



SUCCESSFUL RESTORATION OF SEVERELY DISTURBED LANDS: Predisturbance/Baseline Inventory

This bulletin provides general information appropriate for all Wyoming ecological sites.

Part of a series by the University of Wyoming Cooperative Extension Service and the Wyoming Reclamation and Restoration Center that describes strategies for restoring ecological functions to disturbed Wyoming lands.

For this series, reclamation means restoration of components that support desired ecological functions, such as forage for livestock grazing, wildlife forage and cover, water supply, water quality protection, and aesthetic values.

This bulletin provides information most relevant to reducing impacts of energy developments to sagebrush wildlife habitats in Wyoming. The information applies to sites where energy development is planned, is progressing, or has occurred. The bulletin is framed to provide information to avoid or lessen impacts to sagebrush wildlife habitats including fragmentation and human disturbance that could adversely affect wildlife habitats and populations.

Introduction

Predisturbance inventory is a critical part of reclamation planning and provides information on ecological structure and functions of a site slated for development and reclamation, including wildlife habitat, forage production, species composition, watershed protection, and aesthetics as well as characteristics that underlie those values and functions – the plants, soil, and landscape features needing maintenance or restoration. The inventory establishes a framework for successful reclamation, monitoring, and evaluation.

The inventory includes two steps necessary to compile complete and accurate information: 1) gather existing site-specific information from reliable sources; and 2) evaluate on-site ecosystem functions and characteristics needing maintenance or restoration.

Summary of components of successful reclamation. See text for more information.

Authors:

Jay Norton, Soil Fertility Specialist, University of Wyoming

Ania Krzyszowska-Waitkus, Consulting Soil Scientist

Calvin Strom, Research Scientist, University of Wyoming

Activity	Critical Components
Initiating baseline inventory	<ul style="list-style-type: none"> • Identify site location • Contact land manager/owner or agency • Consult soil survey maps • Determine Ecological Site Description (ESD) • Consult Wyoming Geographic Information Center (WyGISC) to access aerial photography in color, grayscale, or color infrared (CIR) • Identify wildlife presence or use • If state lands, contact Wyoming Department of Environmental Quality, Land Quality Division for guidelines and or permits.
Conducting baseline inventory	<ul style="list-style-type: none"> • Travel to site • Verify ESD and soil types • Record vegetation types and distribution on the site using an accepted method for collecting the data • Record topographical landforms and surface hydrological features • Take photographs to provide a visual reference • Document data gathering and photos with GPS coordinates



Identifying soil horizon.

Step 1: Gathering Existing Information (prefieldwork)

A great deal of information on Wyoming wildlife, vegetation, soils, water, and other features has been collected by state and federal agencies, the university, landowners, energy companies, and others. Acquiring it may take some phone calls, fieldwork, and footwork; this information is crucial for determining the data to collect during the field inventory and for understanding site complexities that potentially impact development and reclamation activities.

Table 1 lists potential sources of information useful in developing a baseline inventory. Keep in mind information is collected for specific purposes and at coarse or fine scales that make it more or less useful for your purposes. Natural Resources Conservation Service (NRCS) soil surveys and Ecological Site Descriptions (ESDs) are a great place to start.

Soil surveys provide maps and descriptions of soils with interpretations of suitability for many potential uses. Surveys are available for many Wyoming counties either online, in published form from NRCS field offices, or in unpublished form (see Table 1).

The detail included in these surveys is determined by the detail of the survey.

- Order 1 soil survey very detailed: scale < 1:12,000 size < 1.5 acres

- Order 2 soil survey regular survey: scale 1: 24,000 to 1:36,680 size 1.5 to 10 acres
- Order 3 U.S. Forest Service survey: scale 1:24,000 to 1:250,000 size 6 to 640 acres
- Order 4 general soil map of a county: scale 1:100,000 to 1:300,000 size 100 to 1,000 acres
- Order 5 soils of the state: scale 1:250,000 to 1:1,000,000 size 640 to 10,000 acres

Most areas in Wyoming are mapped at the **soil association** or **soil series complex** levels (Order 5), meaning each map unit represents at least several soils with different properties and limitations for development and reclamation. Specific soil properties for reclamation planning must be identified on the ground at individual sites that may contain numerous soil types. For planning from the office, map units must be assumed to have the most severe limitations of the soils within the mapped soil association. On-the-ground surveys are necessary to verify or identify the soil properties.

Important information provided from a field soil survey includes the thickness and properties of soil horizons, which contain the best properties for supporting plant growth, and subsoils, which influence drainage, water-holding capacity, and rooting depth of soils.

Table 1: Sources of information for baseline inventory.

Organization	Type of info.	Description	Where to get it
USDA Natural Resources Conservation Service (NRCS)	Soil survey	Maps and descriptions of soils with suitability for many management activities.	Call the NRCS State soil scientist: (307) 233-6774 List of and links to published soil surveys in Wyoming: http://soils.usda.gov/survey/printed_surveys/state.asp?state=Wyoming&abbr=WY Online soil surveys: http://websoilsurvey.nrcs.usda.gov/app Others available at NRCS offices. See: http://www.wy.nrcs.usda.gov/contact/index.html
	Ecological site descriptions (ESDs) http://esis.sc.egov.usda.gov/ESIS	Soil and plant community information, including species lists and state and transition models.	Call the NRCS range specialist: (307) 233-6766 Overview: http://esis.sc.egov.usda.gov/ESIS/About.aspx Approved ESD reports: http://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type=ESD ESD by soil series via soil survey: http://websoilsurvey.nrcs.usda.gov/app Western Wyoming keys to ecological sites: http://uwyo.edu/WRRC/
United States Army Corps of Engineers United States Fish & Wildlife Service (U.S.FWS)	National Wetland Inventory	Location and classification of wetlands and riparian areas.	Call USACE: Wyoming office (307) 772-2300 or visit their website https://www.nwo.usace.army.mil/html/od-rwy/Wyoming.htm Call the U.S. FWS Wyoming Field Office: (307) 772-2374 Home page offers a number of download and viewing options: http://www.fws.gov/wetlands/
Wyoming Natural Diversity Database	Research unit and database at the University of Wyoming	Distribution and ecology of rare plants, animals, and important plant communities in Wyoming.	Wyoming Natural Diversity Database (WYNDD) http://uwadmnweb.uwyo.edu/wyndd/
U.S. Fish & Wildlife Service Wyoming Game and Fish	Wildlife Inventory	Location of threatened or endangered wildlife and plants. Critical habitats including sage-grouse core breeding areas and big game migration corridors.	Call U.S. FWS Ecological Services: (307) 772-2374 http://www.fws.gov/mountain-prairie/wy.html Call Wyoming Game and Fish: (307) 777-4600 or visit the homepage http://gf.state.wy.us/
Wyoming Geographical Information Science Center (WyGISC)	Downloadable GIS maps	Many GIS compatible layers available.	General: http://www.sdvc.uwyo.edu/ WyGISC Data Server: http://partners.wygisc.uwyo.edu/website/dataserver/viewer.htm
Wyoming State Geological Survey, Google Earth	USGS topographic maps Aerial photos	Downloadable maps and aerial photos for sale and for free.	http://www.wsgs.uwyo.edu/sales/topo.aspx or call 1-888-275-8747 to order maps. Download Google Earth: http://earth.google.com/
Department of Environmental Quality, Land Quality Division	Inventory guidelines	Guidelines and baseline information from other projects.	Call (307) 777-7756 http://deq.state.wy.us/lqd/ http://deq.state.wy.us/lqd/guidelines.asp
State Historic Preservation Office (SHPO)	Archeological Resource inventory	Archeological information and clearance.	Call (307) 777-7697 http://wyoshpo.state.wy.us/

Ecological site descriptions

provide information (for rangeland) on site characteristics, important soil properties, and plant communities potentially present on the site, and interpretations of those plant communities and services the site may provide. Each potential plant community description includes a species list with a range of production values for that site. The lists can be used to set goals and develop seed mixes for reclamation. When developing seed mixes, select seed originating from the same soil and climate (ecotype) to ensure long-term viability of vegetation (Monsen & Stevens, 2004).

More than 200 ESDs covering most of Wyoming are available online (see Table 1) but, due to the site specific nature of ecological sites, very little of the state has or will be mapped with respect to ecological sites.

Other sources of information for specific sites may be obtained from offices or individuals owning or managing particular sites. Federal, state, and Tribal agencies often have specific inventories of soil, vegetation, weeds, wildlife habitat, forage production and grazing use, or other relevant site characteristics (surface and groundwater information). Prior to collecting baseline information, determine if the site is critical habitat for **wildlife** including threatened or endangered species (both plant and animal) by contacting the U.S. Fish and Wildlife Service (USFWS), Wyoming Game and Fish (WGF) and Wyoming Natural Diversity Database (WYNDD). Links to contact information for Wyoming field offices are listed in Table 1.

Step 2: Field Survey

The second step requires a field survey to verify and expand upon existing information. Table 2 lists some characteristics to be surveyed on site to verify the ESD, soils, and other information is accurate for a particular site. Some specific parameters that should be systematically examined with reliable sampling protocols and recorded include topsoil depth and quality, groundcover composition, topography, ephemeral stream characteristics, and wildlife habitat parameters (see

Finding Your Ecological Site Description

For western Wyoming, start by using keys developed by NRCS (available from the WRRRC Web site under "reclamation information"). For other parts of the state, go by soil texture and precipitation to choose from the ESDs for your region. Once you've determined the name of the ESD that applies (for example, Loamy 7-9" Green River and Great Divide Basin), you can find it on the Ecological Site Information System:

1. Go to: <http://esis.sc.egov.usda.gov/ESIS/>;
2. Click on Ecological Site Description in the center of the screen;
3. Click on Approved ESD Reports in the upper left;
4. Scroll down and, under State, select Wyoming and Submit;
5. Find the ESD and click on the ID;
6. Make sure your site lies within the area highlighted on the map, then click on Plant Communities along the left side of the screen;
7. This screen gives a great deal of information about interactions among rainfall, management, and plant community composition. Scroll down to see the state and transition model of plant community response to management and disturbance. Scroll down further to see the list of plants and their high- and low-end production for the several stable plant community states. Employ this information, your observations of the site, and check availability of seed to design a site-appropriate seed mix. Plant cover data does not directly correlate with the percent composition by weight data on the ESDs, but both provide similar information about plant community composition. Eventually, NRCS will include cover data on the ESDs.



Determining soil type.

Table 2), among others. For mining operations, the Land Quality Division (LQD) of the Wyoming Department of Environmental Quality (WYDEQ) should be contacted for the requirements before any predisturbance baseline sampling of soil and plants occurs.

Sampling protocol is well-defined in WYDEQ LQD guidelines available online at <http://deq.state.wy.us/lqd/guidelines.asp>. The LQD sampling guidelines can be applied to oil, gas, and wind energy operations.

Table 2. Selected parameters and techniques for predisturbance/baseline field survey.

Parameter	Technique
Topography and landforms	Develop a map of landforms that determine differences in soils and vegetation, such as slopes, ridges, drainage ways, terraces, etc. Access maps and geologic information on USGS website http://www.usgs.gov/
Geology and overburden assessment	Provide geological cross sections (depending on size and slope of site); provide overburden analysis (qualitative and quantitative) if necessary. Guidelines for making an assessment can be found at Wyoming Land Quality Division guide 1. http://deq.state.wy.us/lqd/guidelns/guide1.pdf
Hydrology	Perform groundwater assessment if necessary. Surface water information (drainage basin description, surface water quality, channel characteristics, perennial or ephemeral flow, if necessary). More information at http://www.usgs.gov/ or WYDEQ LQD at http://deq.state.wy.us/lqd/guidelns/guide8.pdf Develop a storm water prevention plan. Information available from the Environmental Protection Agency website cfpub.epa.gov/npdes/stormwater/swppp.cfm
Vegetation data	Establish transect within each major plant community (ecological site) with at least three soil/veg data collection points. The number of points should increase with site variability. Guidelines for establishing transects available at http://deq.state.wy.us/lqd/guidelns/guide2.pdf
Soil assessment	Soil color: use Munsell soil color chart to detect decrease in soil organic matter between surface and subsoils by increase in value and/or chroma. http://soil.gsfc.nasa.gov/pvg/munsell.htm Texture: Use-texture-by-feel method to determine depth of clay increase or other change in particle size. NRCS provides a guide to the soil texture by feel method at http://soils.usda.gov/technical/aids/investigations/texture/ Clay content more than about 40 percent (clay and clay loam texture) generally causes clodding, poor infiltration, and poor drainage properties that can cause excessive runoff and erosion. Sand content more than about 70 percent (sand and loamy sand texture) causes low water holding capacity and excessive drainage that create droughty conditions that don't support reclamation. Carbonates: Observe strength of effervescence with 10 percent solution of hydrochloric acid to determine depth where carbonate content increases. Soil materials that effervesce, or fizz, strongly or violently generally have high contents of calcium carbonate and other salts that limit water and nutrient availability to plants, especially seedlings in reclamation projects. pH and electrical conductivity (EC): Determine increase in both using field meter or test kit. pH lower than 6.0 and higher than 8.0 limit availability of nutrients to plants. EC higher than 4 dS/m indicates high salinity that constricts water and nutrient availability. Lab analyses: Determining basic fertility parameters in predisturbance soils, including at least soil organic matter and plant-available nitrogen, phosphorous, and potassium; enables comparison to post-reclamation conditions for possible soil amendment remediation measures. For more information, consult NRCS soil survey.
Subsoil physical properties	Dig at least one soil pit per landform to determine soil horizons, measure thickness, bulk density, and water-holding capacity of subsoils. Use same field tests and lab analyses as for topsoil to determine subsoil properties. http://soil.gsfc.nasa.gov/pvg/hor1.htm
Vegetation Inventory	Use transects, grid sampling, and photos to determine species composition of shrubs, forbs, grasses, and noxious weeds present. See Table 4 for sampling methods.
Wildlife use and habitat, species of concern, endangered, etc.	Perform rapid assessment of habitat features and use (e.g., fecal pellets, ungulate tracks, small mammal burrows, bird nests) for site-specific wildlife species. Consult U.S.FWS Habitat Evaluation Procedures Handbook at http://www.fws.gov/policy/esmindex.html Consult Habitat Evaluation Procedures (HEP) at http://www.fort.usgs.gov/products/software/hep/



Predisturbance inventory.

Sampling intensity: There are many ways to sample a site, but the number of samples, sampling scheme, and the level of detail depend upon the size and variability of the site. Flat, uniform sites might require only a few sample points, while sites with variable topography or obvious plant community changes may require collection of more samples. Sample points might include observations and sampling for soil properties; observations of vegetation cover by species, bare soil, plant residue, etc.; wildlife use observations; and other information.

Topography and landforms: A site visit will confirm if United States Geological Survey (USGS) topographic map (1:24,000) or a topographic survey utilized as existing information confirms the topographic slope conditions. Recent or historical aerial photographs (Google Earth or WyGISC) can provide useful up-to-date information regarding landform structure. The landform map you develop provides informa-



Marking soil strata.

tion for determining the potential extent of disturbance and soil and vegetation sampling locations across contour intervals, as vegetation may change with elevation.

Geology and overburden assessment: For sites where deeper material will be brought to the surface, such as mines, oil and gas pads requiring deep cuts in hillsides, geologic stratigraphy (the order in which rock strata are distributed and the chronology of their formation) based on geologic cross sections, including overburden analysis (qualitative and quantitative), if necessary, will provide information about physical and chemical properties of the overburden. This will identify which materials are overburden and those suitable for use as topsoil and subsoil (suitable growth medium) and those containing substances unsuitable for plant growth or problematic to successful reclamation. This analysis will identify proper material handling to avoid potential risks of ground water contamination. For more information on overburden analysis consult WDEQ LQD Guideline no 1. (<http://deq.state.wy.us/lqd/guidelines/guide/guide1.pdf>)

Hydrology: Restoration of ecological functions, especially watershed protection function providing resistance to erosion and minimize sediments leaving the site, requires documenting characteristics of the site that impact surface runoff and sediment movement, as well as possible impacts on ground water. Documentation of surface for hydrology pattern is crucial for site stabilization early in the reclamation process and restoring ecological functions. Hydrology is important on all sites especially those with complex, sloping topography and evidence of flowing water. Improper reclamation of such sites can lead to erosion and pollution of downstream waters with sediment. Characteristics affecting surface hydrology include soil, water infiltration rates, subsurface flow rates, slope steepness and length, surface soil texture, vegetation, amount of bare soil, evaporation rates, presence of rills, gullies, and ephemeral

stream channels, as well as any alterations such as check dams or reservoirs, and their condition. Impacts to perennial streams are very difficult to mitigate both during and after development activities and should be avoided. The WYDEQ LQD provides comprehensive guidelines on documenting hydrology prior to disturbance (see <http://deq.state.wy.us/lqd/guidelns/Guide8.pdf>)

The nature of and potential for impacts to ground water can be documented based on regional information on depths and flow characteristics compiled by the Wyoming State Engineer's Office. Call (307) 777-6163 or check the Web at <http://seo.state.wy.us/GW/> for more information.

Soil properties: The goals of predisturbance inventory of soils are to identify suitable soil salvage depths to facilitate revegetation and identify any problematic soils or soil horizons that may exist on the site. In Wyoming, suitable soil depths can vary from very little to 18 inches or more depending on location and landscape position. A

soil survey should cover the entire area to be disturbed. Soil sampling frequency for baseline purposes for coal and non-coal operations is explained in WDEQ LQD Guideline 1 (<http://deq.state.wy.us/lqd/guidelns/guide1.pdf>)

Soils develop over thousands of years as organic materials from plants and animals on and near the surface are decomposed and infiltrating water moves clays and soluble salts deeper into the soil profile. The result is loamy topsoil, or A horizons, with good properties for plant establishment and growth, and subsoil, or B horizons, with higher clay and salt contents that hold moisture but can impede root growth and penetration. Material under A and B horizons can be called overburden material that is not suitable for plant growth.

For reclamation purposes, we should think of “topsoil” and “suitable growth medium” as both referring to the material salvaged for use during reclamation with the realization that it consists of the A and upper B horizons. The lower boundary between the suitable horizon and overburden material is determined by a drop in clay content and, most important, by a change in color.

Soil and plant scientists have developed ranges of soil physical and chemical properties that do not impede plant growth (Table 3). These properties should be analyzed by



Soil sampling.

depth and mapped during the predisturbance inventory. Results will be a map of soil salvage depths across the site for use as reclamation topsoil. Topsoil management before, during, and after reclamation will be covered in more detail in an upcoming bulletin in this series.

Table 3. Criteria to identify suitable soil material for salvage and use in reclamation. Suitability must be determined case by case if predisturbance values for A horizon soils are in the marginal or unsuitable range (from WYDEQ LQD: <http://deq.state.wy.us/lqd/guidelns/guide1.pdf>).

<i>Parameter and method†</i>	<i>Suitable</i>	<i>Marginal‡</i>	<i>Unsuitable</i>
pH (acidity or alkalinity)	5.5-8.5	5.0-5.5 8.5-9.0	<5.0 > 9.0
Salt content by electrical conductivity (EC) (mmhos/cm)	0-8	8-12	>12
Texture by feel	Loams < 40% clay, <90% sand or silt	clay, silty clay, sand	
Sodium ion activity (Sodium Adsorption Ratio)	0-10	10-12, clay soils 10-15, other soils	>12 >15
Gravel (>2mm)(% vol)	<25%	25-35%	>35%

- † pH and EC can be determined with simple field meters.
- Texture by feel can be done using the textural triangle and flow chart available on the WRRRC webpage under Reclamation information.
- SAR content should be determined by a soil laboratory.
- Gravel content by volume can be visually estimated by sieving a soil sample through a 2 mm (10 mesh) sieve.
- Suitability depends on values for predisturbance soils.



Soil profile.

Vegetation: A site visit is required to determine the species present on a given site. Documenting the types of grasses (bunch, rhizomatous, bluegrasses) forbs (annual, perennial), shrubs, exotics (halogeton, cheatgrass, etc.) and noxious weeds (www.wyoming noxious weed list) present on the site will determine the seed mix used in reclaiming the site. Document species composition by determining the percentage each species occupies of the total vegetation cover on the site. Some counties have added species to their noxious weed lists that may or may not be on the state list. This information will determine if pre-plant treatments are necessary to control noxious weeds that may be present. Taking photographs of vegetation prior to disturbance will provide a visual aid that complements the method of data collection (see Table 4) used to inventory the vegetation.

The Bureau of Land Management (BLM) recommends image-based data collection using Sample Point software (developed by the USDA Agricultural Research Service), which utilizes photographs to inventory the species composition and to monitor reclamation efforts.



Daubenmire sampling.

On-site vegetation inventory can be completed using one or more methods. Table 4 lists several methods used for the collection of vegetative inventories (genus and species) that are essential prior to disturbance and after reclamation to measure progression toward successful reclamation of the site.

Wildlife use and habitat: An assessment of important habitat features using the guidelines in the U.S.FWS, *Habitat Evaluation Procedures Handbook* (HEP) (<http://www.fws.gov/policy/esmindex.html>) defines beneficial habitat features desired by various species, by recording fecal pellets, ungulate tracks, small mammal burrows, bird nests, and other signs that intercept transects across landform vegetation units. The USGS has a computer program available online (<http://www.fort.usgs.gov/products/software/hep/>) that aids in the development of a HEP, using the philosophy that an area can have various habitats that meet the requirements for different species. USGS contends these differences can be quantified using Habitat Suitability Indices (HSIs), which is a system of programs that uses mathematical models to compute an HSI value for selected species from field measurements of habitat variables. The development and use of these models is described in the Ecological Services Manual (ESM 103) and the HEP Training Course HEP 500 (Habitat Evaluation Procedures). <http://www.fort.usgs.gov/Products/Software/HSI/>

For BLM lands contact the area field office to determine if the area to be assessed is in core sage-grouse habitat.

Conducting a predisturbance inventory prior to disturbance provides specific information necessary for successful reclamation of the site. An accurate assessment of soil properties, vegetation present, topography, and wildlife use is needed for developing your reclamation plan for the site. This bulletin provides step-by-step information on how to collect and use the information needed for successful reclamation of sites disturbed during construction activities. Visit the website at Wyoming Reclamation and Restoration Center for additional information: <http://uwadmnweb.uwyo.edu/wrrc/>.

Table 4. Methods for collecting vegetation inventory.

<p>Cover by life form</p> <p>Wyoming Rangeland Monitoring Guide</p>	<p>Cover by life form combines line point-intercept with photography. For additional detail the photographs may be used with the Sample Point software to provide additional data.</p> <p>http://www.wyorange.net/</p>
<p>Line-point intercept</p>	<p>Line-point intercept quantifies cover by vegetation types, litter, rocks, and biological soil crusts.</p> <p>Monitoring Manual for Grasslands, Shrublands, and Savanna Ecosystems Vol II (Herrick et al, 2005)</p>
<p>Daubenmire method</p>	<p>This method estimates canopy cover, frequency, and percent cover of vegetation types. Litter, rocks, and bare soil.</p> <p>www.blm.gov/nstc/library/pdf/MeasAndMon.pdf.</p>
<p>Sample point</p> <p>Computer program facilitating the evaluation of photographs.</p>	<p>Sample Point is a manual image analysis program designed to facilitate vegetation, litter, soil, and rock cover measurements from Nadir (aerial) digital images.</p> <p>It is available online at the USDA-ARS Cheyenne website and is free.</p> <p>http://www.usda.gov/services/software/download.htm?softwareid=254</p>



Predisturbance vegetation.

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Monsen S. B., Stevens R. (2004). Restoring Western Ranges and Wildlands. Vol 1 (121-154)

Wyoming Department of Environmental Quality (www.deq.state.wy.us)

USDA Department of Natural Resources and Conservation Service (www.nrcs.usda.gov)

United States Geological Survey (www.usgs.gov)

USDA-Agricultural Research Service (www.ars.usda.gov)

Herrick et al. (2005). "Density, frequency, and line-point intercept alternative methods" Chap. 15 in *Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems*, Vol II. New Mexico: USDA-ARS Jornada Experimental Range, 2005.

Daubenmire, R. (1959). A Canopy Coverage Method of Vegetational Analysis. *Northwest Science* 33: 43-63

U.S. FWS *Habitat Evaluation Procedures Handbook*
(<http://www.fws.gov/policy/ESMindex.html>)

EPA Storm Water Pollution Prevention Plan (cfpub.epa.gov/npdes/stormwater/swppp.cfm)

U.S. Army Corp of Engineers (<https://www.nwo.usace.army.mil/html/odrwy/Wyoming.htm>)

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Graphic Designer: Bernadette van der Vliet, College of Agriculture and Natural Resources, Office of Communications and Technology



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