Modernization of collection and analysis for range spatial data

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Abstract

Throughout the United States livestock grazing on public lands is managed by the United Sates Forest Service (USFS).  The decisions made by the local specialist are a large part of management and have major impacts on the sustainability.  Through informed decision the forest specialist can maintain the forest in a balance of utilization for todays' benefit and into the far future. Data collection and analysis are important to inform any decisions that are made.   This project focuses on the management, collection, and analysis of range spatial data on the Okanogan-Wenatchee National Forest (OKW) in central Washington.  Most spatial data is stored in a forest level SDE geodatabase; data collection is done to determine the suitability and capability of allotments throughout the forest. Each of these aspects are important in informing any range decision made by the USFS staff. The first half of the project develops and applies a modernized workflow for storing and gathering spatial range data.  Utilizing ArcGIS Online (AGOL) platform data is collected using handheld tablets and synced back to this national SDE database. This workflow eliminates the need for double data entry – once in the field and again the office – creating a more efficient work force.  The second half of the project modernizes the capability and suitability analysis.  Theses parameters are essential to determining a suitable number of cattle per allotment. By building a standardized model for each assessment the parameters are easily obtained and mailable to the unique parameters, elements, circumstances of each allotment.

Table of Contents

Introduction

The principle responsibility of the US Forest Service (USFS) is to manage their lands multiple uses. Most of the public see the forests as vast tracks of land for recreation; when in fact, much of the land is also utilized for timber harvest and livestock grazing research, mineral extraction, wildlife habitat, and many more. Each year thousands of cattle are turned out on USFS lands. Range specialists working in the field track cattle numbers, utilization, and range improvement conditions. Therefore, accurate data collection in this field of management is extremely important.

The geospatial component of the range program is a small but powerful piece – it is but a single cog in the wheel. Having a strong organized base makes a difference in being able to collect and maintain data seamlessly. This leads to the main objectives of this project: 1) to create a well-organized and efficient spatial data collection and storage system; and 2) to build an efficient analysis workflow for determining the capability and suitability of allotments.

Range Permitting Process

The US Forest Service cares for 190 million acres of federal land - mostly in the western United States - and manages it for grazing, timber harvest, recreation, minerals, water supply and quality, and wildlife habitat. (GAO 2016).USFS began issuing permits for grazing livestock on Forest Service lands over 100 years ago starting in 1897 with the Organic Administration Act (Ch. 2, 30 Stat. 34). Over time, there have been 10 further congressional acts that regulate grazing on USFS property with the most recent being the Public Rangelands Improvement Act in 1978 (USDA Forest Service 2005).

In 2015 in Region 06 (Oregon and Washington) the USFS issued 5,860 permits for cattle grazing with a total of 7,995,098 cow calf pairs for 30 days. The Okanogan-Wenatchee NF alone issued permits for 46,689 AMUs (20% of the regional AMUs) over 1,590,538 acres (49% percent of the total Okanogan-Wenatchee NF) (GAO 2016).

A cattle livestock grazing permit is available to any US citizen, corporation or partnership who owns 80% of the capital stock (GAO 2016). At its inception, a livestock-grazing permit establishes and specifies the number of cattle and duration allowed on the allotment. The permit also sets the maintenance responsibilities for range improvements and grazing fees for both the USFS and the permitee. A term permit, the most common type, commonly lasts for 10 years, and, barring the absence

of violation of the terms of the permit, they are renewed to the standing permittee.  There are a few types of permits, but the most common is a term permit which can last 10 years. Other types of permits apply to different situations. An on/off permit allows a permittee who owns the neighboring property to include their property in the permit for pushing cattle through or expanding their pasture's capacity. A temporary permit is a useful tool for the district ranger; it can be utilized as a probation tool for permittees in a non-compliance status or to take advantage of an un usually productive season. Temporary permits can be issued by the district ranger and do not exceed one year (USDA Forest Service 2005).

Each permit follows a standard of operations. The process starts with an Allotment Management Plan (AMP), which establishes what should and can be done in the area.  At this point, other specialties within the USFS - such as hydrology and wildlife - can add their input and voice concerns of impact to their particular resource. Following a successful AMP, permits are issued. The permit outlines the responsibilities and expectations of the permittee and USGS, and often includes the location and maintenance of range improvements like fence lines and water developments.  For every permit, an Annual Operating Information (AOI) document is put together to keep both parties informed and make sure that things are running smoothly. Commonly, that is the time to adjust for unexpected events such as fire or flood which impact range availability. In addition, it gives the opportunity to verify the condition of range improvements and communicate about forage utilization.  These meetings include the range staff, district ranger and permittee, and normally they represent field time and data collection done by the district's Range specialist.

## Grazing on Public Lands

Livestock grazing on public lands has been a highly studied, often debated and somewhat contentious subject since the 1950s.  There are at least two sides to every story.  First consideration will be a look at the benefits that can come from a well managed livestock grazing program. After that, a description of the hazards that result from a poorly managed system.

When livestock grazing is well managed there are benefits to the forest health and the local economy(Oles et al. 2017).  Grazing can decrease plant competition and allow timber to grow benefiting logging operations (plant association guide).  When managed in collaboration with thinning and prescribed burning, livestock grazing contributes to an overall increase in biodiversity (Middleton, Holsten,

and van Diggelen 2006).  Additionally, there are some locations where cattle grazing can shift noxious weed-dominated areas (Davy et al. 2015).

In addition to ecological benefits, the benefits livestock grazing can economically benefit the local rural community in the form of jobs.  That is a huge asset in rural communities across the Western United States.  The governing agency, namely the USFS, also gains economic benefit through the associated grazing fees. Grazing fees are paid by the permittee to the USFS for a variety of services: 1) for permission to graze cattle on Forest Service lands and calculated per Animal Month Unit (AMU). 2) for range improvements like 'artificial revegetation', fences, driveways, corrals, and stock watering devices, 3) for 'control of range-destroying rodents' and 'eradication of poisonous plants and noxious weeds,' and 4) for altering holes on public lands for the purposes of trapping, killing, wounding, or maiming any of these animals (USDA Forest Service 1995 -Granger-Thye Act of 1950). However, the reality is that the USFS rarely breaks even between the expense of managing grazing permits and the fees it charges and collects in its national range management program. In fact, in 2004 the Government Accounting Office found that "the total grazing fees generated by federal agencies amounted to less than one-sixth of the agencies' expenditures to manage grazing in 2004" (Fleischner 1994).

Ultimately, the biggest beneficial aspects of cattle grazing is the production of beef. As an agricultural commodity, it is highly prized around the world but especially here in the United States.  The US is set to break record levels of beef consumption this year (2018) with the average American consuming an average 222.2 lbs. of beef per year (Singh 2018).  Furthermore, beef raised on the wildlands of the United States before heading to the feed lots are healthier themselves and healthier for those who consume them (Pollan 2007).

On the other hand, grazing has negative impacts; especially when left unregulated.  Throughout the Western United States, studies have shown that when livestock grazing is removed from a system there in an increased species richness and an improvement to the overall health of the population (numbers, size etc.) of flora and fauna alike.  These studies examined impacts to the more obvious things like grass density, as well as less obvious impacts on things such as grasshopper numbers and trout health (Fleischner 1994).

Studies done in specifically in Washington State show that grazing leads to a shift in the vegetative composition of the area resulting in a transformation from a 'parklike' Ponderosa Pine forest with a dense Pine Grass understory to an area dominated by tree encroachment resulting in higher fuel loads and decreased grass density and species richness.  (Fleischner 1994; Society 1951).  Currently, the western United States is feeling the grave impacts of these changes: fuel loads in the forests are so high there is a paradigm shift such that a historically beneficial light strike wildfire now erupts into a season-long event easily burning 150,000 acres (Wright and Agee 2004; Haugo et al. 2010; Everett et al. 2000).

Livestock grazing impacts go beyond the flora and fauna of an ecosystem; it also has a significant impact on soils. Overgrazing causes increased runoff, and when cattle stay in one place it compacts the soil and makes it uninhabitable to vegetation.  Grazing livestock directly compete for forage with native wildlife, and thereby change the grazing patterns for deer, elk and other grazing ungulates(Society 1951).

Study Area: Okanogan-Wenatchee National Forest

In 1908, President Theodore Roosevelt designated 1.4 million acers of Washington State as Wenatchee National Forest and nearly 2.5 million acers as the Chelan National Forest (later to be renamed the Okanogan National Forest) (Davis 1983).  Over the next century each of these forests would grow and shrink and redraw district boundary lines many times.   Eight distinct wildernesses would be designated within their boundaries which still exist today: Goat Rocks Wilderness and Glacier Peak Wilderness, both on the Wenatchee National Forest were established 1964; the Alpine Lakes Wilderness established in 1976; and the William O. Douglas Wilderness, the Norse Peak Wilderness, and the Henry M. Jackson Wilderness - all established 1984.  In 1968 Congress designated 532,000 acres of the Okanogan National Forest as the Pasayten Wilderness. Then in 1984 they designated Lake Chelan - Sawtooth Wilderness, which crossed the boundaries of the Okanogan and Wenatchee National Forests. Today these two forests have been combined (the official name change was in 2008) to form the Okanogan-Wenatchee National Forest which is comprised of 4 million acres with jurisdiction over all or part of eight previously established wildernesses(Davis 1983; "Okanogan-Wenatchee National Forest - About the Forest" n.d.).

The Okanogan-Wenatchee National Forests contains many different vegetation and geological types ranging from alpine lakes surrounded by lodge pole pine and larches, to ponderosa pine forest, to the sagebrush hillsides leading to the Columbia basin.  This forest is home to many different endangered species, from white headed woodpeckers to the elusive lynx, from the wolverine coming down across the border from British Columbia to the *chinook* salmon which use the streams of this forest for their breeding habitat (Dowd-Gaile 2014).  Because of this rich ecological diversity, many people come to enjoy the Okanogan-Wenatchee National Forest.  In 2010, a visitor use survey estimated 361,000 people visited the Okanogan National Forest and 1,228,000 visited the Wenatchee National Forest for a total of 1,589,000 visitors for the combined forest (United States Department of Agriculture Forest Service 2010; "National Visitor Use Monitoring (NVUM) Report Okanogan National Forest" 2010).

The Okanogan-Wenatchee National Forest has a robust Range Management Program in the northern end of the forest. There are 68 allotments and 207 pastures on this forest covering 1,675,338 acres which is close to 50% of the whole forest.  With that workload combined with the vast expanses of land under permit, it takes a large number of people a great deal of effort to track and mange (GAO 2016).

Every decision made by the Forest Service or any government agency is scrutinized by the public and is eligible for public comments- a major component of the NEPA process.  If a general governing body is mismanaging public lands, that agency is not only subject to public scrutiny but also to lawsuits from displeased individuals and non-profit groups or coalitions. The USFS makes a great effort to ensure that every decision is backed by information – from its scientific community and data collected in the field. When that data is clean, accurate and efficiently collected, then those the land managers can have confidence in their decision. In addition, it provides a record of why the decision was made and supplies justification and explanation in court. Furthermore, having good clean data helps explain decisions to those at the higher levels and to those in other disciplines within the agency.

An example of a data driven decision is the question of renewing or declining a grazing permit at the Annual Operating Information (AOI) meeting to review a current grazing permit. If a permittee is outside the regulations (agreements) of their permit, they are issued letters of non-compliance which can results in fees or a loss of their permit if the situation is not rectified. These are high stakes. It is absolutely

essential to have the numbers/data to validate every and any letter of non-compliance the range staff writes in order to keep them standing on solid ground.  Without the data, decisions have less authority and are less likely to survive if challenged by the permittee, the public, or those higher up the chain of command.

Having well managed, organized data is important. Each district on the forest has a range specialist on staff, whom is either in charge of a large program with many permittees or in charge of multiple programs; they don't have time to waste on looking for data.  Organization and management take effort and skill so any automation of data/information tremendously helps the system.  Simple workflows and procedures are going to most benefit a program.  Once the system is organized with a degree of standardization, technology can assist with part of the workload through automated calculations and summary tools. This decreases the workload on the range staff and decreases turnaround time for reports.   A quicker turnaround time means that the land and the people can be better cared for.   The better the care the land receives the more sustainable the program, which ensures there are still healthy lands long into the feature.

## Chapter 1: Organization – Collection – Reporting

### Introduction

The first section of this project establishes a foundation for ensuring a smooth ride for those who will be using the data long into the future.  ArcGIS Online is a recent cloud-based platform that will be a key component in this workflow, along with associated Environment System Research Institute (ESRI) mobile apps, web apps, and some basic scripting.  While the development and background maintenance of this updated system requires some technical skills, the final product will be an easy-to-use system from range data collection thru reporting both internally and externally.  The objective of this project was to devise an efficient, user-friendly method of data collection that would be 1) easily gathered in the field and 2) effortlessly uploaded to the home/master database.

### ArcGIS Online (AGOL)

ArcGIS Online (AGOL) is a cloud-based GIS mapping and analysis platform developed and supported by Environment System Research Institute (ESRI). Being a web-based system, the information

and tools have a wide range of applications and are available from a web browser and include specialized mobile applications. With the wide availability, accessing and sharing spatial data becomes easier than ever(Environment System Research Institute (ESRI), n.d.).

AGOL, much like ArcMap, has a large and developing set of building blocks to make it a powerful spatial data storage and analysis tool.  The base for AGOL is the feature service which stores the geocoordinates and attributes for all points, lines, and polygons collected.  Feature services are viewed and manipulated in a web map, which is a *mirror product* to the mxd.  Each web map has at least one feature service and a basemap.  ESRI provides a suite of basemaps ranging from imagery (aerial photography) to USGS topological maps to basic gray map. There is also the option to upload specialized basemaps for use within an organization.    All editing and interacting with the feature service is based on the web map.  AGOL also acts as a sharing platform, there are large amounts of publicly available data provided from a vast number of sources from individual account holders to ESRI.  They host multiple basic feature services such as roads or current wildfire points for everyone to utilize in maps and analysis.

From the web map, AOGL continues into web apps and the branches further into mobile applications.  To help the end user utilize AGOL's full potential ESRI has develop a web builder application.  AGOL web applications provide a template for creating unique *interfaces/views/experiences* with the AGOL data.   It has a suite of widgets (mini plug in applications) for the web apps. These provide easy to use buttons and interfaces for editing, analyzing and reporting – all as easy as a click of a button - which makes them accessible to even the less experienced GIS user.  (Environment System Research Institute (ESRI), n.d.).


Supporting Apps

ESRI has also developed several mobile apps for use on tablets that utilized AGOL services and also tap into other technologies. The three apps we utilized in this project are Survey123, Collector and S1. Each of these applications allow for disconnected editing of a feature service.  This allows the user to take a mobile device off the internet and into the woods to collect data, come back to an internet connection, and sync (update) back to the feature service.  Collector, as indicated by its name, is used for colleting data. In an automated process with the mobile app, the user can download a basemap and

create a runtime geodatabase of the feature service.  The user can then take the data out in the field

completely disconnected from the online environment.  After collecting new features or editing existing

ones, when connected back to web map via an internet connection, the updates are synced back to the

feature service and made immediately available to anyone with access to the feature

service(Environment System Research Institute (ESRI), n.d.).

S1 is very similar to Collector but is a product of the collaboration of USFS and BLM through the

service first program.  They utilized the concepts of Collector for disconnected editing but added features

found beneficial to field going employees.  S1 is somewhat a merger between Collector and handheld

GPS devices such as Garmin Rhinos.  A few benefits to S1 over Collector include that 1) it allows the

user to collect data directly onto the device without the need for a prior setup webmap or feature service;

2) it can snap Georeferenced photos; and 3) it can lay a bread crumb trail (track) in the background.

These assets make S1 a more field -friendly app than Collector for this project. One major drawback is S1

is only programed for the Android operating system.  The end user can use either app when working with

the range feature service.  (Bureau of Land Management, n.d.).

Survey 123 is different from Collector and S1; it is form-based while the others are map-based

interfaces.  Survey123 takes the historically used, paper forms and translates them to a tablet interface

and adds spatial location and photos to the forms.  Survey 123 has more of a focus on the attributes

being collected rather than the spatial location as in the Collector and S1 With the smart question feature

in Survey123; the form can be build to limit the number and types of data entry error, creating a cleaner

more accurate data set (Environment System Research Institute (ESRI), n.d.).


Tablet accuracy, capabilities, advantages

When collecting data, accuracy of the instrument is an important factor; this is no less true for spatial

data.  Global Positioning Systems (GSP) units determine their location by triangulating signals received

from satellites.  They utilize the 'direct line of sight' for determining where the receiver is located – in a

tablet or on a GPS collard animal etc. Anything that obstructs that view creates an inaccuracy in the

location; trees and canyons are the main hindrances when working in the field. The most common GPS

receivers currently used in the USFS are Garmin handheld GPS units, Trimble units, or Android and

Apple tablets. The most accurate of these, the Trimble units, are being phased out because Microsoft is discontinuing support for mobile operating systems and in turn ESRI is discontinuing the support for ArcPad.  Garmins have been in circulation long enough that most people have used them and are comfortable and familiar with them.  Tablets represent a balance between the two: they have customizable maps (an attribute of the Trimble units), but they have the lower level accuracy of Garmins.  Currently, there are few external Bluetooth units that can be utilized to get better accuracy; therefore, a tablet provides a truly powerful GPS-ing combination of customizability and accuracy.

Tablet characteristics

- Pros
    - Inexpensive
    - Easy to use
    - Small learning curve
    - Efficient data entry
    - Less time in the office entering data by hand
    - Standardized entries – quality control
- Cons
    - Short life span – not intended to be used for more than a couple years
    - New operating systems are constantly being developed and older versions become glitchy
    - Fragile – there are ruggedly-made versions, but that significantly bumps up the price
    - Generalized over all at the bottom of the learning curve as an agency.
    - Limited battery life

## Problem statement

The range spatial data on the Okanogan-Wenatchee NF has historically been organized and maintained at the district level by local range staff.  This has lead to having several different methods, standards, and has made forest-wide organization and reporting more difficult. For example, one district had a simple shapefile for each feature while another utilized Windows Explorer folders to hold shapefiles

for each pasture/permittee. By way of exception, however, allotment and pasture boundaries, which are subject to national standards spanning several years, are stored in a forest-level SDE geodatabase (Okanogan-Wenatchee geodatabase).

<span style="color:green">Historical Data organization Examples</span>

- Tonasket example for "all other data"
  - Separated by windows explorer folders
    - By Allotment
    - By Permittee
      - Shapefiles
        - Water Developments
        - Fence line
        - Cattle Driveways
- Methow Valley Ranger District example for "all other data"
  - Separated out by district
    - Shapefiles
      - Water Developments

This is a disjointed and inconsistent method for handling the data. This can result in loss of data – especially during times of staff transitions when problems arise from not knowing where the data is or if the data exists.  In addition, disorganized data can also lead to low quality reports and make it difficult for other specialist to find necessary data.

Current range data collection is done on a handheld GPS then recorded on a paper form. This method is typical and has been used for years on many projects. The paper copies of data are then transcribed into an Excel workbook and the GPS points are downloaded and transformed to shapefile. The range specialist then contacts the GIS specialist and passes on the updates using the Excel and shapefile documents.  The data is then entered into the Okanogan-Wenatchee geodatabase where it is accessible to everyone on the forest, and map and reporting products are created from there and from the Excel workbooks.  This workflow requires multiple data entry times – on paper, into Excel sheets, into

ArcMap.  At the end of each year, it is a rush to get all the data entered before the seasonal workers get laid off.   This time gap between field visits and reporting too often results in missed opportunities to quickly address problems and frequently, the permittee learns of the problems late in the winter when the season is already over.

## Purpose and objectives

In order to address these poor data management practices, this project will lay basic ground work for improving data organization and range data reporting on the Okanogan-Wenatchee NF.  Standardizing the system for the whole forest will assist in annual national reporting and allow specialists from other departments to refer to the range spatial data with ease and consistency. This objective can be broken into the following goals:

1) Create a geodatabase that complies with national standards.

    a) Incorporate the current data from all the districts

2) Develop a modernized workflow for field data collection and reporting

    a) AGOL (cloud-based storage)

    b) Easy to use platform

    c) Survey 123 form-driven data collection

## Project description/ methods/ application

### Geodatabase design

*"A data model is a blueprint of an information system (database)"* (Zeiler 1999)

The design is an important step in creating a geodatabase.  Since many of the tables and relationships are built on each other it is important to have the 'blueprint' to make sure that nothing gets left out and the project/data runs smoothly.  Three steps go into creating a geodatabase design and development: conceptual model, logical model and finally the implementation design. Conceptual modeling established the basis of who, how, and what data is already out there.  The logical model identifies the objects and subtypes then weaves a web of relationships and topological rules utilizing the smart capabilities of the geodatabase.   The implantation design establishes the schemas, data structure, standards, and mechanisms for the geodatabase. Each step helps to keep the data clean and consistent.

If the proper thought and time goes into the components during the design phase, the implementation and maintenance of the geodatabase become infinitely easier (Zeiler 1999).

*Conceptual model*

The conceptual model is the first step; it involves gathering all the existing data, establishing the roles for both the data and users and identifying the role and questions to be answered with this data. This process can take a long time but is important in order to fully understand the structure of the data, the requirements from the data and the organization of the users (Zeiler 1999).

An overview of a typical range season helps to better under the data needs and roles.

Starting in the spring season…Snow begins to melt, and the vegetation and warming temperatures slowly change the landscape from a muddy brown to a firm green pasture.

The Range specialist emerges from the local ranger district office to check on the allotments (Range Readiness Check and Fence line Condition)

Once the pasture is ready, the rancher pushes cattle from the lower valley pastures up into the highlands of the USFS allotment – where the season is short, and vegetation is rich, and the water runs clean

Occasionally the rye cow will find its way out of its designated pasture. This information is documented and reported back to the range specialist who in turn pass the information to the rancher who rounds them up and pushes them back into the pasture.

As the season progresses the range specialist returns to the field to check on the vegetation, condition of the pasture, and the water developments (Utilization, Stub Height, MIMs (riparian and upland) and WD surveys)

At the end of the season, as the leaves start to change, the cattle are pushed down the driveways to their winter homes.

As the snows begin to fly again, the range specialist retreats to the office where there is a stack of reports to write and annual meetings with the rancher to discuss the past season and make plans for the next.

Over the winter the range specialist works through the NEPA process for this year's set of allotments. This process includes many in depth parts including a capability and suitability analysis.

Knowing the flow of the season helps in the understanding of when and where different types of range data come from.

Within the flow of the season there are serval products (like reports and maps) that need to be generated along the way. Every allotment has a physical folder documenting the history of conditions, decisions, and correspondence - anything associated with that allotment. Since this is trusted standing procedure and much of the data collected in this work flow feeds into those folders, it is important that the data is translated into a physical paper format. Throughout the season there are several written reports including one for each monitoring type (Range Readiness, Utilization, MIMs). Furthermore, it is important to document the condition of range improvements in both written format and also displayed on maps for the Annual Operating Information (AOI) meetings. As the season progresses and range improvements (water developments and fences) are repaired or improved, it is also important to record those changes. Finally, all permits have a map indicating the location and type of range improvements for the allotment, which are signed by the district ranger and become a part of the permit.

Next a closer look at how the data is used and some of the end products.

1. Map products
    a. Signable maps for permits
    b. Annual Operating Information (AOI) maps for yearly planning and discussions
2. Reports
    a. Range readiness
    b. Mims/ utilizations

    c. Improvement condition

  3. Range improvement condition tracking

    a. Fence

    b. WD

  Applying the knowledge of where and how the data is used, the next task in creating the conceptual model is to logically group the data; this will help as we move through the design process. There are a variety of users who will be interacting with this data; range specialists, district rangers, the forest supervisor, other USFS specialists (i.e. Wildlife biologist or timber sale administrator), the GIS specialist, and the public.   Many of those utilizing the data may just need to have access to visualizations while others will be the main stewards since they will be continually editing and utilizing the data.

| User (need to know) | Existing data | Functions |
|---|---|---|
| Range specialist | **Fence (constructed features line) \*** <br> **Point range improvements (constructed features point) \*** <br> **Salt locations** <br> **Range readiness point** <br> **Utilization monitoring point** <br> **MIMs monitoring point (Upland)** <br> **Allotment boundaries\*** <br> **Pasture boundaries\*** <br> **Cattleguards\*** <br> Riparian MIMs (hydrology) <br> Upland MIMs (botany) <br> Gates (engineering) <br> Basedata <br> Forest planning suit and cap <br> Cow sightings (all) | Managing the range program <br><br> Monitoring compliance of permittees <br><br> Tracking range improvements |
| GIS specialist | **Static basedata (contour lines etc.)** <br> **Forest planning suit and cap** | Assisting in spatial data collection and maintenance |
| Other USFS specialists | **Riparian** MIMs **(hydrology)** <br> **Upland** MIMs **(botany)** <br> **Cattleguards (engineering)\*** <br> **Gates (engineering)\*** <br> **Cow sightings (all)** <br> **Editable basedata (roads, streams etc.)** <br> Fence\* <br> Point range improvements (wd)\* <br> Allotment boundaries\* <br> Pasture boundaries\* | Know where range improvements are on the landscape for planning purposes |
| District ranger/forest supervisor | Fence\* <br> Point range improvements (wd)\* <br> Range readiness point <br> Utilization monitoring point <br> Mims monitoring points <br> Allotment boundaries\* <br> Pasture boundaries\* | Approve permits <br><br> Field inquiries from public |
| Public | Allotment boundaries\* <br> Pasture boundaries\* | Nationally public facing data for general consumption |

\*indicate data that has national standards and is/can be synced with EDW.
**Bold** indicates that specialist who maintains/collects that data.

Table 1 Concept modeling: existing data, procurers, user groups and uses for the range program on Tonasket RD, Okanogan-Wenatchee NF.

At this point the data begins to fall into a few thematic groupings. First, since part of the data comes from a national standard, it has been grouped, which is represented by the individual feature layers –RMU (allotments), subRMU (pastures). The local data is not reported nationally and makes up the second category in the first level of thematic groupings. This category is the main focus of this project.

The local data is broken down into two main groups: improvements and monitoring.  The improvements grouping is mainly used when referencing permits and at annual meetings.  The USFS provides physical resources such as troughs, fence posts, and wire to the premittees for maintaining their improvements. These represent a physical investment and keeping track of those investments is a part of the range specialist's job.

The data collected in association with the monitoring group keeps track of the impacts on the natural environment, which also is an important responsibility of the range specialist position.  The monitoring data keeps track of several important details such as whether the rancher is following scheduled on and off dates and how much the cattle are eating.   This information helps determine the allowed number of cattle for each permit and whether those are sustainable numbers.  Yearly monitoring is important since things unforeseen changes can have a high impact on rangeland such as fire (eliminating or increasing forage), floods (keeping cattle from getting to meadows), or late snow-melt. Since cattle have a potential to have negative a impacts to resources such as streams, vegetation, recreational opportunities, it is important to have a strong monitoring system in place.   Breaking the data into groups informs the next steps in the design process, logical modeling.

## Logical modeling

*"The key task  in building a logical data model is to precisely define the set of objects of interest and to identify the relationships between them"* (Zeiler 1999).

For the finest level of grouping being used for this database, subtypes will be used. Subtypes are categories within a feature layer designated in the geodatabase schema.  For example, in this range geodatabase, the feature service 'monitoring points' is broken into four subtypes: Utilization, Stubble Height, Range Readiness, and MIMs points.   Each subtype can have unique dropdown menus, default values, relationships and topology rules (Environment System Research Institute (ESRI), n.d.).   Each of these feature layers in the local thematic group are broken into subtypes, as shown in the table below.

| Feature Layer | Subtype |
|---|---|
| Fence (cf_ln) | Interior Allotment Fence |
|  | Allotment Boundary Fence |
| Range | Cattleguards |

| Improvements | |
|---|---|
| | Gates |
| | Water Developments |
| Monitoring Points | Stubble Height |
| | Utilization Monitoring |
| | Range Readiness |
| | MIMs |
| Range Lines | Cattle Driveways |
| Range Points | Salt Locations |
| | Cow Sightings |

Table 2 Subtypes Layers in the Range geodatabase are broken down into subtypes for better organization

## Relationships

Relationships are an integral part of any database and make them powerful tools in data management.  They can be established between two features, a feature and an object or between two objects as a one to many, one to one, and many to many relationships. The type of relationship depends on the needs of the data. Relationships make it possible for a single sample point to be connected to a table with years of sampling data without resorting each point having a point in the same place each year. Creating a parent child type connection – when the point is the parent and each sample year is a child.

The following relationships are used in the range geodatabase:

1. Allotment – one to many – pastures

2. Permittee – one to many – pasture

3. Permittee – one to many - fence, range points, range lines, constructed features

4. Monitoring point – one to many – yearly monitoring data table

5. Fence conditions point – many to one – fence line

## Topologies

Topologies are the spatial rules of the database; it defines the where and how things can be laid out.  For example, if a line must stop at an intersection or if the edges of a polygon must mirror the edge of another polygon.  Topologies can aid in reducing the number of spatial errors in a dataset. For the range dataset there are few spatial regulations and therefore only a few topology rules and mainly

concerning the allotment and pasture layers. Since the data resides in the same database as the other Okanogan-Wenatchee spatial data, there can be topological rules that interact with roads, forest service boundaries and other forest level data.

The following topology rules are used in the range geodatabase -

1. Allotment/pasture boundaries (RMU and subRMU)
    a. Must not overlap themselves
    b. Pastures must be within allotments
    c. Both must be within forest administrative boundary
    d. Must not have gaps
    e. (pasture) must be covered by feature class of (allotment)
2. Fence (cf_ln)
    a. Must not self-overlap
    b. Must not self-intersect
    c. Must be a single part
3. Range developments (cf_pt)
    a. (cattleguards) must intersect with (fence)
    b. (cattleguards) must intersect with (road)
    c. (gate) must intersect with (fence)

*Implementation design*

Up to this point, the design and development have focused on the geodatabase; as the process moves into implementation, the data collection process relies (*focuses)* specifically on ArcGIS Online (AGOL).  The elements developed during the conceptual and logical modeling provide the base for all the AGOL feature services and tools.  Each object's logical modeling yields a one to one exchange between the AGOL feature services and the geodatabase.  The subtypes, relationships and topology rules are unique to the geodatabase and are essential in keeping a clean dataset; that is why the process was based on the development of the geodatabase and not the AGOL feature service.

There are two parts to the implementation design (A) the development of the necessary tools, and (B) the use of these tools.  The development and maintenance of the system is done by the GIS specialist and the remainder of the workflow is carried out by the range staff.

Finally, after conceptually laying the building blocks for the geodatabase it's time to get to work. The implementation design is simply the workflow of how to create and maintain the designed geodatabase.  The following 9 steps describer the set up of the database, data collection methods, necessary maintenance, and the process for producing reports and maps with the new data.

*Step 1: Build Surveys*

The surveys were built using the ESRI desktop applications Survey123 and the editing app Survey123 Connect.  Survey123 is a form-based data entry format so it more closely resembles the traditional paper format than other apps like Collector or S1.  Survey123 was a good choice of tools since most of the data collected in the field was attributes and the actual geographic location was less important.  Suvey123 utilizes XLSForms to drive the form interface. By using Survey123 Connect, the survey author can manipulate most aspects of the survey.  XLSForms forms are smart, meaning they can have answer dependent questions(Institute Environmental Systems Research Inc. (ESRI) 2018). For example, pasture are a sub section of an allotment, so when an allotment is selected on the form only those pastures associated with that allotment are displayed for selection.   Each survey and additional details on design for this project can be found in Appendix A.

*Step 2: Build AGOL Feature Service*

Once refined and double checked, each survey is published which creates an individual feature service directly related to that survey.  For ease of syncing the data back to the geodatabase, all the AGOL layers need to be in a single feature service.  To do this, each survey feature service is downloaded as a file geodatabase and merged to create one geodatabase with all the survey data.
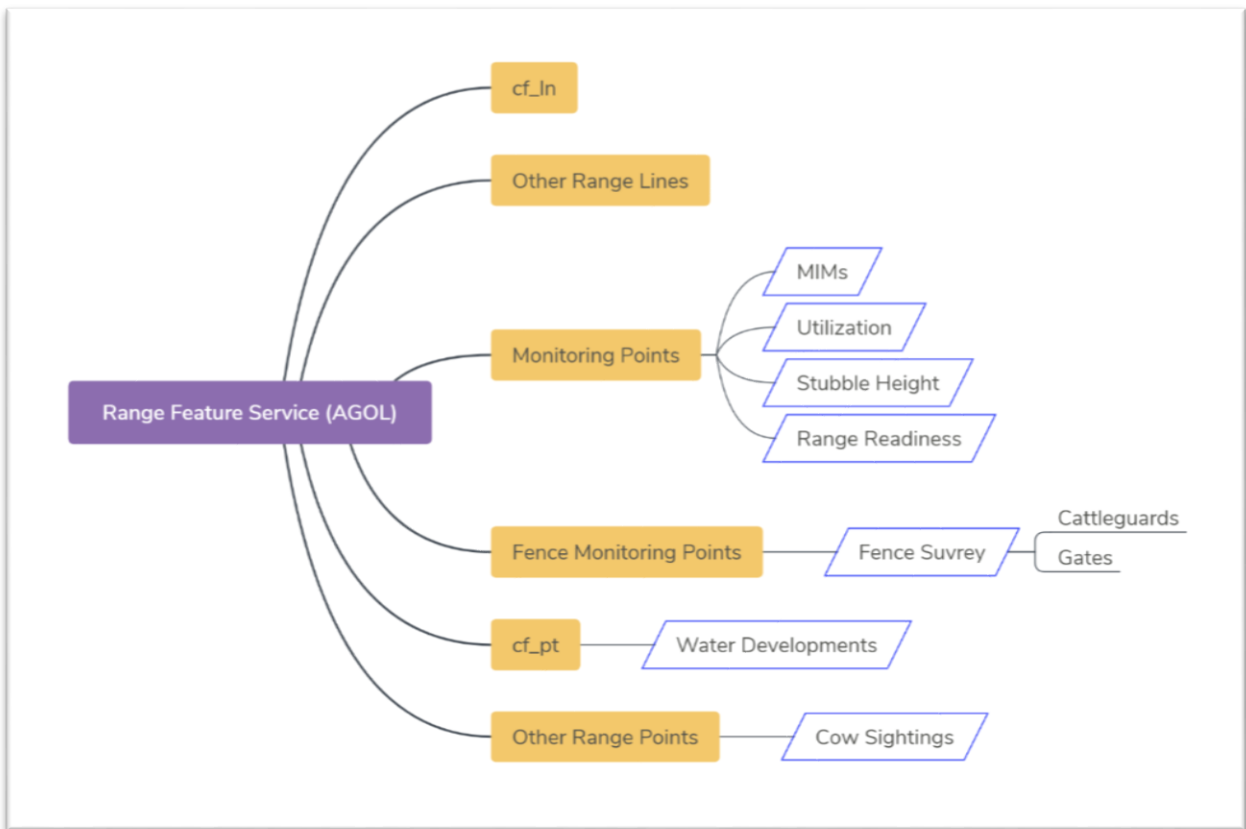
Figure 1 Feature service is broken down into layers which are symbolized and utilized in web mapping applications.

*Step 3: Build Range Geodatabase*

The next step is to build the schema, domains, relationships, and topologies laid out in the logical model. All of the range data is built into the range feature group within the Okanogan-Wenatchee geodatabase. Once the schema is built, it's ready to receive the existing data from the current shapefiles.
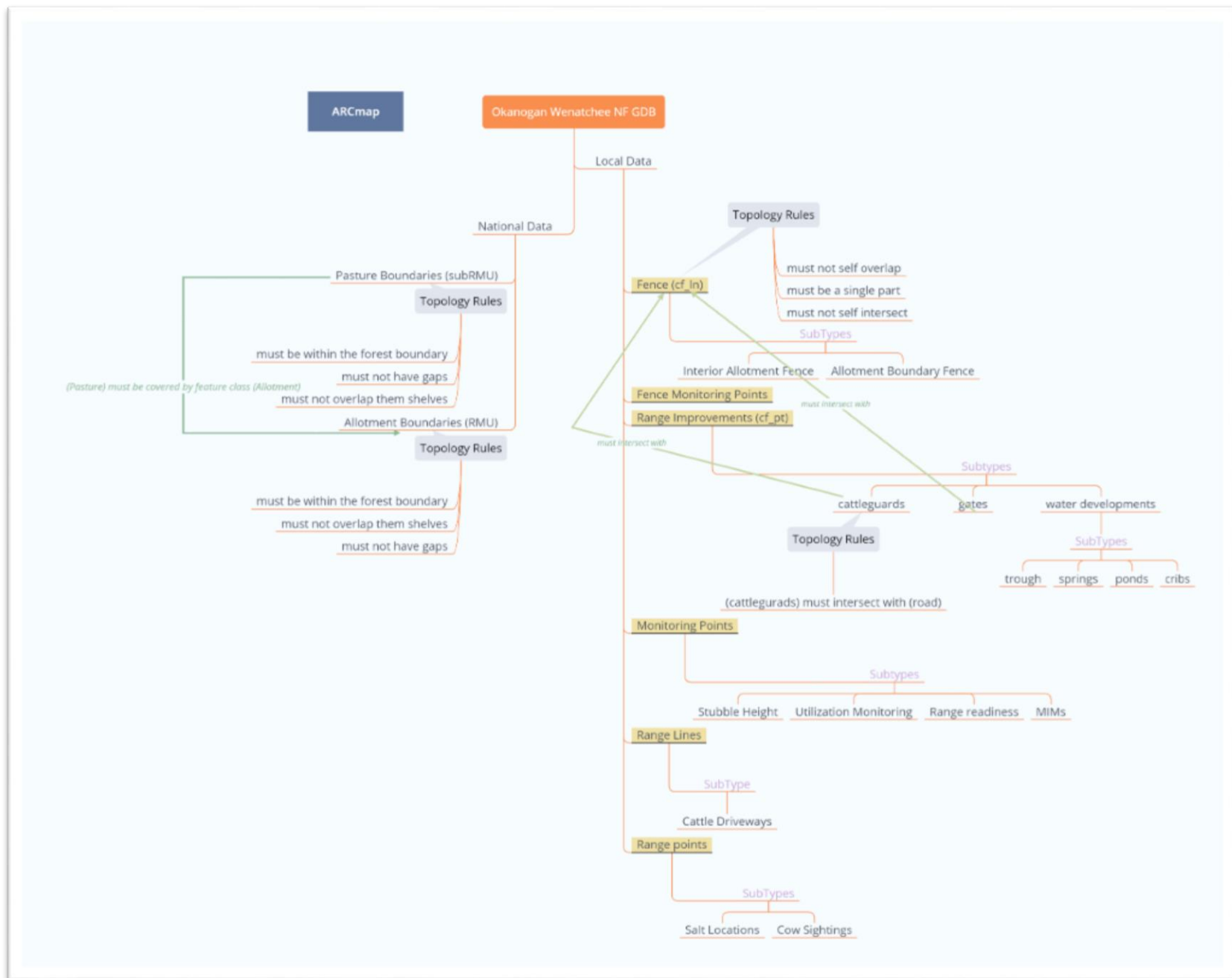
Figure 2 Database model - representation of the relational aspects of the range proportion of the Okanogan-Wenatchee SDE geodatabase.

*Step 4: Publish Range AGOL Feature Service*

Now that all the data is in the same place and the schema has be verified, the next step is to publish the Range feature service based on an edit version of the Okanogan-Wenatchee geodatabase. This feature service will be from here on out be the working feature service and will contain all the local range data for the Okanagan-Wenatchee NF. In the AGOL environment, the ability to interact with data sets (view or edit) is dependent on the permissions given to groups and individuals. The Okanogan-Wenatchee NF Internal group has viewing permissions but not editing capabilities for this feature service. The Okanogan-Wenatchee NF Range group has editing and view capabilities. This protects the data from being edited by those outside of the range working group but still allows users throughout the forest to see the range spatial data. If individuals outside these two groups needs access; it can be granted on an induvial basis.

All of the data in AGOL has layers / symbology built in and it carries between platforms. So, whether the data is viewed on a web map or in Collector all the symbols are the same. Any user can change the symbology on their own maps without affecting the master feature layer.

*Step 5: Edit the Submission URL*

Once the feature service is published, the original surveys created in step one need to be pointed to the correct feature service, otherwise they will still be looking at their independent feature services and any data collected will not be added to the range feature layers.

Each feature service has a unique URL from there each layer has a unique name for example the feature service is called "R06_OKW_Range_SurveyData"; the feature service is broken down in to 8 feature services one of which is "RangeMonitoringPoints". So, all the data collected from the "Utilization" survey will feed in to the "Monitoring Points" feature service but so will all the data from the "Range Readiness" survey. Each survey only updates those attributes found with in the survey and leave the others blank. Each feature layer is also made up a different subtype, such as monitoring points which has four different surveys that feed into it. The survey will only update the attributes that are present in that survey, so the Utilization Survey only fills in the attributes for the Utilization relevant attributes and leaves the other

attributes as "null'. This makes it possible for there to be several surveys feeding into a single feature layer.

*Step 6: Data collection*

A few things need to be set up in advance for this new workflow. This all depends on having tablets with tablets with Global Position System (GPS) and Wi-Fi capabilities. Before going out into the field Survey123 and Collector/S1 apps need to be download on to the tablets. Then Collector or S1 need the range map downloaded and Survey123 with all the range survey downloaded. Crew members also need their own AGOL login. Having unique accounts allows all edits to track and, should an inconstancy or question arise, it is possible to contact the person who collected the data for clarification.

In the field all line and polygon features are collected with Collector or S1, while all point features are collected using Survey123 on the tablet. All apps can be used simultaneously, so in the field a tech can collect a cow sighting while walking a cattle driveway or fence survey points and a fence line – all at the same time.

After collecting data in the field and reconnected to Wi-Fi, each tablet must be synced back to AGOL server. This pulls the data off the tablet and brings edits from all the other users on to the tablet - no tricky shapefile transformations or in-office data entry. At this point, all the synced data is available for use via the AGOL server; it can be accessed via the apps on the tablet, via a web browser using the web maps or web apps, or via a GIS server in ArcMap. Each of these options requires an AGOL login and designated permissions, which is a smaller scope of people than the intended end-user group for the data.

*Step 7: User friendly editing*

In the AGOL web environment, the range techs can edit any data collected in the field. Sometimes it's easier to type things out on a keyboard or make sure all the boxes are checked when the sun isn't causing weird reflections on your tablet screen. Using the range feature service and web map, a specific range data editing web creates an easy-to-use interface for editing and basic analysis. Within the web app there are widgets that help the range staff quickly navigate all the range data. Snapshots of the web editing app can be seen in Appendix B: AGOL Interface. Editing in ArcMap requires a skill set that not

everyone has. Range specialists with little to no knowledge of how to use ArcMap have successfully used the web map interface. This allows for timely edits without waiting for the GIS specialist, and data can be corrected when it is still fresh in the mind of the collector. Editing can also happen from any web browser with an AGOL account login.

*Step 8: Connecting AGOL feature service with SDE*

All the spatial data at the forest level has quality control checks; these are standardized and built into the Okanogan-Wenatchee geodatabase. The geodatabase is the end location that the range data needs to be for connecting to the national reporting. This step is getting the data from the AGOL feature service to the Okanagan-Wenatchee geodatabase. The entire USFS houses its GIS data in an SDE geodatabase; all edits are done through versioning to protect and keep the data clean. ESRI hasn't developed a tool for this unique and semi obscure situation but they have published a work around using a python script. As data is collected in the field, it syncs back to the AGOL feature service which is then synced back with the versioned GDB -via a python script. After running the script, the versioned database can then be reconciled and posted – going through the USFS quality control checks. And the data will be available to the forest in the same format as the rest of the spatial data on the forest. The national data (RMU and subRMU) are a part of a public facing dataset maintained by the national AGOL administrator and can only be referenced by all other users. So that data is not updated using this workflow.

*Step 9: Products*

Once the data has been collected and synced back to the AGOL server and to the Okanogan-Wenatchee geodatabase, it can now be distributed to the whole user base, in the fore of several type of products.

*Step 9.1: Survey123 Reports Word document reports*

On the web platform for Survey123, ESRI has developed a beta report function. This allows the user to create reports based on submitted surveys. Since it's in beta, there are still some bugs being worked out, but this is a great way to produce standardized, timely, easy-to-use reports. Much of the everyday business and data storage on the forest is still done in hard copy format, but this function provides a good transition and record keeping work flow for range staff and permittees.

The Suvey123 reports are based on a Microsoft Word template using ESRI's Arcade expressions (Environment System Research Institute (ESRI) 2018a). Each report is based on a single survey (multiple survey reporting is in development) and can be comprised of any combination of the answers to the survey questions, feature service attributes, map representations of points, and photos(Environment System Research Institute (ESRI) 2018b). Examples of the templates and resulting reports can be seen in Appendix C: Survey Reports

*Step 9.2: Static Map Creation*

Like the range editing web app described earlier, a similar web app with summary widgets is created so all the data collected can be easily shared and understood by forest service staff. There are many different reasons to reference the range data. For the timber staff it is important to know where improvements are located to protect them during logging operations. For hydrologist it's important to know the utilization near streams to ensure they are being protected. The district ranger needs to know the big picture on the district as a whole. For these perspectives, a non-editing web app can be created so a quick look can give the summary that they are seeking. From there they can also create a pdf printout for sharing and referencing with other staff, the permittee or others outside the US Forest Service. The advantage of putting time into these web apps lays in the ability of each staff member to access current data tailored to their specialty, independently and from anywhere with an internet browser. The Okanagan-Wenatchee forest is xxx million acres and the drive-times can be daylong affairs and coordinating schedules can be a difficult task, so having the ability to access the needed information at any time is both an asset and an efficient tool, beyond just the range staff.

Step 9.3: Range feature layers

Data can often be hard to find, especially if it is stored in numerous geodatabases. Across the Forest Service agency as well as the Okanogan-Wenatchee NF, GIS data is organized into a set of layers for each of the departments in the Forest Service. In order to standardized symbology across USFS maps and to provide easy access, the range data is also organized into layer files for the SED database. Standardization of symbology allows for quick recognition of features and prevents the stalling of the discussion when referencing a map. In the Okanogan-Wenatchee SED geodatabase, each feature layer

with standardized symbology, labels and query are laid out in the figure below. All the monitoring points are symbolized to highlight what measurement they represent.  The Utilization points are color coded by high, med, low usage and labeled with the percent utilization.  Each of the range improvement subtypes have a unique symbol and are color coded by condition and labeled with the name of the feature and/or the permittee's last name as well as who has the maintenance responsibly.
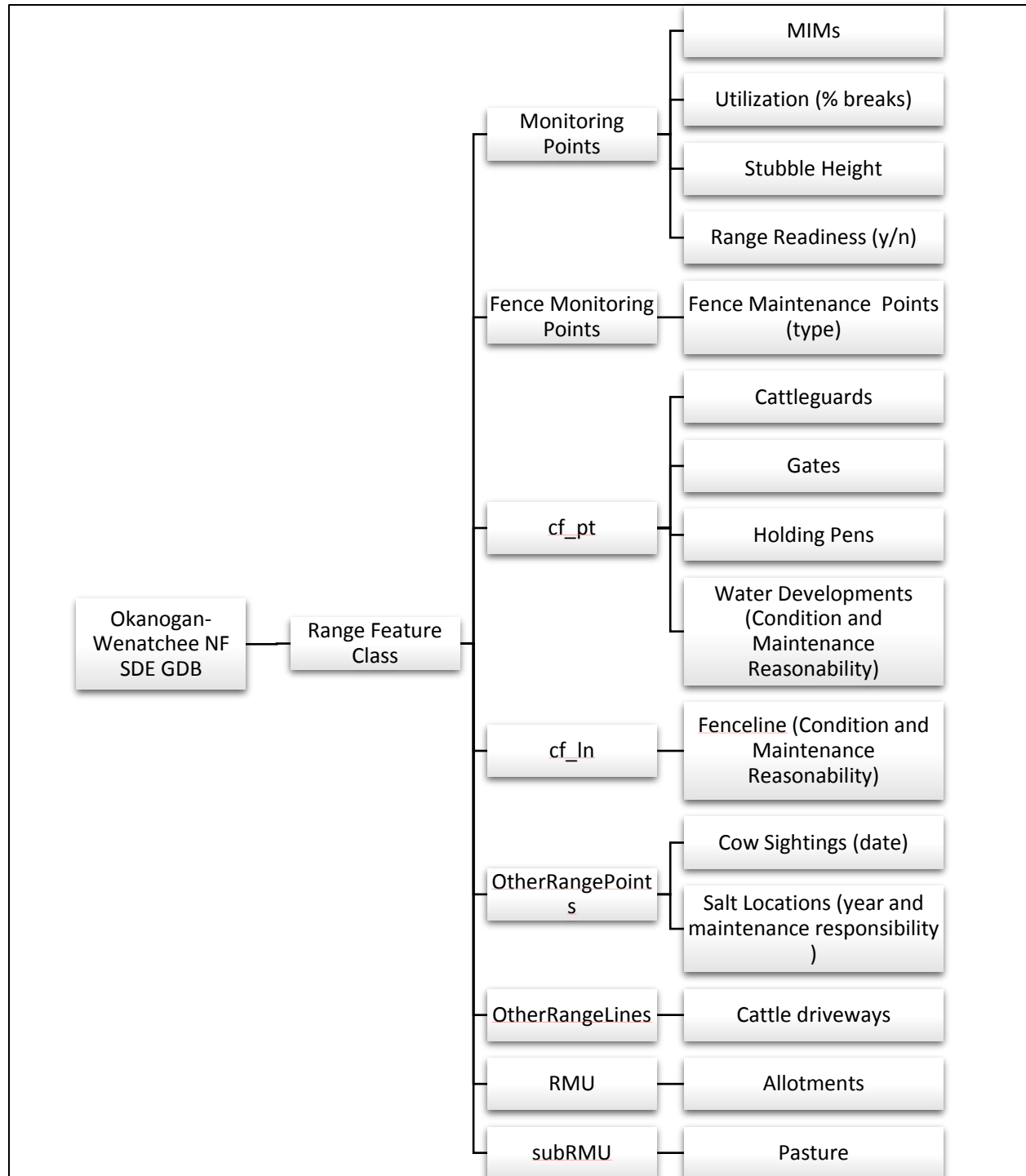
Figure 3 Shows the established feature services. This helps keep standardized symbology, find range data, and single out specific data points (ex. salt lick locations)

Discussion/conclusions

The creation of a more consistent and efficient data collecting and organizing workflow is bringing the range department into the 21$^{st}$ century by transitioning away from paper datasheets and hand-held GPS units.  These have been the long-standing methodologies - tried, tested, and true.  New technology like tablets have a little bit of learning curve and are bound to have some bumps and hiccups along the way, but perseverance and an open mind will lead to advances in accuracy and efficiency.  Setbacks are hard to accept when workloads and stakes are high.  In the Spring of 2018, the Tonasket Ranger District range staff was trained on early season data collection on the tablets as a pilot program before going to the whole forest.  Early on there were some tweaks that we made to the surveys to ensure the correct data was being collected and for ease of use.  After the training, and over the next couple of weeks, a few technical issues were resolved, and the range staff was able to collect a limited amount of data but paired with a big fire season; insufficient time was available for further training.   A few major blows this season resulted in limited data collection but many great learning opportunities.  First the range department was understaffed, they had openings for three seasonal technicians but were only able to fill one; two emergency hires were brought on for a few months, but overall, for the season they were short people to be in the field collecting data.  The emergency hires were not able to attend the training in the spring. Next about a month into the season, one of the tablets got smashed and was rendered incapable of collecting data. Most of these setbacks occurred in the early part of the season, we might have still been able to have a successful data collecting season. Ultimately, they conducted surveys using the tried and true paper and handheld GPS method.  That not only affected data collection, but also, without the tablet data collection for the season, the reporting and syncing features could not be evaluated. Most of the examples in this write up are based on the test collected.

Data collection and reporting are not the only aspects to this part of the project. The transition from scatter and disorganized shapefiles to a group of layer files in the Okanogan-Wenatchee geodatabase was successful. Getting to know the data and laying out a design ahead of time ensured that each data type had a place to go.  The associated layer files are being used across departments; some changes are made.   One of the major changes that was implemented was that most of the other departments don't need the maintenance responsibility indicated on their maps, this seems to only be

28

relevant to the range department.  In response, a second set of layers was created for 'general use' and the range maintenance layer are also available but only seem to be relevant on range maps.  Templates for signable permit maps and Annual Operating Information (AOI) maps have both been developed and make generating maps for these purposes much easier than searching through folders.  Another aspect that is nice, is when creating a map that crosses district boundaries all the data comes from one location and you can be confident that you are getting an overall view of the whole landscape not just what's within that particular allotment/pasture.

## Chapter 2: Suit and cap and stocking

### Introduction

Standardization of management practices prevents bias towards a discipline or use; the USFS uses standard operating procedures and established definitions as guidelines. In the Range Program, the base of operations is the management of livestock (mostly cattle)- where they can go and how much they eat.  The biggest impacts, ecologically and economically, a range specialist can have is in determining the number of cattle per allotment.  *Capability* and *suitability* of the land for livestock are set during forest planning, which was last passed on the Okanogan-Wenatchee NF in the 1980 before the forests were joined. The capacity analysis done during the NEPA process is one tool of many used to inform the range specialists in their decision. However, it does not bind them to the calculated stocking capacities nor does it change the official calculations in the Forest Plan.  The NEPA process gives the opportunity to revisit and refine these analyses; it provides better calculations/information so the range specialist can make the best decision possible.   The livestock grazing permit system was in existence prior to NEPA (National Environmental Policy Act), and the permits were grandfather in.  In 1995, with the Range Recommences Act, Congress mandated that all permits must be processed through NEPA and gave a timeline for when each allotment needed to be done.

### Problem statement

According to the current timeline laid out by the Range Reconnencens Act for the Okanogan-Wenatchee NF there are 9 allotments that will go through the NEPA process by 2022 and one more by 2025 (Service 2017).  With this ruling, over the next few years there will be an extensive amount of this

type analysis; the capability and suitability values will need to be calculated for each allotment. The current capability and suitability layers created for the Forest Plan are too broad. Finer analysis is needed to make a fully informed decision.

## Purpose and objectives

The purpose of this portion of the project is to create a standardized model for calculating the suitability, capability, and stocking rates for AMPs on the Okanogan-Wenatchee NF.  With this new model, each analysis can be adapted to local knowledge from the range staff and IDT (Interdisciplinary Team) members of the focus allotments.

## Project description/ methods/ application

### Study Area: Toats Coulee

The study area for the project are the allotments included in the Toats Coulee Environmental Analysis on the Tonasket RD.  The allotments have been grouped together because they are all scheduled for NEPA analysis by 2019 and are close together.  They include the Deadhorse, Goodenough, Toats Coulee, and Goodenough allotments (Service 2017).

These allotments are the most northern allotments–touching the Canadian border on the west side of the Tonasket Ranger District.  To the east of the focal allotments is mostly state-owned land but there are small sections of private land as well. To the west is all USFS land, which falls under the jurisdiction of neighboring Methow Valley Ranger District, and along the northwestern part is the eastern edge of the Paysaten Wilderness.  The project area is sandwiched within a large section of public lands.

Throughout the study area there is relatively low recreation activity with few trailheads and campgrounds.  The main draw is the solitude that this area provides.

The higher country is made up of Lodge Pole Pine, Subalpine Fir, Engelmann Spruce which fades into Douglas Fir with Ponderosa Pine.   Wet seeps and meadow are commonly found in this area providing water and rich vegetative biodiversity. Logging and fire have both played a role in shaping the ecosystem.  "Remnant Douglas-fir can be found scattered on the south slopes of this area.  Some of these remnants are very large (up to 72" DBH) and up to 500 years old." (Schellhaas et al. 2001).

Historically both cattle and sheep have been grazed on these allotments; currently there are only permits for cattle.

## Model builder

A model or analysis sounds bold and significant and a little bit intimidating.  In this age of big data, they are used everywhere from determining product placement in the store to predicting the amount of rainfall next week.   Every model or analysis is just a math problem describing, to the best of our knowledge, what is happening based on what we have observed in the past.  Each one can be broken down into simple understandable equations and tidbits of knowledge.  The same can be done with spatial models. Model builder is an ESRI feature built into ArcMap and ArcPro which can help with the process. Instead of small math equations, in a spatial model there are series of geoprocessing tools linked together to create a model (Environment System Research Institute (ESRI) 2017).  Each model in this project breaks down the given definitions of capability and suitability into a spatial definition and then translates that into layers and geoprocesses. These are strung together in Model Builder and then can be used to create a user-friendly tool for running that model.  By using model builder like this, each capability and suitability analysis for each allotment is standardized and manipulatable.

In this project, the range analysis is broken into three different models; the break down allows the model to run in a timely manner. When grouping numerous processes, the larger the model the long it takes to run.  Breaking it apart also helps narrow down problems when trouble shooting.

## Model One: Collect data

The first section in this work flow begins by pulling the standardized data needed for the Okanogan-Wenatchee NF, which comes from several geodatabases on the national, forest, and local levels.  Each layer is clipped to the focus allotments and put into a file geodatabase.   This step is dependent on what goes into the following steps, there is a little bit of reverse engineering. There are a couple of reasons to do this step in a model first: to make sure everything required is there and to ensure that naming conventions are standardized for use in the next steps.  Also by pulling all the data into a single database, it creates a snap shot and a record of what data was used to make the determinations – this is useful because some of the original data sources are dynamic and could change before the end product is

produced and definitely will change before the lengthy NEPA process is complete. Having a static copy of the data is also useful with litigation processes, to verify the data that decision were based on.

1. The first part of the model lays the ground work for the project, creating a file geodatabase to work off and use a snap shot of the data used for the analysis.
    a. Input = name of the EA
    b. Input = location of the gdb/ project folder
2. Next the allotments for the analysis are selected and the project area layer is created.
    a. Input = the names of the allotments
3. There are three SDE database that hold the necessary data – EDW, R06 and OKW.  This step takes up the bulk of the model – clipping and pulling all that data into the geodatabase.
    a. Each of these databases have standardized naming conventions and data types
    b. This part of the model would have to be adapted if this was used on another forest but should need the least amount of change for forests in Region 06 because each of the forests have similar gdb organization and naming conventions.
    c. All of the vector data is clipped and the raster data is extracted by mask.
        i. The slope is calculated from the DEM model in this step as well since the slope is the needed model variable.

Once built the model can be run from model builder or as a tool.  The tool interface makes the process more accessible to everyone.

Figure 4 Data Collection Model: Model builders uses shapes and colors to represent the geoprocesses in a model. This figure show the first model - collecting and organizing the data.

*Capability: The potential of an area of land to produce resources, supply goods and services, and allow resource uses under an assumed set of management practices and at a given level of management intensity. Capability depends upon current resource conditions and site conditions such as climate, slope, landform, soils, and geology, as well as the application of management practices, such as silviculture or protection from fire, insects, and disease.* (36 CFR 219.3 and FSM 1905)

Capability looks at in the physical characteristics of the landscape prior to any management actions. Each element is selected for non-capability areas/parameters, merged together and then erased from the project area to get a polygon feature layer with just the capability polygons.

As each layer is created for each of the parameters, a new field is added to the layer and the acers are calculate, summed and added to the Capability Table. The USFS has given direction regarding what should be considered capable and suitable grazing areas. Each step is a description of physical characteristics. The first step is to identify the corresponding spatial layers and geoprocesses to fulfill each description as laid out in the table below. The next step is to build the model.

*Capability Parameters*

| Parameter | Value | Method | Layer |
|---|---|---|---|
| **Rocky outcrop** | Values for rocky outcrop | Select rocky areas and cover to raster | Soil |
| **Soil communities that at site potential inherently produce <200 lbs/acre** | produces less than 200 lbs/ac | Reclassify the raster | Soil |
| **Lakes, reservoirs, and ponds** | Waterbodies: glaciers, ponds, lakes etc | | Water bodies |
| **Major Rivers and Perennial Streams** | 3 ft Buffer for major rivers/perennial stream | Buffer the streams, convert to raster | NHD Streams |
| **Road beds (not restored/revegetated)** | 8 ft Buffer | Buffer the roads, convert to raster | USFS Roads |

| Slopes greater than 60% (not capable cattle) | >60% slope | Create a slope raster with the DEM 10m data; reclassify the slope raster | DEM slope conversion |
|---|---|---|---|
| Slopes between 41-60% (secondary grazing) | 40-60% slope | | DEM slope conversion |
| Optional: areas w/out drinking water capability | 1-mile buffer around water developments | buffer water developments convert to raster | Constructed features – water development subtype |

Table 3 Each parameter in the definition of 'suitabity' is broken down into parameters within a spatial layer, this table idenifis those layers and the cooresponsing paratmeters.

Next each step is built into the model. Below each outlined description/step is listed and corresponding model component is described. All newly created layers are saved in the project geodatabase.

1. Begin with all lands within the project area that are National Forest System (NFS) lands.

   For each analysis the NFS lands are the area within the focal allotment(s). The allotments are a manual input from the user, which is then selected and used to create the ProjectArea layer.

2. Subtract soil types that are dominated by a large percentage of rock outcrop and rubbleland, loose granitic or highly erosive soils, very wet and boggy soils, and sites with high mass movement risk. Optional - to identify erosive areas, a geologic layer to identify active landslides, slumps, etc. may be used.

   The Okanongan-Wenatchee NF is fortunate to have a complete, detailed soil layer which is distributed by the USGS. The attributes for the soil polygons layer have a soil type and foraging potential. For this step, the 'Rocky Outcrop' polygons were selected and exported to the project geodatabase to create the Project_RockySoils layer.

3. Subtract soil types that are not inherently capable of producing more than 200 pounds of forage/acre within their Potential Natural Community (such as badland outcrops, nutrient-poor soils, shallow soils, or alkali salt flats). If a figure other than the "200 pounds per acre" is used, document the rationale.

   The soil types are based on the percent composition of several soil characteristics, each of the

soil characteristics are assigned a potentail foraging production value.  The potential foraging

value for the soil types was calcuated based on the percent composition times the production

value and then added together for each soil type.  [(percent composition for A /100)*(foraging

production value for A) +[(percent composition for B /100)*(foraging production value for B) =

production value for soil type]

The table of caclculated production values for the soil types were then joined to the copy of the

Soil Layer in the Range spatial data folder (on the Tdrive) for future use and refence.

Within the model, the soil types with greater than 200lb production rates were selected and

copied to the project geodatabase to create the Project_Soils200lbs layer.

4.  Subtract areas that consist of lakes, reservoirs, or ponds, e.g. the area covered by water at the

    high water mark.

This step is represented by the Project_Waterbodies layer without any further mainipulation.

This layer also includes the area covered by the wide areas of the major rivers.

5.  Buffer major rivers by the actual width (averaged for individual reaches if need be) and subtract.

The actual width of all the major rivers on the Okanogan-Wenatchee NF are included in the

waterbodies layers.  The major rivers layer does not have an 'actual width' and those areas

covered by a singificant area of water are included in the waterbodies layer utlized in step 4.

6.  Buffer perennial streams by the actual width of the water surface at the mean high water mark, or

    use an average width of 3 feet on either side of center line and subtract.  The 6-foot width for

    perennial streams represents an average width for a stream's water surface and can be used as

    a Unit-wide average for purposes of modeling.

Perennial streams are selected from the Project_Stream layer and buffered using a 3ft buffer (for

a total width of 6ft) in the 'buffer' geoporocessing tool.  This creates the Project_Streams_3ft

layer.

7. Buffer National Forest system roads by 8 feet on either side of center line and subtract.  The 16-foot width for roads represents an <u>average</u> width for a road's surface and can be used as a Unit-wide average for purposes of modeling. The road surface is not considered to be capable unless the road surface has been obliterated and revegetated in which case, the road surface will remain within the capable land base.

All roads except the "Decommisoned" roads are selected and buffered by 8 ft to create the Project_RoadBed layer.

8. Subtract slopes meeting the following criteria:

   a. Subtract slopes greater than 60% (not capable for either sheep or cattle).  Keep track of capable acres for cattle and sheep separately (may also need to track separately for other kinds and classes of livestock such as bison, if the need presents). The 60% figure can be modified for each specific Forest or Geographic area to fit with local situations (with documented rationale).

   From the Project_Slope layer the raster is reclassified with the 100-60 slopes identified as '1' and all other values as '0'.  The new raster is then converted to a single feature polygon (Project_Slope_60).

   b. From the above (a) capability calculations, subtract slopes greater than 40% (slopes of 41-60% are capable for sheep but not normally for cattle). The 40% figure can be modified for each specific Forest or Geographic area to fit with local situations (with documented rationale).

   For the local analysis this is considered 'secondary' cattle grazing.  The model is written to include the acres table, but it is not included in the overall total for capable habitat and is not included in the suitablity rangeland.  The 40-60% slope range is relatively small when looking at the total acres for an allotment.

   From the Project_Slope layer the raster is reclassified with the 40-60 slopes identified as

'1' and all other values as '0'.  The new raster is then converted to a single feature polygon: secondary grazing.

9. Optional:  subtract areas that lack available water, or lack the potential to develop water, within approximately 3 miles of the center of the polygon for Grasslands or one mile in mountainous rangelands. This figure can be modified for each specific Forest or Geographic area to fit with local situations (with documented rationale).

The water developments are selected from the range points layer and buffered by 1 mile for mountainous rangelands.  This layer is then merged with the waterbodies and stream buffer layers to create a layer where there is readily avaliable water.  The layer is also excluded from the capablity rangeland calculation, but is instead used for base as a tool to determine where the establishement of potential water development sites can have the highest impact and expand the area which cattle are utilizing.

10. The remaining area is **Capable Rangeland.**  The capable rangeland may be displayed as two separate map displays and acreage tables: one map/acreage table set displays capable polygons/acreage for cattle; and, a second set displays capable polygons/acreage for sheep if appropriate. Other displays may be used for other kinds of animals as needed.

Once all the non-capabale layers have been created they are merged and dissolved to create the Project_Noncapable layer.  The 'Erase' tool is used to subtract the non-capable areas from the project area and create the Project_Capable land.  This and the Project_Seconday layers can be used for map making and for calcuating capable rangeland acres. At the end of each step, the acres are calculated and put into a table for easy reference and to fulfil the guidelines for the NEPA write-up for this type of analysis.
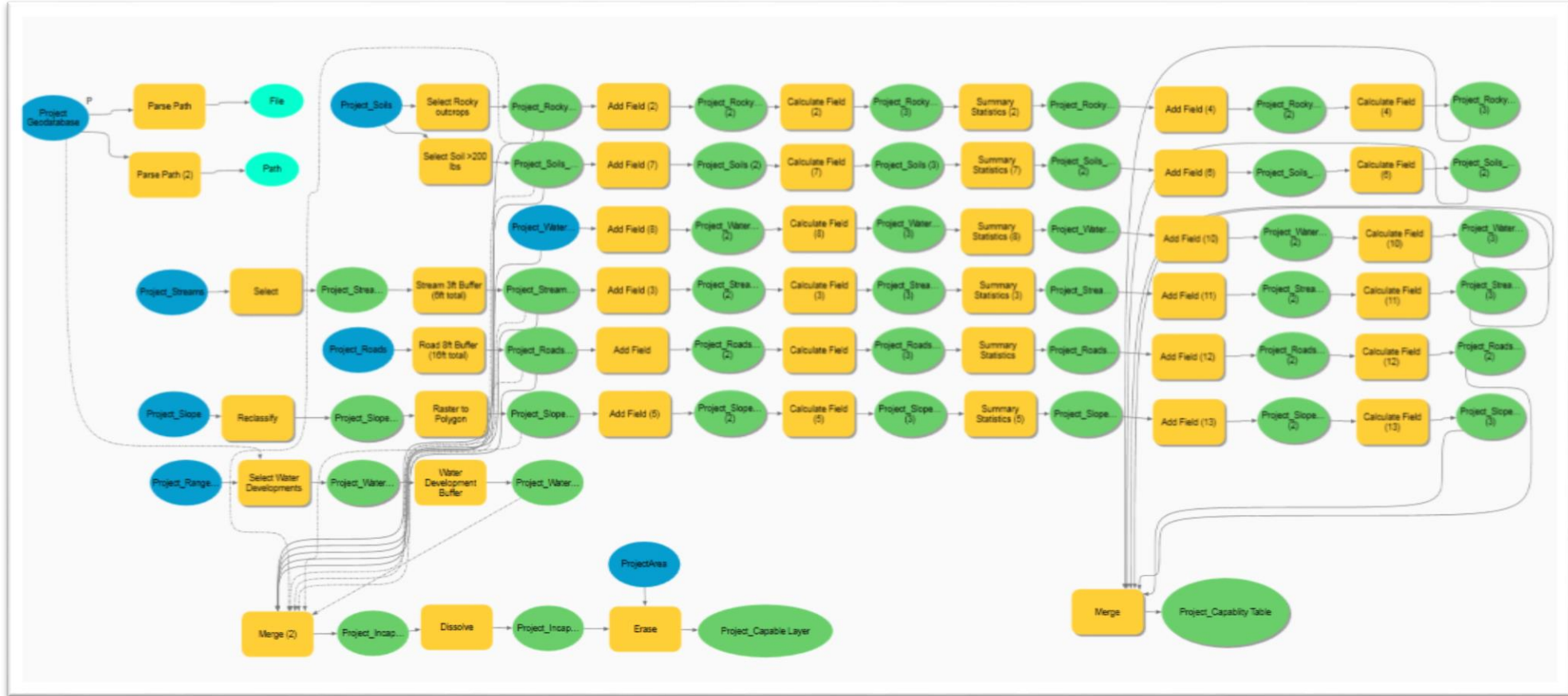
Figure 5 Capability Model Capability Model: A snap shot of the Model Builder interactive face for the Capability Analysis. Layers are represented by ovals and the geoprocessing tools are rectangles. All connections (ie inputs/outputs) are represented by directional arrows.

39

*Capability Results*

| Parameter | Acres Deducted | Running Totals |
|---|---|---|
| Net National Forest System Acres | | |
|     Deductions for Other Than Capable Acres | | |
|     Rock outcrop | | |
|     Soil communities that at site potential inherently produce <200 lbs/acre. | | |
|     Lakes, reservoirs, and ponds | | |
|     Major Rivers and Perennial Streams | | |
|     Road beds (not restored/revegetated) | | |
|     Slopes greater than 60% | | |
|        Slopes between 41-60% (not capable cattle) | | |
|     Optional: areas w/out drinking water capability | | |
| Total capable including secondary cattle grazing | | |
| Total capable for primary cattle grazing | | |

Table 4 This table respresents what would be the end resutls presended in table format for the capablity model. The table would be included in the body of the NEPA wirte up.

## Model Three: Suitability

The next part is to look at management actions and current conditions, this defines the suitable

rangeland.

*Suitability: The appropriateness of applying certain resource management practices to a particular area*

*of land, as determined by an analysis of the economic and environmental consequences and the*

*alternative uses forgone. A unit of land may be suitable for a variety of individual or combined*

*management practices*. (36 CFR 219.3 and FSM 1905)

Suitability Parameters

| Parameter | Value | Method | Notes |
|---|---|---|---|
| **Existing canopy cover >70%** | > 70% canopy cover | Convert to polygons and select | |
| **Management Actions (MA) prescription does not provide for grazing (ex: some Research Natural Areas, Research Facilities, Municipal Watersheds, etc.).** | 7,15,17 | Selected from the forest MA layer | |
| **Excluded recreation sites** | | | IDT identified |
| **Administrative Sites excluded from grazing** | 50 ft buffer | Buffer | communication towers |
| | | | |
| **Fenced Cultural/Special Management Areas** | | | |

| | | | |
|---|---|---|---|
| **Permanent Enclosures** | | | IDT identified : for wildlife habitat or the seed orchards. |
| **Special Use Sites excluded from grazing** | | | IDT identified |
| **Road ROW – excluded from grazing** | 100ft (primary) and 33ft (secondary) | Buffer | |
| **Railroad ROW – excluded from grazing** | 100 ft | Buffer | |
| **Areas not within allotments or areas closed to grazing by decision** | | | IDT identified |
| **Threatened and Endangered Species (TES) habitat permanently excluded from grazing** | | | IDT identified |
| **Other areas identified by IDT to be excluded from grazing** | | | IDT identified |

Table 5  Each parameter in the definition of 'suitabity' is broken down into parameters within a spatial layer, this table idenifis those layers and the cooresponsing paratmeters.

1. Subtract areas determined to be other than capable as determined in the capability evaluation above.

   This model uses the primary capable rangeland. It can also easily be maipulated to include the secondary rangeland, but this would only be done at the request of the IDT or the range staff. Since the directive is to only inlcude the primary rangeland, that is what this model follows.  Much like the capablity model, all the non-sutiable parameters areas are calculated and merged together.  This is then erased from the capable rangeland.

2. Subtract areas that currently have an overstory of tree canopy cover and/or unpalatable shrub canopy cover greater than 70% (note: local exceptions to the 70% figure may be determined to be appropriate for specific situations, such as Aspen communities, provided that the rationale is documented).

   The canopy cover layer is a raster layer, so the layer is reclassifed for 0-70% canaopy cover as '1' and everything else as '0'.  This layer is then converted to polygons as Project_CanopyCover70 layer.

   a. Transitory range will normally be considered as a special short term instance where suitability occurs because of the removal of the overstory vegetation (as by fire or

harvest). However, since the long term site potential is normally a moderate to dense canopy with little understory production, and since these areas are normally dedicated to timber (and other resource) production, these areas are generally considered to be suitable for grazing only for the lifespan of the time that it takes for the canopy to once again close back to 60% or greater, and only if the costs or viability of adequately mitigating effects relative to livestock grazing on forest vegetation regeneration are acceptable.

b. Use harvest maps and records to determine if specific areas currently meet the suitable criteria and if they are expected to remain within that criteria for the life of the plan. If so, they are determined to be suitable. If the transitory site will become other than suitable during the life of the plan, either portray it as being other than suitable, or show it as being suitable only for the estimated time that it will continue to meet suitability definitions.

c. Optional: Certain vegetative types (such as some Aspen communities) may be suitable for a given type of livestock in certain geographic areas and not in other areas. If appropriate, these vegetative communities may be subtracted out of the suitable acres as needed. (Document the rationale for the decision.)

Since the model is intentned to be utlized for NEPA, the transitory range parameter was not built into this model. If the need arises these parameters could be added into a copy of the model – this is what makes having the model as oposed to just layers a more useful long term tool.

The optional removal of certain vegetatition types apply to lodgepole and blue spruce dominated areas high elevation and typically the tree desnity is hgiht and little foraging grows here (Improvement 2009). These are selected out using a reclassify and have been saved as a polygon layer: Project_NonSuitVeg.

3. Subtract areas that have a proposed management area prescription allocation that does not allow

42

for livestock grazing (e.g., certain Research Natural Areas, experimental forests, municipal watersheds). Subtract only management area prescriptions that have proposed standards & guidelines that do not allow for livestock grazing management, or where decisions have previously been reached that livestock grazing is incompatible with the planned land management prescription and the proposed alternative would continue that incompatibility finding.

The 07, 11, and 17 designated Mangement Areas don't allow for grazing. The majority allow grazing but these restrictions are addressed when determining the stocking numbers, rather than with a limited percent ultization.

The Management Areas that don't allow grazing are selected and exported to the Project_NoGrazMA layer.

4. Subtract fenced recreation areas, developed recreation sites, administrative sites (except administrative pack and saddle stock pastures), minerals production sites, fenced cultural resource sites, permanent exclosures, and appropriate special use sites, where livestock use has been determined to be incompatible with the primary land use and/or where the alternative proposes to exclude livestock use.

There is a limited amont of data concerning the adminstrative sites that are fenced. Most of this information identifies the location and type but rarly the fencing. For this example, the model pulls in the communication sites as fenced adminstrative sites and buffers them by 50ft. This creates the Project_CommSite50ft layer.

This is another point where the range staff or other local knowledge would feed into the data/model to create a more robust and accurate analysis than the Forest Plan layers.

5. Buffer primary roads (from Infra Travel Routes). Primary roads are defined by the actual fenced area, or where a fence is known or proposed to exist but the exact location is unknown, buffer by 100 feet on either side of the center line and subtract.

The primary roads are selected from the Project_Roads layer and buffered by 100 ft. This layer

is saved as the Project_PrimaryRoadBuff.

6. Buffer secondary/county roads by the actual fenced area, or where a fence is known or proposed to exist, but the exact location is unknown, by 33 feet on either side of the center line and subtract to account for the area that is fenced along secondary/county roads.  Only use when the road (or road segment) is fully excluded from livestock grazing on NFS lands.  The road surface itself is not considered to be capable.  The fenced area alongside the road is capable of growing harvestable forage, but is unsuitable for livestock grazing if decisions have or will be made that livestock grazing is incompatible with other objectives associated with the ROW/easement.  Road surfaces are taken out at the capability analysis level and fenced areas along roads are taken out at the suitability analysis level.

   The seconday roads are slected and buffered by 33 ft.  This layer is saved as Project_SecondaryRoadBuff.

7. Buffer railroads by 100 feet on either side of center line or by the actual fenced area where a fence is known or proposed to exist, and subtract.

   There are not any railroads that run through any of  the alloments on the Okanogan-Wenatchee NF, so this step of the model was not included in this model.

8. Subtract areas that are closed to grazing. The reason for past or proposed closure or current lack of livestock grazing activity should be explained (e.g., lack of access, conflicts with wildlife, conflicts with recreation, etc.).

   Throughout the forest there are a few study areas and seed orchards which are all closed to grazing. These are fenced and can be found in the ResearchNaturalArea.  For the model these are merged and saved as the Project_ClosedGarz layer

9. Subtract areas where decisions have been made that specific TES habitats, including habitat for Forest Service sensitive species, need to be excluded from livestock grazing due to an established incompatibility.

While there are several TES species on the Okanaogan-Wenatchee NF and conserted efferts are being taken to protect and help them grow in number, there are not any designated areas closed to grazing specifically for TES species.  This is another place where input from the IDT would be helpful as areas are closed off. If and when this happens, the layers can be merged and saved as the project_TESclosedGraz layer.

10. Have IDT specialists on the planning team identify any additional areas where conflicts occur between livestock grazing and other resources to the extent that the conflicts cannot be resolved or satisfactorily mitigated, and where the other resource values are proposed in the alternative to take precedence over livestock use. If the planning recommendation is that livestock use in these areas is incompatible, or the conflicts are incapable of being resolved in a satisfactory manner, these lands will be designated as other than suitable for the specific alternative for this planning cycle.  Clearly document the reason for the other than suitable determination.

At this point there are not any specific areas identified. For this step in the model any layers with closed areas can be added to the model and merged to make the Project_IDTclosedGraz layer.

11. The remaining area is **Suitable Rangeland** as determined at the Forest Planning level in compliance with Forest Planning Regulations.   The suitable rangeland may be displayed as multiple map displays and acreage tables with one map/acreage table display for each alternative.

Now that all the layers needed for the suitablity analysis have been created and stored. The acres for each step are calcuated and copied into a suitablity table. The layers are then brought together with the 'dissolve' tool to make one layer with all the non-suitable areas in one polygon. Then using the 'erase' tool that polygon is taken out of the capabliaty layer created in the previous step to give the suitable rangeland.  The layer is saved as Project_Sutiable layer and the

.0.acres are calculated and distributed to the range staff and IDT.
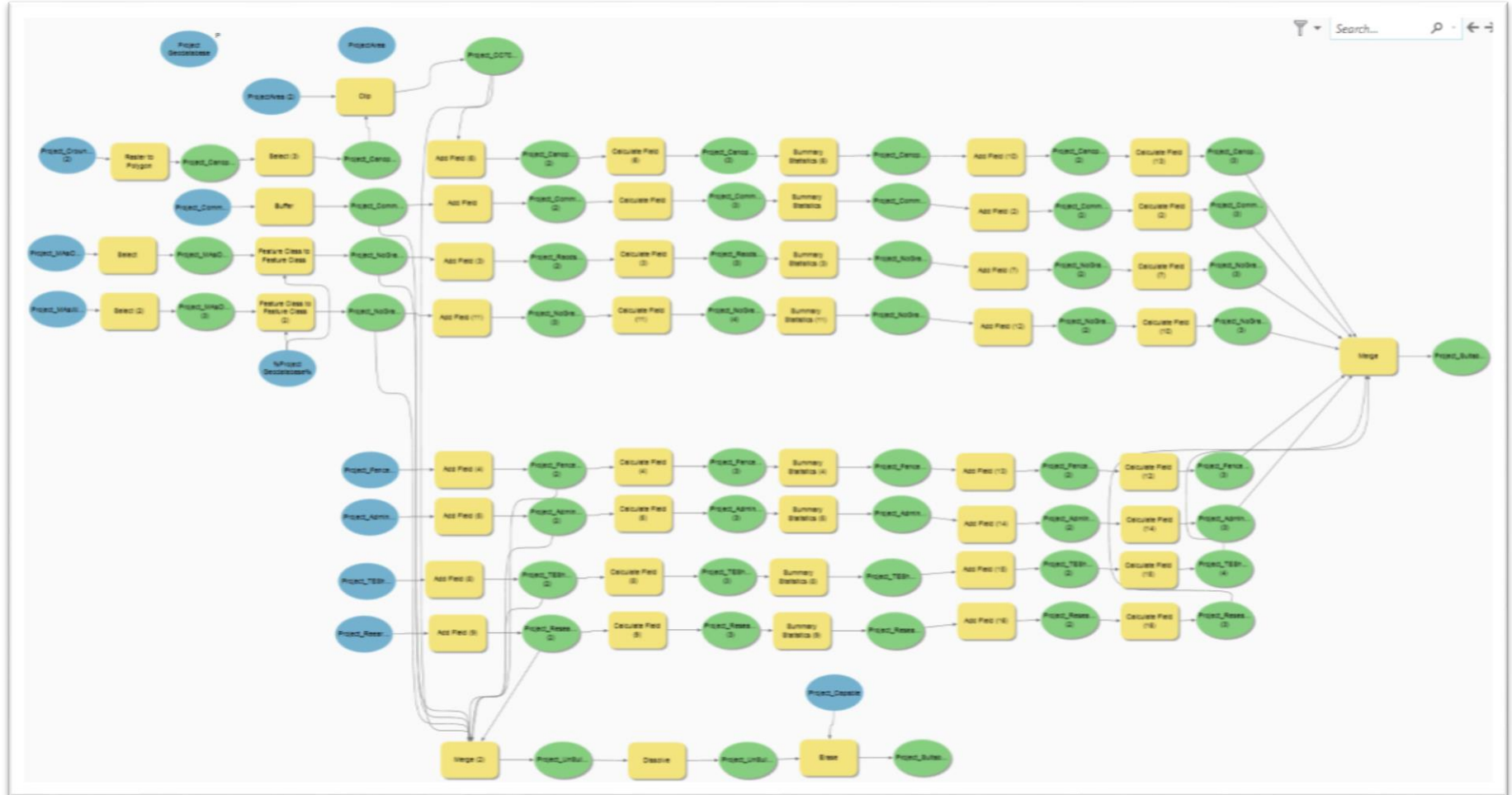
Figure 6 Suitability model: Model builders uses shapes and colors to represent the geoprocesses in a model. This figure SHOWS THE third model – determining the suitable areas.

| Classification/Description | Acres Deducted | Running Totals |
|---|---|---|
| Net National Forest System Acres | | |
| Deductions for Other Than Capable Acres | | |
| Deductions for Other Than Suitable Acres | | |
|     Existing canopy cover >70% | | |
|     M.A. prescription (S&G's) does not provide for grazing (ex: some Research Natural Areas, Research Facilities, Municipal Watersheds, etc.). | | |
|     Excluded recreation sites | | |
|     Administrative Sites excluded from grazing (excepting admin horse pastures) | | |
|     Minerals Production Sites | | |
|     Fenced Cultural/Special Management Areas | | |
|     Permanent Enclosures | | |
|     Special Use Sites excluded from grazing | | |
|     Road ROW – excluded from grazing | | |
|     Railroad ROW – excluded from grazing | | |
|     Areas not within allotments or areas closed to grazing by decision | | |
|     TES habitat permanently excluded from grazing | | |
|     Other areas identified by IDT to be excluded from grazing | | |
|     Total Suitable acres (cattle) | | |
| | | |

Table 6 This table respresents what would be the end resutls presended in table format for the suitablity model. The table would be included in the body of the NEPA wirte up.

Discussion/conclusions

Each part of the *capability* and *suitability* analysis is standardized through national definitions, this allows for comparison between allotments. Each allotment is analyzed based on the same parameters so decisions can be more broadly applied. When comparing two allotments with similar capable and suitable rangeland, the impacts of managerial decisions (ie the length of the season) can be teased out. This can help the range specialist make the best decisions possible for the land and the permittee.

Since the analysis is now in model builder and set up with tool parameters – anyone can use it. The range specialist can run the model on specific allotments as changes occur. Since the model is relatively small there is the possibility to run a variety of scenarios to look at impacts to the rangeland such as closing a pasture for rest after a timber harvest or wildland fire. These types of changes can have a large impact on both the land and the permittee but are rarely looked with the in-depth level analysis, with the model this at least the capability and suitability rangeland impacts can easily be obtained.

With the modernization of the data storage and collection and the new models for the capability and suitability analysis allows the range program to run more efficiently and takes some of the workload off the staff.  By using the AGOL tools and platform data entry happens in the field and QAQC checks are done instantaneously.  Faster data entry enables faster reporting and getting the information out to the permittees.  Faster response times make caring for land more effective, catching and correcting any troubles earlier.  The development of the analysis models standardizes and quicken the process.  Thus, allowing the range staff to easily analyze different scenarios and quickly assess the impacts of changes to allotments.

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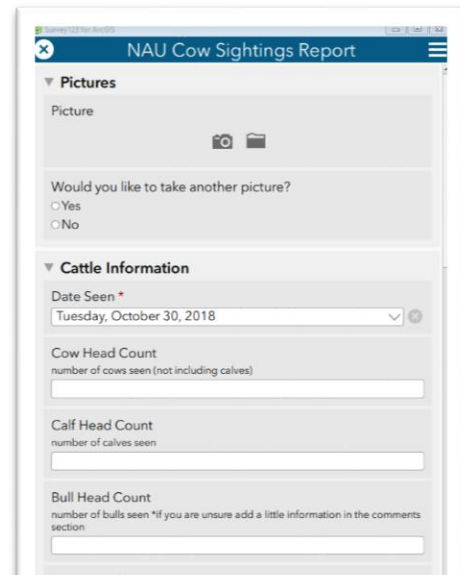
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## Cow Sightings

- A quick form for collecting information about cow sightings on the district

- Can be used by any field going employee

- Picture, point, general cow information

- Most fields are optional – with only the location being

  mandatory

- Multiple pictures

- Pre-loaded allotments and associated pastures

- Area to hand draw brand

- In the background also auto-collecting the AGOL

  username, e-mail, and date of survey
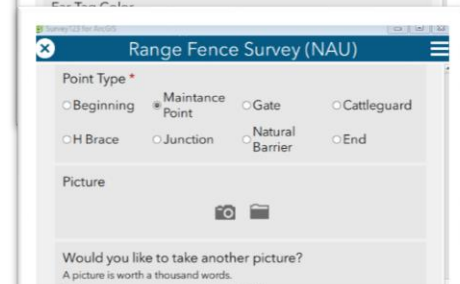


## Fence condition and location surveys

- Survey123

- Form for collecting points

- Tracks in s1 or on the Garmin

- Collect additional information on paper for condition

  information

- Collect a line in s1 or collector

- Collect a kml line in Avenza



## Range readiness

- Point location and photo for each readiness indicator



1

- Readiness indicator is based on set number of species

- Dropdown with species specific readiness

- Return if the pasture is not ready

- Repeat within the same survey

- Soil conditions are important

- Firm – soft – muddy

- Finally, a yes/no for readiness for quick/easy to look at for those in the office/ rancher.

- 

## Water development survey

- Water developments are an important component to range management

- Shift utilization – protecting sensitive riparian areas

- Provide easily access to water for cattle

- USFS puts a lot of money into the water developments – providing troughs, fencing material etc.

- Require maintenance to make sure the developments are not drowning hazards, fencing in place to protect the resource.

- Done by the permittee (mostly) monitored by USFS

- Quick and easy way to track location and maintenance of wd

- Communicate with ranger, rancher, office range specialist

## Monitoring Points range surveys (Utilization, MIMs, Stubble Height)

- How much are the cows eating?

## NAU Utilization

**None - 0%-5%**
No evidence or negligible apperance of grazing

[ - ] [                    ] [ + ]

**Slight - 6%-20%**
Browse plants have the appearance of very light use. The avaliable leaders of key browse plants hae the appearance of ver light use. The avaliable leaders of key brose planse are little disturbed.

[ - ] [                    ] [ + ]

**Light - 21%-40%**
Obvious evidence of leader use. The abaliable leaders appear cropped or browed in patches and 60% to 80% o fhte avaliable leader growth of the key browse plants remain intact.

[ - ] [                    ] [ + ]

**Moderate - 41%-60%**
Browse plants appear rather uniformly utilized and 40%-60% of the avaliable leader growth of key browse palnts remain intact.

[ - ] [                    ] [ + ]

**Close - 61%-80%**
The use of the browse gives the appearance of complete search. The preferred browse plants are hedged and some plant clumps may be slightly broken. Nearly all avaliable leaders are used and few terminal buds remain on key browse plants. Between 20-50% of the abaliable leader growth of key browse plants remain intact.

[ - ] [                    ] [ + ]

**Extreme - 81%+**
There are indications of repeated coverage. There is no evidence of terminal buds and usually less than 20% of avaliable leader growth on the key browse plants remain intact. Some, and often, much of the second and third year's growth has been utilized. Hedging is readily apparent and the browse plants are more frequently broken.

[ - ] [                    ] [ + ]

---

## NAU MIMs

▼ **Plot**

**Plot Number**
[                              ]

▼ **Greenline Composition**

**SpeciesRockWood**
[                              ]

**Percent**
[                              ]

**Woody Species Height Class**
○————○————○————○————○————○————○
1      2      3      4      5      6    blank

▼ **Streambank**

**Alteration**
○1        ○2        ○3        ○4
○5

**Erosional or Depositional**
○Erosional          ○Depositional

**Covered or Uncovered**
○Covered            ○Uncoverd

**Stability**
○Fracture    ○Slump    ○Slough    ○Eroding
○Absent

---

## NAU Stubble Height Monitoring Form

**Forest**
[ Okanogan-Wenatchee NF                    ⊙ ]

**Ranger District**
[                                          ∨ ]

**Allotment**
[                                          ∨ ]

**Pasture**
[                                            ]

**Date Collected**
[ Tuesday, October 30, 2018              ∨ ] ⊗

**Planned Season Start Date**
[ Date                                     ∨ ]

**Planned Season End Date**
[ Date                                     ∨ ]

**Actual Season Start Date**
[ Date                                     ∨ ]

**Actual Season End Date**
[ Date                                     ∨ ]

**Observer**
☐Somkey the Bear    ☐Woodsy Owl    ☐Louie the Lumberjack    ☐Other

Range Improvements Web App: AGOL web interface for range specialist to easily edit data. The pop up window shows a point that was updated using Survey123: Range Waterdevleopments.  In the southern end of the map the two red and yellow dot represent a Cow Sighting points.  All editable attributes can be manipulated.  There are additional widgets which help with 'at a glance' summaries.
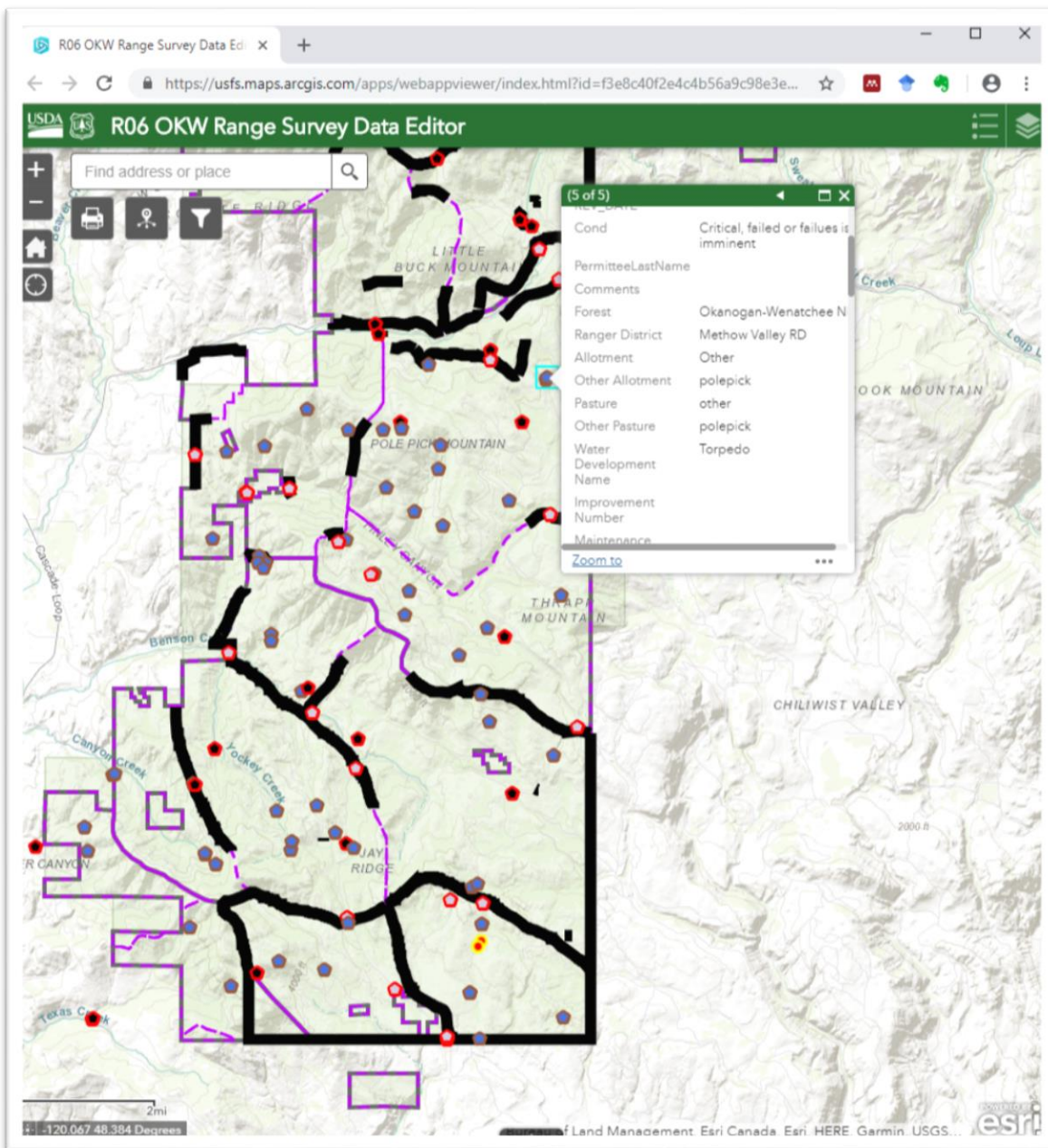
## Appendix C: Survey Reports

The Survey123 reports can be viewed online or exported to a word document using a template.  The Cow

Sightings Survey is used as an example here.

Web based reports can be accessed through Survey123.arcgis.com – this interface shows all of the questions unformatted, a basemap and attribute table.



Each exported Survey123 results report is based on a template.   Attributes can be added or deleted and formatted to desired specifications.

The word document Survey123 report this is useful for record keeping – providing only the relevant information and quickly brings together a standardized report.