard thresholds for individual ecosystem types (Matrix, Large or Small). Each ecosystem type was placed in a patch type category then each discrete ecosystem feature was evaluated against the scorecard thresholds and assigned the appropriate points based on their patch size.

Riparian ecosystem measured the percent of blocked, in-stream habitat of fish bearing streams at the HUC 10 /WLAU Level. The Level 1 analysis leveraged the datasets resulting from the WDFW's Habitat Program's Fish Passage and Barriers Inventory (FPBI).

2.4 Final products and anticipated approach in the next biennium

The indicator scores were summed without weighting and were used to generate summary statistics using the Western Governors Association's (WGA) 1-mile hexagons. Illustrated as a 'heat' map (Figure 1), hexagons possessing a high mean sum Ecological Integrity are dark green and those with low or no ecological integrity are red. These statistics were used to generate a simple comparison table of wildlife area ecological integrity by WLAU (Table 2). All six of the wildlife area Units analyzed in the study area had average ecological integrity scores over 25 (compared to a maximum value of 30).

The equivalent of approximately 0.05 Biennium-FTEs (200 hours) was expended in the Level 1 assessment, including time from Jeff Foisy (WDFW Spatial Data Management Section in the Science Division) and Information Technology Services. We anticipate that this time will increase in the 2013-2015 biennium. WDFW is going to conduct a statewide Level 1 analysis, which, in addition to the indicators described above, will include biotic indicators representing species composition, likelihood of invasive plants, and community structure. Also, we will be pursuing a more robust hydrologic/aquatic condition indicator. The product from this effort (a 'heat' map indicating integrity values across the state) will be used to develop site-specific goals and objectives for individual wildlife areas through the upcoming management planning process. In turn, this will inform where Level 2 and Level 3 EIM are applied, to evaluate the agency's movement towards or away from those goals and objectives. Over the long-term, as Level 2 and Level 3 data are collected, we anticipate that the opportunity will arise to conduct accuracy assessments, sensitivity analysis and weighting of the Level 1 indicators.

Figure 1. EIM Level One Pilot Area 'Heat' Map using Western Governors' Association 1-Mile Hexagon Statistics. Hexagons with high mean sum Ecological Integrity are shown in dark green; integrity scores decline along a color gradient from yellow to dark orange (lowest integrity).

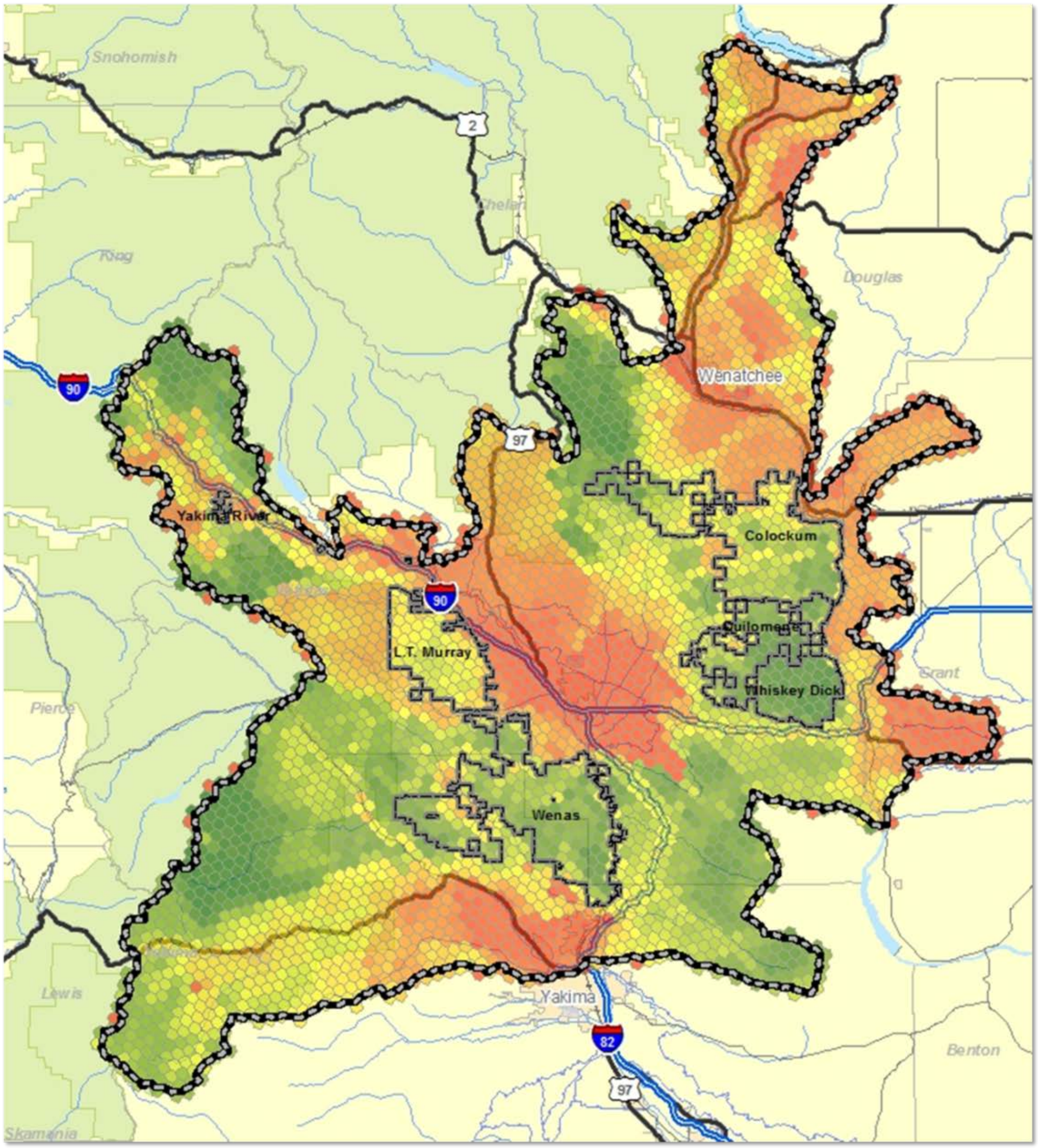


Table 1. Level One Pilot 'Scorecard' used to guide indicator processing.

Metric	Data source	A rank	B rank	C rank	D rank
Unnatural neighbor length/perimeter	Regap (CN level 1)	Natural neighbor ≥75% of occurrence perimeter	Natural neighbor ≥50-75% of occurrence perimeter	Natural neighbor ≥25-50% of occurrence perimeter	Natural neighbor <25% of occurrence perimeter
Area/unnatural buffer intersect	Regap (CN level 1)	Unnatural buffer <25% of occurrence area	Unnatural buffer ≥25%-50% of occurrence area	Unnatural buffer ≥50-75% of occurrence area	Unnatural buffer ≥75% of occurrence area
Landscape condition model	WGA lcv4	≥0.9-1.0	≥0.75-0.9	≥0.5-0.75	<0.5
Connectivity (intactness)	WGA Ll_composite	Intact: Embedded in 90-100% natural habitat	Variegated: Embedded 60-90% natural habitat	Fragmented: Embedded in 20-60% natural habitat	Relictual: Embedded in <20% natural habitat
Absolute patch size for matrix ecosystems	Regap (CN level 1)	>5,000 ha	500-5,000 ha	50-500 ha	<50 ha
Absolute patch size for large patch ecosystems	Regap (CN level 1)	>500 ha	50-500 ha	5-50 ha	<5 ha
Absolute patch size for small patch ecosystems	Regap (CN level 1)	>10 ha	2-10 ha	0.5-2 ha	<0.5 ha
Hydrology condition (loss of riparian ecosystems)	SHEAR fish passage and diversion screening inventory (FPDSI) database	No blockages and diversions present	Blockages and diversions have 0-25% impact	Blockages and diversions have 25-50% impact	Blockages and diversions have >50% impact

Table 2. Level One Score Statistics for wildlife area Units in the Ecological Integrity Monitoring Project pilot area, Kittitas County.

Unit Name	Acres	Min. Score	Max Score	Mean	Sum
Colockum	85,255.85	17	30	27.36	1,394,040.00
Wenas	95,769.11	17	30	27.88	1,595,708.00
L.T. Murray	45,962.48	13	30	26.36	724,010.00
Whiskey Dick	27,160.10	21	30	29.49	478,544.00
Quilomene	38,657.42	17	30	28.51	658,613.00
Yakima River	1,057.69	16	29	25.37	16,035.00
None (Everything Else)	1,443,311.26	8	30	26.16	22,562,044.00

3.0 Level 2 Assessments

3.1 Project management

3.1.1 Summary

In addition to the considerable work that went into completing the tasks under each section in this report, EIM staff met weekly to discuss ongoing efforts and plan the workshops required for volunteer and teacher training. These important coordination meetings involved EIM staff from various Divisions as well as periodic participation of Regional and Human Resources staff. EIM staff also met periodically with experts from Natural Heritage Program to develop protocols and work out efficient means to bring EIA concepts and scientific rigor into the EIM process.

3.1.2 Estimated effort

The equivalent of approximately 0.24 Biennium-FTEs (997 hours) was expended in EIM project management (Table 3), with contribution as follows:

Science	0.15 FTE
Outreach	0.06 FTE
Lands	0.03 FTE
Human Resources	0.01 FTE
Public Affairs	<0.01 FTE

Table 3. Project Management: Activities and time spent during the biennium.

Activity	Division	Personnel	Hours
Weekly Project Meetings	Science	M. Vander Haegen	190
		M. Schroeder	190
		A. Duff	64
		B. Hall	4
		B. Cosentino	4
	Diversity	D. Hays	4
	Lands	J. Gorrell	72
		L. Vigue	24
		K. Guzlas	8
	Human Resources	C. Redmond	57
	Public Affairs	J. Burrows	2
		J. Wettstein	2
	Outreach	M. Tudor, M. O'Malley, C. Gibilisco, J. Anthony	232
Periodic meetings with experts	Science	M. Vander Haegen	16
		M. Schroeder	16
Project Oversight	Science	M. Vander Haegen	128
Total			**997**

3.1.3 Anticipated approach in the next biennium

Similar effort for planning and coordination is projected for the next 2 years. Time will be required to assist with integration of EIM into wildlife area planning. However, by doing so, the work of individual EIM team members may become more efficient, requiring fewer meetings overall.

3.2 Map development

3.2.1 Summary

The first step in completing Level 2 assessments was mapping the ecological systems that occur on the four pilot wildlife areas (Swanson Lakes, Sinlahekin, Scatter Creek, and Johns River). This GIS mapping was achieved using existing data layers supplemented with local knowledge provided by the wildlife area manager and other WDFW staff. These maps formed the framework for identifying areas of interest for monitoring and developing a sampling strategy.

GIS maps with land cover and use data were generated for each of the wildlife areas. Land cover data was based on ecological systems as classified and mapped by NatureServe (e.g., Field Guide to Washington's Ecological Systems; Rocchio and Crawford 2008). Where necessary, ecosystems that were incorrectly labeled were corrected based on input from the wildlife area managers, with technical support provided by Washington Heritage Program and WDFW GIS staff. Land use data included management activity polygons generated through the Wildlife Areas Habitat Conservation Plan (WLA HCP) effort.

Considerable time was taken at the outset of the project to review vegetation layer sources, data quality, and level of effort required to compile and convert potential GIS layers into an adequate product for monitoring. However, the time required to generate each WLA map was not substantial, approximately three or four days, depending on the complexity of the overlay, clean-up operations, and the amount of manual editing necessary. Group discussions were periodically required to review NatureServe Ecosystem classification roll-up options for creating maps with broad land cover classes.

3.2.2 Outcomes and products

- Corrected land cover and land use maps for 4 wildlife areas

3.2.3 Estimated effort

The equivalent of approximately 0.05 Biennium-FTEs was expended on map development. All of this effort was contributed by the by the Wildlife Program Wildlife Science Division and includes time spent by the Spatial Data Management Section (Table 4).

Table 4. Map Development: Activities and time spent during the biennium.

Activity	Division	Personnel	Hours
Consideration and reassignment of ecosystem types	Science	M. Schroeder	80
Compilation and review of existing data layers	Science	B. Cosentino	80
Editing data layers	Science	B. Cosentino	32
Consulting with EIM staff and wildlife area managers	Science	B. Cosentino	8
Cartography and ad hoc GIS activities	Science	GIS shop	16
Total			**216**

3.2.4 Anticipated approach in the next biennium

Developing maps for additional wildlife areas will follow the same procedures and likely will require similar levels of effort. However, time may be reduced given that the Ecosystems Version 2 GIS layer now contains roll-up map categories based on the National Vegetation Classification (NVC) Standard. We anticipate using NVC classes in developing roll-up categories for WLA mapping (e.g., NVC Class, NVC Subclass, NVC Formation, or hybrid of NVC classes). Available data used in development of the wildlife area ecosystem maps include the following.

- National Gap Analysis Program (GAP) Land Cover Data Portal: http://gapanalysis.usgs.gov/gaplandcover/data/
- National Vegetation Classification System: http://www.usgs.gov/science/cite-view.php?cite=1213
- U.S. National Vegetation Classification: http://usnvc.org/
- National Vegetation Classification Standard, Version 2: http://www.fgdc.gov/standards/projects/FGDC-standards-projects/vegetation/NVCS_V2_FINAL_2008-02.pdf/

To our knowledge, a 'crosswalk' between Wetland Classification (Cowardin et al., 1979) and the NVC does not currently exist. For some wildlife areas, recategorizing wetland classes to the NatureServe ecosystem classification or to the NVC may require many hours of work. Therefore, EIM/Wildlife Science may wish to invest additional time compiling this 'crosswalk' between the Wetland Classification (Cowardin et al. 1979) and the NVC. This may require up to 3 days for an initial crosswalk to NVC Division or other broad-level NVC grouping. The draft would need review by biologists for final compilation; time required may vary depending on availability of WDFW, DNR, and other staff.

3.3 EIM Design and Implementation

3.3.1 Summary

The EIA protocols were adapted from Schroeder et al. (2011) and reflect knowledge acquired from two years of pilot research. Metrics were designed to be useful at multiple spatial scales, relevant across ecosystems, grounded in natural history, applicable to management, and flexible. Although the metrics were originally divided into landscape context, vegetation condition, physicochemical and hydrology, and natural disturbance regime (Schroeder et al. 2011), we focused on only the metrics that could be 'measured' in the field in a Level 2 (rapid assessment) context. Consequently, all of the landscape context metrics and many of the natural disturbance regime metrics were not considered.

We combined multiple ecosystems into general categories for the purpose of simplifying data collection. Because the cutoff points for specific metrics are not the same for each ecosystem (see Schroeder et al. 2011 for specifics), protocols were designed to collect general information that could be used to: (1) identify the specific ecosystem and (2) quantify the assessment within the appropriate ecosystem. Metrics are collected in the field and later applied to ecosystem-specific spreadsheets to derive integrity scores.

We also designed a system for collection of photo point data at permanently marked locations of interest. Though not directly related to the EIA approach, photo points are designed to provide long-term insight into changes in ecosystem integrity and the impacts of management.

This approach will take advantage of a long-term photo record (up to 100 years in some instances) on some wildlife areas and represents a new contribution to others.

3.3.1.1 General Protocol

Locations. Locations for EIAs were determined using a stratified random approach. Random points were selected within ecosystems or management units so that points would be distributed in an effective pattern across the broader landscape. The points are spaced so that they are no closer than 50 meters to adjacent points. The initial plan is that these random points will be visited once and that 'new' points will be selected for future EIAs. Sampling plots for EIAs are defined by an 8-meter radius around the random point; vegetation and soil characteristics are estimated for the area defined by the circle.

Basic information. General information collected on all data forms includes a list of the observers, contact information (e-mail and phone number), and date and time of the observation. Location information includes the point number (uniquely identified by wildlife area), UTM coordinates (NAD 83 and zone 10 or 11), and accuracy of the GPS location. Photos are taken in the cardinal directions (north, east, south, and west) for all EIAs. Photos are configured to illustrate most components of the ecosystem, particularly the understory. There is also an opportunity for observers to take photos of other key features such as confusing plant species.

Soil surface rank (general condition of surface). This condition ranking is collected for most ecosystems and should consider the current and historical impacts of disturbance. Some of these effects may be apparent (bare ground), but others (old ruts) will be somewhat concealed by vegetation. Bare ground is soil surface not covered by vegetation (basal and canopy, litter, standing dead plants, gravel/rock, and mosses and lichens. The amount and distribution of bare ground is a direct indicator of site susceptibility to accelerated wind or water erosion (Pellant et al. 2005).

Disease/mistletoe rank (general condition of trees). This condition ranking is collected for eastside forest ecosystems and should consider the current manifestation of disease (such as beetles or disease causing witches' brooms) and/or mistletoe. Forest pathogens are an important feature of forest ecosystems. Although native pathogens are usually present in naturally functioning ecosystems, native and/or non-native pathogens can dramatically affect forest structure. The primary difference between a 'heathy' ecosystem and one that has been altered is the relative impact of pathogens on the observed range of variability in the ecosystem.

Trees. Tree cover is estimated for most ecosystems, even where trees are not present. Tree cover is the proportion of the ground shaded by tree species (above 1.3 meters). Tree size and age are important structural attributes of a functioning forest, with its natural range of variability (Agee 2003, Hessburg et al. 2005). Late seral trees are the target of most timber harvesting and their structure is lost to forest functions. In addition, the amount and spatial distribution of young trees is important to maintaining historical structure and is an indication of integrity of disturbance regimes. Canopy cover and condition refers to the dominant tree layer, including the density, stem size, and canopy cover relative to reference conditions. Intact areas have a diversity of age classes. The distribution of total cover, crown diversity, and stem size reflects natural disturbance regimes across the landscape and affects the maintenance of biological diversity, particularly of species dependent upon specific stages.

Shrubs. Shrub cover is a combined estimate for all species present and is recorded for most ecosystems. Cover should be estimated using the same categories that were used for trees. In some ecosystems, fire-sensitive shrubs are deep-rooted, non-sprouting shrubs (big sagebrush and bitterbrush) that respond negatively to fire. Natural fire regimes promote patchy cover fire-sensitive species. Shrub cover can also be indications of ecosystem type.

Dominant native shrub. The name of the dominant shrub should be recorded for most ecosystems. The dominant shrub is a key feature in defining ecosystem type and in understanding ecosystem condition. The cover of the dominant shrub should be estimated using the same categories as was used for trees.

Grasses and sedges. This category is recorded for most ecosystems and is the combination of all grasses and sedges. The cover should be estimated using the same categories as was used for trees. Native bunchgrasses dominate native shrubsteppe and related grasslands, but grasses are also important in some westside and forest ecosystems. Abundance of grasses and sedges can be an important indicator of ecosystem type and condition.

Mosses and lichens. This category is recorded for most ecosystems and is the combination of all mosses and lichens. In the eastside shrubsteppe ecosystems this is commonly referred to as 'biological crust'. The cover should be estimated using the same categories as was used for trees. There is abundant evidence that biological crust occupies most of the vascular plant interspaces where natural site characteristics are not limiting (i.e., steep unstable slopes, south aspects, sandy soil or heavy vascular plant cover). Biological crust provides resistance to erosion, soil stabilization, and enhanced soil water retention. Livestock trampling and other physical site disturbances break-up biological crust and its cover is an indicator of site disturbance (Belnap et al. 2001).

Coarse woody debris. The number of large (30+ cm diameter) branches and trees on the forest floor was included as a metric for all forest ecosystems. Woody debris refers to accumulated dead woody material including downed logs and snags. Accumulation of coarse woody debris can be minimal in some forests due to recurring fire, and too much debris can increase risk from fire. The metric is adapted from Franklin et al. (2008).

Key native and invasive species. Invasive species refer to the percent cover of a selected set of plant species that become established in habitats and inflict a suite of ecological damage to native species including loss of habitat, loss of biodiversity, decreased nutrition for herbivores, competitive dominance, overgrowth, resource depletion, and alteration of biomass, energy cycling, productivity, and nutrient cycling (Dukes and Mooney 1999). Invasive plant species can also affect hydrologic function and balance, making water scarce for native species. Native species may become invasive when a process has been altered, such as fire suppression, or changed in duration or intensity as with novel grazing regimes. Exotic invasive species can introduce new system responses to natural processes.

Important native and exotic species were identified for each ecosystem type from the EIA scorecards supplemented with local knowledge and consultation with the wildlife area manager.

3.3.1.2 Specific Ecosystems

We developed protocols that can apply to each of the terrestrial systems found on the wildlife areas where the pilot project was applied. These 4 protocols incorporate metrics suitable for a wide range of ecosystems that fit in 4 major categories described below. Combining these common ecosystems has allowed us to simplify collection of data in the field while still providing robust data that can be applied to the individual score cards for each of the individual systems.

Eastside shrubsteppe, grassland, and savannah. This combined protocol (Appendix 3) reflects a compilation of metrics from multiple ecosystems including: (1) Columbia Basin Foothill Canyon Dry Grassland; (2) Columbia Basin Palouse Prairie; (3) Columbia Basin Steppe and Grassland; (4) Columbia Plateau Scabland Shrubland; (5) Columbia Plateau Low Sagebrush Steppe; (6) Intermountain Basins Semidesert shrubsteppe; (7) Intermountain Basins Montane Big Sagebrush Steppe; (8) Intermountain Basins Big Sagebrush Steppe; (9) Intermountain Basins Semidesert Grassland; (10) Northern Rocky Mountain Ponderosa Pine Woodland and Savanna; (11) Northern Rocky Mountain Foothill Conifer Wooded Steppe; and (12) Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland. Most of these ecosystems are cumulatively referred to as "shrubsteppe". They are all characterized by having a dominant shrub or herbaceous layer of vegetation and being relatively arid systems. When trees are present, they are usually scattered, with the herbaceous and/or shrub component of the ecosystem dominant.

Eastside forest and woodland. This combined protocol (Appendix 4) reflects a compilation of metrics from multiple ecosystems including: (1) Rocky Mountain Aspen Forest and Woodland; (2) Northern Rocky Mountain Subalpine Woodland and Parkland; (3) Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest; and (4) East Cascades Oak-Ponderosa Pine Forest and Woodland.

Westside woodland and forest. This combined protocol (Appendix 5) reflects a compilation of metrics from multiple ecosystems including: (1) North Pacific Hypermaritime Sitka Spruce Forest; (2) North Pacific Hypermaritime Western Redcedar-Western Hemlock Forest; (3) North Pacific Maritime Dry-Mesic Douglas fir-Western Hemlock Forest; (4) North Pacific Maritime Mesic-Wet Douglas fir-Western Hemlock Forest; (5) North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest; and (6) North Pacific Dry Douglas-fir Forest and Woodland.

Westside prairie and savannah. This combined protocol (Appendix 6) reflects a compilation of metrics from multiple ecosystems including: (1) Willamette Valley Upland Prairie and Savannah and (2) North Pacific Oak Woodland.

3.3.1.3 General Photo Point Protocol

Photo points are designed to replicate previously obtained photos. Sometimes these photos are historical in nature (dating back decades), other times the photos are recent. Regardless of the history, photos can be used to gain insight into changes in ecosystem condition. Photos also offer one of the simplest methods to involve volunteers and schools in wildlife monitoring activities. These EIM participants only need to be able to navigate to a geo-referenced photo point, take photos in the required direction(s), and label and upload the photos to the Internet. Photo points also offer wildlife area managers with an opportunity to focus monitoring attention on key features of their respective landscapes. The monitoring protocol requires relatively basic information (Appendix 7).

3.3.2 Outcomes and Products

- EIM protocols for ecological systems on 4 wildlife areas
- Data collection forms for 4 combined protocols
- Photo point protocols
- Written instructions for all vegetation and photo-point data collection

3.3.3 Estimated Effort

The equivalent of approximately 0.31 Biennium-FTEs was expended on EIM design (Table 5). All of this effort was contributed by the by the Wildlife Program Wildlife Science Division, Eastside Research Section.

Table 5. EIM design and implementation: Activities and time spent during the biennium.

Activity	Division	Personnel	Hours
Design of level 2 EIA scorecards	Science	M. Schroeder	240
Development/standardization of EIA protocols, including forms	Science	M. Schroeder	320
Site visits to test protocols	Science	M. Schroeder	120
Correction, editing, testing, and modification of EIA protocols	Science	M. Schroeder	400
Development of photo point protocols	Science	M. Schroeder	80
Site visits for photo point establishment	Science	M. Schroeder	90
Preparation of miscellaneous presentations	Science	M. Schroeder	56
Total			**1,306**

3.3.4 Anticipated approach in the next biennium

The approach in the next biennium will be to apply the lessons learned on ecological integrity monitoring to wildlife areas where management plans are developed. Because these additional areas may have ecosystems that have not been incorporated into existing protocols, effort will be required to develop new protocols or adapt existing protocols to the 'new' ecosystems. This approach should require less time because of the previous efforts to standardize the basic protocols. Consequently, it is likely that the amount of time needed per wildlife area should decline as the number of wildlife areas involved in the program is increased.

It is likely that some effort will be directed toward riparian ecosystems, for both EIM purposes and defining monitoring protocols for the Wildlife Areas HCP. These systems were not addressed in the previous biennium because of their complexities. The desired approach for riparian areas (photo points and/or EIAs) has not been finalized and will be considered in the next biennium. The HCP is adopting multiple indicator monitoring (MIM) in riparian zones where grazing occurs. Ultimately, EIM in riparian areas on wildlife areas may be based on a combination of metrics taken from EIAs and MIM.

Finally, some effort will shift from protocol development to analysis and evaluation of collected data. We intend to compare data collected by volunteers to that collected by biologists and land managers. In addition, we will test validation of Level 1 data outcomes with Level 2 data.

3.4 Data Management and Evaluation

3.4.1 Summary

Wildlife Survey Data Management (WSDM) developed a spatial database (ArcGIS Geodatabase), web services, and web maps to capture EIM project data and photos and to support mission planning and site identification for EIM volunteers and teachers. The data and web services that were developed for EIM are maintained on the Amazon Cloud using the same hardware and software infrastructure as other WDFW citizen science applications (Wolf Reporting Web Page, Public Wildlife Observation App). Project web services are hosted on ArcGIS Server and are integrated into an online web mapping application using ArcGIS Online.

Prior to the first EIM workshop, WSDM spent several weeks developing the baseline data structure and web services to support the project. Throughout the course of the pilot project, as new paper data entry forms were developed for each protocol, WSDM would enhance the data structures, web services, and web maps to accommodate the new or modified information that was to be collected. WSDM was also responsible for uploading new data points (random locations for habitat and photo points along with images) into the cloud Geodatabase so that this baseline data was available for mission planning activities of the volunteers and teachers (mission planning = identifying the locations of sites that had not been visited and obtaining GPS coordinates and photo directions). WSDM also managed the database of users who could access the application because data entry is limited to "registered" participants. This included formatting and batch uploading new user accounts prior to each pilot area training opportunity.

In addition to developing data structures and entry forms, there was also a data development component which consisted of drawing stratified random samples of habitat points within each pilot area and working with wildlife area managers or other EIM project team members to develop the baseline data for photo point locations at each pilot area. The drawing of random samples relied on data generated in the section 3.3 (Map Development). At first this data development work was completed by WSDM (Andrew Duff), but was later transferred to the Spatial Data Management section (Brian Hall). Once Brian completed the data development, new datasets would be appended to the existing data stored by Andrew. Finally, Brian developed paper maps that could be used by the volunteers for navigation.

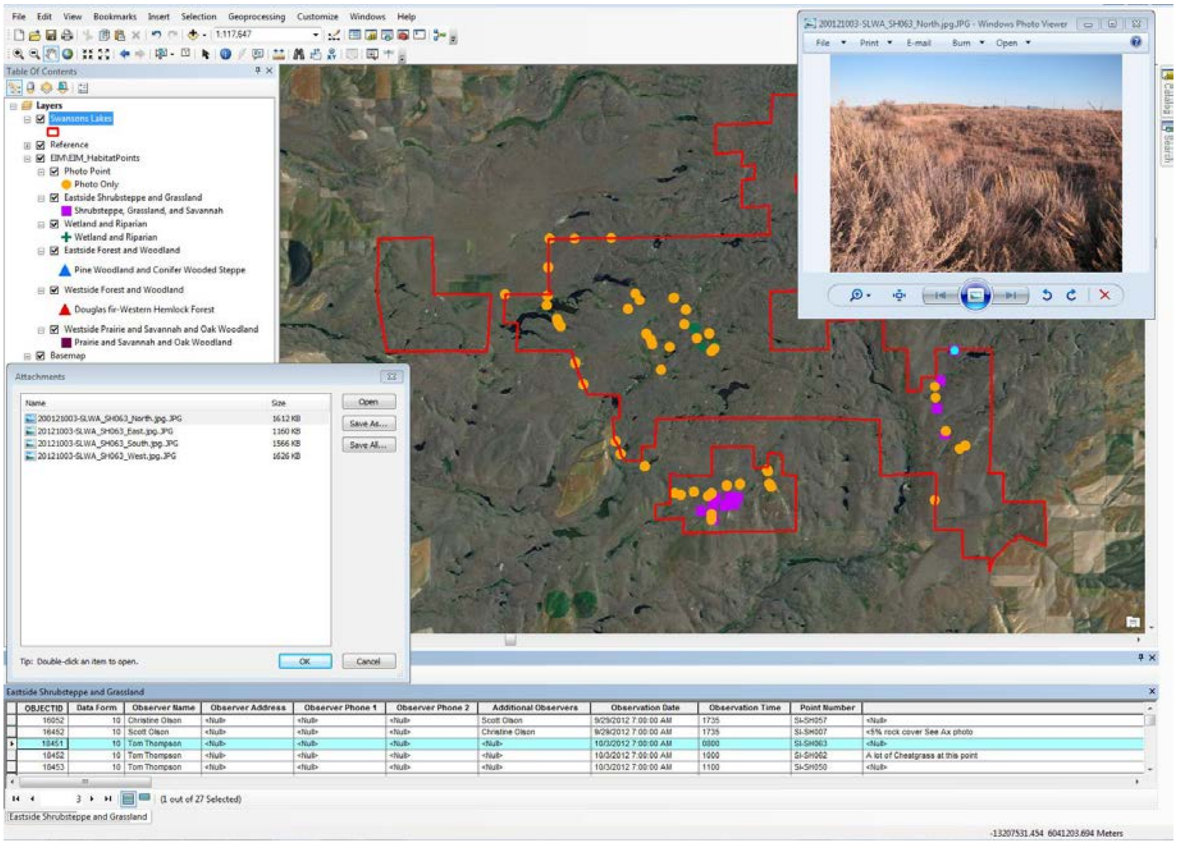
WSDM also developed a series of supporting files for each pilot area which included GPX and CSV (comma separated values) files of survey locations. Once everything had been uploaded into the cloud database, these files along with pdf versions of the protocols were delivered to John Burrows of the web development team for posting on the WDFW website just prior to training workshops in each pilot area.

Finally, WSDM played a central role in conducting volunteer and mentor training sessions by being the lead for the data entry portion of these workshops. This typically involved a 1-2 hour training session during EIM workshops where volunteers and teachers practiced using the data entry interface using sample data collected during the morning field session of the workshop.

3.4.2 Outcomes and Products

- Geodatabase feature classes and web services for habitat and photo points (supporting both new volunteer data and baseline trip planning data)
- Web Maps that provide an interface to enter and explore EIM data (Figure 2)
- Baseline datasets for photo points and habitat points at each wildlife area
- Supporting mission planning files (GPX, CSV files) for the WDFW website
- User accounts and maintaining the user store for the project (~ 80 EIM users)
- Paper maps with habitat and photo points on them for volunteer use in the field
- Data entry training sessions during 6 training workshops

Figure 2. Screen shot of the ArcGIS Online web mapping application that allows volunteers to locate points and upload data and digital images.



3.4.3 **Estimated Effort**

The equivalent of approximately 0.26 Biennium-FTEs was expended on data management and evaluation, (Table 6) with all but two hours contributed by the Science Division. Two hours were contributed by Public Affairs.

Table 6. Data management and evaluation: Activities and time spent during the biennium.

Activity	Division	Personnel	Hours
Date structure, web services and web maps development	Science	A. Duff	96
Updates to data structure for each new pilot area or at each major protocol change (total)	Science	A. Duff	40
Web Map troubleshooting and resolution	Science	A. Duff	32
Produce supporting project files (GPX, CSV) and upload to website	Science Public Affairs	A. Duff J. Burrows	10 2
Upload new user accounts	Science	A. Duff	8
Conduct User Training at EIM workshops	Science	A. Duff	96
Data development for new Pilot Areas	Science	A. Duff, B. Hall	48 48
Generate paper maps of point and plot locations	Science	B. Hall	32

Table 6 . Continued.

Activity	Division	Personnel	Hours
Report and document preparation	Science	M. Schroeder	320
Development of protocol and spreadsheets for data analysis	Science	M. Schroeder	160
Preparation, labeling, and interpretation of photos	Science	M. Schroeder	160
Preliminary analysis of EIA data	Science	M. Schroeder	40
Total			**1,092**

3.4.4 Anticipated approach in the next biennium

Overall we anticipate using similar strategies for the upcoming biennium with the exception of including a new interface for data entry and photo uploading and providing new tools for data review and summarization on the web. Due to the number of "bugs" and inadequacies in the ArGIS Online application, we intend to replace the "out of the box" application with a more customized data entry form similar to the wolf reporting web page. In addition, we hope to develop some dashboarding tools that will facilitate simple reporting of data for volunteers and managers. This will allow volunteers to see how their contributions are being used by the department and to facilitate quality assurance of the data by volunteer mentors. These dashboarding tools may also be one of the primary ways that we provide data access for wildlife area managers. We anticipate spending 5 days creating the new interface for all of the forms, 3-5 days enhancing the data structure to be more robust (normalized data structure) and migrating existing data, 2-4 days developing the dashboarding tools.

3.5 Building the Citizen Science Network

Due to the lack of capacity within WDFW to collect monitoring data, WDFW's intent is to engage skilled volunteers and schools, under a citizen science model, in the collection of Level 2 assessment data by conducting photo point monitoring and collecting measurements at randomized vegetation plots.

Ecological Integrity on Wildlife Areas in Washington State (Schroeder et al. 2012) was drafted by WDFW Community Outreach and Environmental Education Specialist Margaret Tudor and Science Division Research Scientists Michael Schroeder and Matt Vander Haegen. This document articulated how to implement EIM on WDFW Wildlife Areas using volunteers and schools, who by providing their own computers, smartphones or digital cameras, could accomplish Level 2 EIM assessments.

3.5.1 Summary

3.5.1.1 Volunteer and teacher recruitment

The WDFW Wildlife Outreach Division initiated volunteer and teacher recruitment efforts in Spring of 2012. These efforts included letters and phone calls to educators and non-governmental organizations, as well as EIM recruitment flyers that were posted online or at public locations. The WDFW public website, *Conservation – Species and Ecosystem Science – Monitoring Resources on State Wildlife Lands*, included detailed recruitment announcements, continues to include information about the current EIM effort while also serving as a point of public contact for those interested in learning more about EIM opportunities. In addition, WDFW issued a news release to inform a broad audience about EIM opportunities.

Volunteer and teacher recruitment and registration were managed through the Community Event Registration and Volunteer Information System (CERVIS) database. CERVIS enables WDFW staff to recruit volunteers and other event participants online, coordinate and manage additional volunteer opportunities, and communicate with volunteers and teachers. Further, volunteers and other project participants are able to store information, indicate their specific interests in various WDFW service projects, and log hours worked.

3.5.1.2 EIM training and resulting data collection

The WDFW EIM Team trained a total of 59 individual volunteers as of June 30, 2013. Three individuals received advanced training as mentors. Two of these volunteers were educators, one of whom also participated in EIM basic training. The other educator was a member of the Wenatchee North Central Educational School District Science Cadre. The third volunteer trained as a mentor was a retiree from the US Forest Service. Interest expressed by westside volunteers, plus the success of the advanced training on the eastside, prompted the EIM Team to organize an advanced training session for the Scatter Creek and Johns River Wildlife Areas.

In 2012, basic training occurred in July and October for Swanson Lakes and in September for Sinlahekin Wildlife Areas. In 2013, basic training occurred in May for Scatter Creek Wildlife Area. Advanced training (for mentors) occurred in June 2013 for Sinlahekin and Swanson Lakes Wildlife Areas and in August 2013 for Scatter Creek and Johns River Wildlife Areas.

Because the initial EIM training occurred in late July of 2012 in eastern Washington, after the K-12 and college school term had ended, teachers and students were not available for incorporating EIM into classroom assignments. In addition, triple-digit temperatures made field work hazardous for some volunteers, and negatively impacted vegetation, particularly forbs, making plant identification virtually impossible in some ecosystems. As a result, EIM data collection, particularly with respect to random habitat points, was less than hoped for in 2012. However, as of June 30, 2013, at least some data collection had occurred on all wildlife areas (Table 7).

Of 15 volunteers who received basic training at Sinlahekin Wildlife Area in September 2012, six (46%) became actively involved in data collection at the Sinlahekin. Of 11 and 22 volunteers who received basic training at Swanson Lakes Wildlife Area in July and October, respectively, five (45%) and one (5%) became actively involved in data collection at Swanson Lakes. Of 12 volunteers who received basic training at Scatter Creek in May 2013, four (33%) became actively involved in data collection at that wildlife area.

Table 7. Number of photo points and vegetation plots established and visited (as of June 30, 2013).

Wildlife Area	Photo Points		Vegetation Plots	
	Established	Visited (%)	Established	Visited (%)
Swanson Lakes	63	36 (57)	109	11(10)
Sinlahekin	65	0 (0)	453	26 (6)
Scatter Creek	20	5 (25)	90	23 (25)

3.5.1.3 Volunteer and teacher retention—management and administration

Volunteer and teacher retention was supported by conventional email messages and phone contact, regular updates to the WDFW public websites, and development of an EIM Facebook page. The Facebook page was designed with the goal of serving as a forum for the WDFW EIM Team and EIM volunteers to share project information and coordinate field work, while having the benefit of attracting and inviting the public to learn more about EIM.

In addition, WDFW offered incentives to volunteers and teachers that participated in EIM training and data collection. In 2012, EIM became a Discovery Pass-eligible project; EIM volunteers who contribute a minimum of 24 hours of time towards EIM earn a free Discover Pass, giving them vehicle access for a year to WDFW, DNR and State Parks lands. Some volunteers received other forms of compensation for participating in EIM (e.g., teachers or students fulfilling education requirements) and were not eligible for a Discovery Pass. Additional incentives included meals provided at all training sessions and ongoing reimbursement for roundtrip travel expenses (56.5¢ per mile) from the volunteer's place of residence to the Wildlife Area and back, up to 200 miles total per outing. In addition, official WDFW Volunteer ball caps and blaze-orange safety vests were distributed to those who were interested.

3.5.2 Outcomes and products

- Four basic EIM training sessions (2 at Swanson Lakes, 1 at Sinlahekin and 1 at Scatter Creek Wildlife Area) and one advanced (mentor) session were offered.
- Fifty eight volunteers and teachers received basic EIM training. Three trainees participated in advanced EIM training.
- EIM training notebooks, including photo point & habitat protocols, GPS instructions, EIM ArcGIS Web Map instructions, ecosystem scorecard information, vegetation identification, administrative paperwork, and field safety essentials, were prepared and provided to all training participants. Participating volunteers and educators also received eight-meter measuring cords created for vegetation plots and orange safety vests.
- 3 EIM equipment bags/bins, including GPS units, extra batteries, GPS instructions, 8-meter cord, and laminated vegetation identification cards, were prepared and located (at each wildlife area and at the WDFW headquarters office in Olympia) for volunteer use.
- Three interactive online modules were developed: *Introduction to Ecological Integrity Monitoring*; *Citizen Science Skill Builder—Scatter Creek Wildlife Area*; and *What is an EIM Mentor?*
- EIM Facebook page launched May 22, 2013.

3.5.3 Estimated effort

The equivalent of approximately 1.05 Biennium-FTEs (4365 hours) was expended on building the citizen science network (Table 8), with contribution as follows:

Science	0.18 FTE	Human Resources	0.06 FTE
Outreach	0.78 FTE	Public Affairs	0.01 FTE
Lands	0.02 FTE	Diversity	<0.01 FTE

Table 8. Citizen Science Network: Activities and time spent during the biennium.

Activities	Division	Personnel	Hours
Volunteer and Teacher Recruitment/EIM Public Outreach	Outreach	All	690
	Science	M. Vander Haegen M. Schroeder A. Duff	20 20 20
	Human Resources	C. Redmond	4
	Public Affairs	J. Burrows	4
Training Preparation: Development of EIM training modules/materials (including binders, sheet protectors, laminated vegetation ID cards, etc.); acquisition of training venue, meals, logistics, and EIM equipment	Science	M. Vander Haegen M. Schroeder A. Duff	20 40 20
	Lands	S. Sherlock	5
	Outreach	C. Gibilisco, J. Anthony, All	1,059
	Human Resources	C. Redmond	180
Swanson Lakes Basic Training – July 2012: 11 Trainees	Science	M. Vander Haegen M. Schroeder A. Duff	56 56 56
	Lands	WLA Staff	33
	Outreach	M. Tudor, C. Gibilisco, J. Chandler	90
Sinlahekin Basic Training – Sept 2012: 13 Trainees	Science	M. Vander Haegen M. Schroeder A. Duff	48 48 48
	Outreach	M. Tudor, C. Gibilisco, J. Chandler, Interns	120
	Lands	WLA Staff	16
Swanson Lakes Basic Training – Oct 2012: 25 Trainees	Science	M. Vander Haegen M. Schroeder A. Duff,	32 32 32
	Lands	WLA Staff	16
	Outreach	M. Tudor, C. Gibilisco	60
	Human Resources	C. Redmond	23
Scatter Creek Basic Training – May 2013: 12 Trainees	Science	M. Vander Haegen M. Schroeder A. Duff	32 40 24
	Outreach	C. Gibilisco, M. O'Malley, J. Chandler, J. Anthony, Intern	49
	Human Resources	C. Redmond	4
	Lands	WLA Staff	16
	Diversity	D. Hays	8
Sinlahekin/Swanson Lakes Advanced Training—June 21-22, 2013: 3 Trainees	Science	M. Vander Haegen M. Schroeder A. Duff	32 32 32
	Outreach	C. Gibilisco, J. Anthony	60
	Human Resources	C. Redmond	6

Table 8. Continued.

Activities	Division	Personnel	Hours
Volunteer and teacher retention (Management & Administration): Discover Pass, Business Pass, TEV, EIM emails, phone contact follow-ups; CERVIS development/ administration; EIM Facebook initiation and administration; Field supplies.	Public Affairs	M. Luers, J. Burrows	40
	Human Resources	C. Redmond	18
	Outreach	M. O'Malley, M. Tudor, J. Chandler, C. Gibilisco, J. Anthony	708
	Outreach	C. Gibilisco, J. Anthony	410
	Human Resources	C. Redmond	6
Total			**4,365**

3.5.4 Anticipated approach in the next biennium

In the 2013-2015 biennium, efforts to build the citizen science network will be narrowly focused around the individual wildlife areas where EIM is being initiated through the wildlife area management planning effort. Outreach staff will develop a statewide EIM citizen science communications plan that outlines potential EIM volunteer and teacher recruitment and retention methods. With the involvement of Wildlife Area Managers and Community Relations/Public Affairs and the Human Resources Volunteer Program, a site-specific communications and outreach plan will be developed for each wildlife area targeted for integration of EIM into the wildlife area management planning process.

Outreach staff will continue to work with the Human Resources Volunteer Program manager to develop and post additional training modules to increase public awareness of EIM. WDFW will continue to use Facebook and explore other social media as well as other forms of communications with Community Relations/Public Affairs for spreading the word about EIM and volunteer and local school opportunities with WDFW.

Finally, WDFW is considering a formal partnership with a non-governmental educational organization to focus on targeting educators to integrate EIM in school curriculums. WDFW is understaffed to effectively integrate projects like EIM into Washington State school curriculum. Such a partnership will help WDFW articulate the value of EIM in the classroom and hopefully encourage educators to incorporate EIM field activities into their science curriculum.

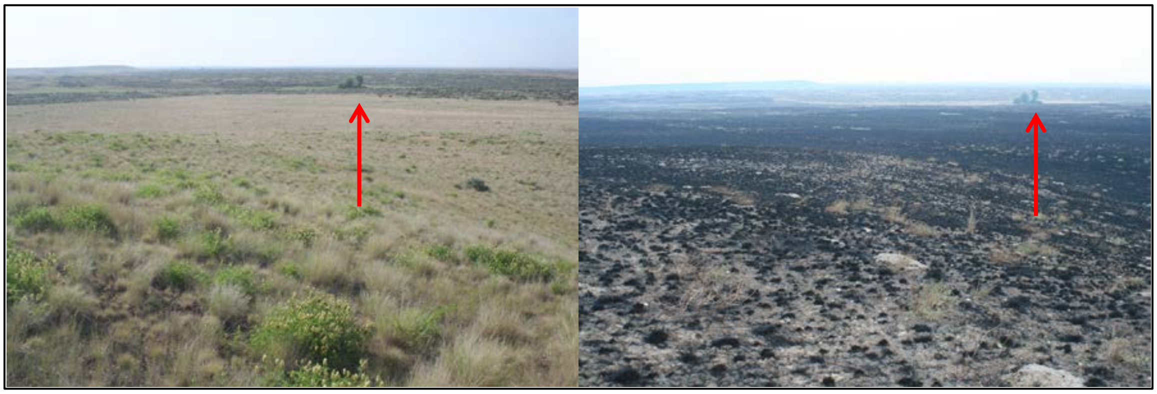
3.6 Preliminary Level 2 Data Analysis

The following section is a report of the overall 'outcome' of the effort described, expressed as data collected along with a preliminary evaluation of ecological integrity on sampled sites. Staff effort for this task appears in Table 6, *Data management and evaluation.*

3.6.1 Photo points

During the 2012-2013 period 148 photo points were established at Swanson lakes (n = 63), Sinlahekin (n = 65), and Scatter Creek (n = 20). In most cases photos were taken in more than one direction from a photo point, so the total number of distinct photos was 391. Citizen science volunteers were able to repeat 82 of the photos including 69 at Swanson Lakes and 13 at Scatter Creek (Figure 3). No photos were repeated at Sinlahekin.

Figure 3. Example of repeat photography at Swanson Lakes Wildlife Area. The photo on the left was taken by WDFW personnel when the photo point was originally established and the photo on the right was taken by a citizen science volunteer following a wildfire. The arrow illustrates a grove of trees that is visible in each photo.



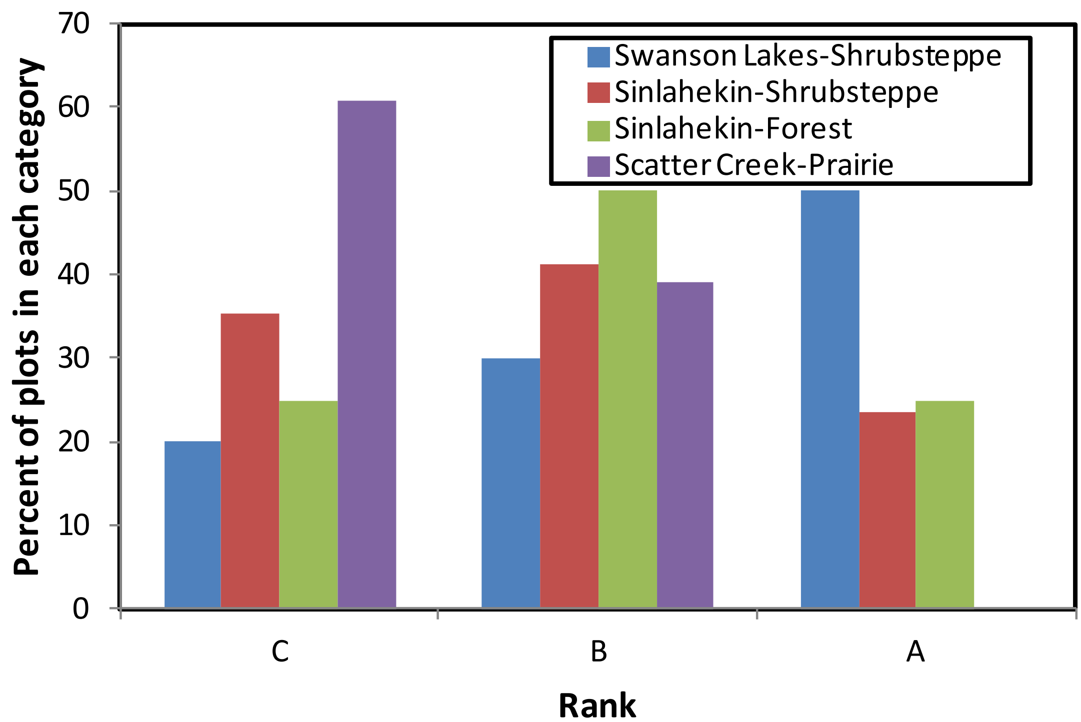
Initial assessment of the photos indicated that repeat photos were very useful in providing: (1) insights into changes in ecosystems; (2) observations of key vegetation, including invasive species; and (3) indications of ecosystem integrity. Volunteers often took photos correctly, but on 85 occasions they took photos in incorrect directions. This was because they took photos in Cardinal directions (north, east, south, and west), rather than the directions that had been established for the photo point. This confusion may have been partly due to the required photos in Cardinal directions for Ecological Integrity Assessments. In the future, protocols will be further clarified to reduce this error rate.

3.6.2 Ecological Integrity Assessments

We conducted a preliminary analysis of ecological integrity for target ecosystems on the Swanson Lakes, Sinlahekin, and Scatter Creek wildlife areas. The analyses were conducted with the aid of scorecards developed for each ecosystem. Each parameter was assessed on a scale of A (highest) to D (lowest) and all parameters for a plot within an ecosystem were averaged equally (no weighting of different parameters). Ten plots were examined on the Swanson Lakes Wildlife Area with scores ranging from C to A in quality (Figure 4). Plots were evaluated using scorecards for their specific ecosystem (e.g., 'Columbia Plateau Scabland Shrubland' and 'Columbia Basin Steppe and Grassland') and then combined into a general shrubsteppe category. The distinction was important, because the ranking criteria were different for each ecosystem. Twenty-one plots were examined on the Sinlahekin Wildlife Area in forest ('Northern Rocky Mountain Dry-mesic Montane Mixed Conifer Forest' and 'Rocky Mountain Aspen Forest and Woodland') and shrubsteppe ('Intermountain Basins Big Sagebrush Steppe' and 'Northern Rocky Mountain Montane, Foothill and Valley Grassland') ecosystems. They ranged in rank from C to A in quality (Figure 4). Twenty-four plots were examined on the Scatter Creek Wildlife Area in forest ('North Pacific Maritime Douglas-fir-Western Hemlock Forest') and prairie ('Willamette Valley Upland Prairie and Savanna') ecosystems. They ranged in rank from C to B in quality (Figure 4).

Although the sample sizes were low, the ecological integrity assessments provided an opportunity to: (1) examine the usefulness of the protocols; (2) consider the ability of volunteers to collect this type of data; and (3) consider potential changes in future efforts. Overall, the analysis of ecological integrity illustrated a range in variation that appeared to be consistent with expectations for the ecosystems. Volunteers also were able to collect all the data necessary to obtain complete assessments of the ecosystems at survey points. Every point was geo-referenced, either with UTM coordinates or a unique point number that was linked to UTM coordinates. There was clearly some confusion with some of the data, but most of this confusion was due to the evolution of the protocols during the course of the pilot project and not the fault of the volunteers. This type of issue should diminish in the future. The error rate was likely reduced with the use of 'dropdown' menus in data entry. Dropdown menus insure the collection of specific types of data within the range of expectations (e.g., not out of the range of possible numbers).

Figure 4. Ecological integrity assessments for Swanson Lakes shrubsteppe (n=10), Sinlahekin shrubsteppe (n=17), Sinlahekin forest (n=4), and Scatter Creek prairie (n=23). The figure does not show a single Scatter Creek forest plot that was ranked as a B.



3.6.3 Future direction

Photo points were clearly successful during this pilot study. Volunteers appeared to be very willing to collect photo point data on all the pilot areas and successfully uploaded images using the Web ArcGIS application. We intend to identify suitable EIM mentors to take on the task of reviewing photos as they are uploaded in the future. Although ecological integrity assessments involving vegetation plots were less popular among volunteers, part of the 'problem' was that the protocols were being developed during the course of the pilot project and these protocols essentially presented a 'moving target'. These protocols are mostly established now and it is likely that that few changes will be needed in the future. This will allow more time for encouraging additional data collection and for volunteers and teachers to get used to an established system for collecting and entering data. As with the photo point images, we intend to identify suitable EIM mentors to review vegetation data for completeness as they are uploaded. Having volunteers monitor the completeness of data entered over the Web will relieve agency staff of this task.

We plan to compare the EIM plot data collected by volunteers and schools with data obtained using other, more intensive, techniques (Level 3) as a means of assessing the utility of citizen science data. For example, there are points on the Swanson Lakes, Sinlahekin, and Scatter Creek wildlife areas where detailed data has been collected in conjunction with other research projects. We plan to focus volunteer and school data collection on a subset of these same points, thus enabling an evaluation of ecological integrity ranks from citizen science data with that derived from data collected by professionals.

We plan to evaluate the efficacy of using the photos taken at EIM plots to derive metrics typically estimated on the ground by volunteers. Currently, photos taken at EIM plots are used to verify the ecological community of the plot and to document the general vegetation structure. Photos of sufficient quality may allow us to go further and extract data useful to EIM ranking.

4.0 EIM in the 2013-2015 biennium

As stated above, the WDFW Lands Division has adopted the Ecological Integrity Assessment (EIA) method as a tool to measure ecological integrity on Wildlife Areas. The agency is initiating a planning process for all of the Wildlife Areas in early 2014; the Lands Division feels that EIM will be most effectively and efficiently applied in Wildlife Area Management if the EIM process is integrated in to this process and the EIM 'plan' for each wildlife area is written into the Wildlife Area management plan. Therefore, EIM work conducted in the 2013-2015 biennium, as described above, will become part of the wildlife area planning process. Performance measures identified for this integration include:

1) A state-wide Level 1 assessment, including a state-wide depiction of current ecological integrity and tool that allows the Lands Division to evaluate relative contributions of each stressor to integrity ranks;
2) 8 wildlife areas (total) have EIM photo points established;
3) 4-6 wildlife area management plans that include ecological integrity goals and objectives, have EIM integrated, and drafted Ecological Integrity Monitoring plans;
4) 90 percent of photo points per wildlife area on which they are established are visited per year, and data generated by staff, volunteers, teachers and students is submitted to the WDFW central database;
5) 50 vegetation plots across all wildlife areas are visited during the biennium, and data generated by staff, volunteers, teachers and students is submitted to the WDFW central database;
6) Mentors trained in the 2011-2013 biennium have implemented the task to which they agreed, including volunteer and teacher recruitment, guidance, and data QA/QC;
7) At least 1 mentor has been recruited per candidate wildlife area in the 2013-2015 biennium and has implemented the tasks to which they agreed;

8) Outreach staff, with assistance from WDFW Human Resources Volunteer Program and Community Relations/Public Affairs, have developed and implemented a structured communication plan to keep volunteers and educators engaged and active, and site-specific outreach plans have been developed on wildlife areas where EIM is integrated; and
9) Protocols for integrating EIM with multiple indicator monitoring (MIM) and HCP-covered species-specific metrics have been developed to satisfy monitoring requirements of the Wildlife Areas HCP.

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*Appendix 1. Ecological Integrity Rank definitions**

Ecological Integrity Rank	Description
A (Excellent)	The highest quality ecosystems have major ecological attributes functioning within the bounds of natural disturbance regimes. The landscape contains natural habitats that are relatively large and essentially unfragmented (reflective of intact ecological processes) and with little to no stressors. Vegetation structure and composition, soil status, and hydrological function are well within natural ranges of variation. Non-native species are essentially absent or have negligible negative impact.
B (Good)	Not the highest quality, but major ecological attributes are mostly within the bounds of natural disturbance regimes. The landscape contains natural habitats that are relatively large and unfragmented (reflective of intact ecological processes) and with few stressors. Vegetation structure and composition, soil status, and hydrological function deviate slightly from the natural ranges of variation. Non-native species are present, but the impacts are minimal.
C (Fair)	There are a number of unfavorable characteristics outside the bounds of natural disturbance regimes. The landscape contains natural habitats that are relatively small and/or fragmented with several stressors. Vegetation structure and composition, soil status, and hydrological function deviate substantially from the natural ranges of variation. Non-native species may be abundant.
D (Poor)	The ecosystem is clearly outside the bounds of natural disturbance regimes. The landscape contains natural habitats that are small and/or fragmented with many stressors. Vegetation structure and composition, soil status, and hydrological function deviate dramatically from the natural ranges of variation. Non-native species may be abundant. The system is so severely altered, restoration may not be possible.

*Table adapted from Faber-Langendoen et al. 2009, and Schroeder et al. 2011

*Appendix 2. Summary of 'three-level' approach to ecological integrity assessments**

Level 1 – Remote assessment	Level 2 – Rapid assessment	Level 3 - Intensive assessment
General description: Landscape condition assessment	**General description:** Rapid site condition assessment	**General description:** Detailed site condition assessment
Evaluates: Condition of individual areas/occurrences using remote sensing indicators	**Evaluates:** Condition of individual areas/occurrences using relatively simple field indicators	**Evaluates:** Condition of individual areas/occurrences using relatively detailed quantitative field indicators
Based on: GIS and remote sensing data layers typically include land cover / use other ecological types	**Can be based on:** Stressor metrics (e.g., ditching, road crossings, and pollutant inputs); and condition metrics (e.g., hydrologic regime, species composition)	**Can be based on:** Indicators that have been calibrated to measure responses of the ecological system to disturbances (e.g., indices of biotic or ecological integrity)
Potential uses: Identifies priority sites, status and trends of patches across the landscape, condition of ecological types across the landscape, and targeted restoration and monitoring	**Potential uses:** Supports integrated scorecard reporting, monitoring for implementation of restoration or management projects, landscape / watershed planning, and general conservation and management planning	**Potential uses:** Informs integrated scorecard reporting, status and trends of specific occurrences or indicators, and monitoring for restoration, mitigation, and management projects
Example metrics: Include landscape development index, land use map, road density, and impervious surface	**Example metrics:** Include vegetation structure, invasive plant species, and forest floor condition	**Example metrics:** Include structural stage index, invasive plant species, floristic quality index, vegetation index of biotic integrity, and soil calcium:aluminum ratio

*Table adapted from Brooks et al. 2004, USEPA 2006, and Schroeder et al. 2011.

Appendix 3. Data form for Eastside Shrubsteppe, Grassland, and Savannah.

Habitat Point Data Form
Eastside Shrubsteppe, Grassland, and Savanna

Observer:			
e-mail:	Phone 1:	Phone 2:	
Additional observers:			
Day:	Month:	Year:	Time:
Wildlife area:	Point #:	Accuracy (meters):	Did you revise the location?

Specific location (UTM or lat-long)	NAD:	Zone:	UTM-E:	UTM-N:
	Latitude:		Longitude:	

Photos N:	Photos E:	Photos S:	Photos W:
Other photos:			

Soil surface rank		Planted wheatgrass cover	
Are there any trees on the plot (Y or N)?		Moss and lichen cover	
Tree cover		Downy and Japanese brome cover	
Shrub cover		Russian thistle cover	
Name of dominant native shrub		Knapweed cover	
Cover of dominant native shrub		Dalmatian toadflax cover	
Grass and sedge cover			

Tree species (number by DBH class)	≤2.5 cm	>2.5-15 cm	>15-30 cm	>30-60 cm	>60-100 cm	>100 cm	Snags	Stumps
Ponderosa pine								
Other:								
Other:								

Additional notes or details:

Appendix 4. Data form for Eastside Forest and Woodland.

Habitat Point Data Form
Eastside Forest and Woodland

Observer:		
e-mail:	Phone 1:	Phone 2:
Additional observers:		

Day:	Month:	Year:	Time:
Wildlife area:	Point #:	Accuracy (meters):	Did you revise the location?

Specific location (UTM or lat-long)	NAD:	Zone:	UTM-E:	UTM-N:
	Latitude:		Longitude:	

Photos N:	Photos E:	Photos S:	Photos W:
Other photos:			

Soil surface rank		Cover of dominant native shrub	
Course woody debris		Grass and sedge cover	
Are there any trees on the plot (Y or N)?		Downy and Japanese brome cover	
Disease/mistletoe rank		Russian thistle cover	
Tree cover		Knapweed cover	
Shrub cover		Dalmatian toadflax cover	
Name of dominant native shrub			

Tree species (number by DBH class)	≤2.5 cm	>2.5-15 cm	>15-30 cm	>30-60 cm	>60-100 cm	>100 cm	Snags	Stumps
Ponderosa pine								
Other:								
Other:								

Additional notes or details:

Appendix 5. Data form for Westside Woodland and Forest.

Habitat Point Data Form
Westside Forest and Woodland

Observer:			
e-mail:	Phone 1:	Phone 2:	
Additional observers:			
Day:	Month:	Year:	Time:
Wildlife area:	Point #:	Accuracy (meters):	Did you revise the location?
Specific location (NAD 83)	Zone (circle): 10 11	UTM-E:	UTM-N:
Photos N:	Photos E:	Photos S:	Photos W:
Other photos:			

Soil surface rank		Scotch broom cover	
Course woody debris		Himalayan and cutleaf blackberry	
Are there any trees on the plot (Y or N)?		Holly cover	
Tree cover		English ivy cover	
Shrub cover		Purple foxglove cover	
Name of dominant native shrub		Robert geranium cover	
Cover of dominant native shrub		Sword fern cover	

Tree species (number by DBH class)	≤2.5 cm	>2.5-15 cm	>15-30 cm	>30-60 cm	>60-100 cm	>100 cm	Snags	Stumps
Douglas fir								
Western hemlock								
Other:								
Other:								

Additional notes or details:

Appendix 6. Data form for Westside Prairie and Savanna and Oak Woodland.

Habitat Point Data Form
Westside Prairie and Savanna and Oak Woodland

Observer:			
e-mail:	Phone 1:	Phone 2:	
Additional observers:			
Day:	Month:	Year:	Time:
Wildlife area:	Point #:	Accuracy (meters):	Did you revise the location?
Specific location (NAD 83)	Zone (circle): 10 11	UTM-E:	UTM-N:
Photos N:	Photos E:	Photos S:	Photos W:
Other photos:			

Soil surface rank		Roemer's fescue cover	
Are there any trees on the plot (Y or N)?		Moss and lichen cover	
Tree cover		St. John's wort cover	
Shrub cover		Narrowleaf plantain cover	
Name of dominant native shrub		Sheep's sorrel cover	
Cover of dominant native shrub		Oxeye daisy cover	
Scotch broom cover		Clover cover	
Grass and sedge cover		Catsear cover	

Tree species (number by DBH class)	≤2.5 cm	>2.5-15 cm	>15-30 cm	>30-60 cm	>60-100 cm	>100 cm	Snags	Stumps
Oregon white oak								
Douglas fir								
Other:								

Additional notes or details:

Appendix 7. Data form for photo points.

Photo Point Data Form					
Observer:					
e-mail:		Phone 1:		Phone 2:	
Additional observers:					
Day:	Month:		Year:	Time:	
Point #:		Accuracy (meters):			
Did you find exact point?		How is the point marked?			
Specific location (UTM or lat-long)	NAD:	Zone:	UTM-E:	UTM-N:	
	Latitude:		Longitude:		
Photo 1 direction (use compass):			Photo 2 direction (use compass):		
Photo 3 direction (use compass):			Photo 4 direction (use compass):		
Other photo:			Other photo:		
Additional notes or details:					