Virtual Boundaries FACT SHEET

October 29, 2019

- ### What does this work respond to?

One of the nine action items identified at the 2017 Accelerating Restoration Implementation Workshop. Discussions between Region 6, the 4FRI team and Forest Products Modernization Team regarding virtual boundaries and the potential costs savings and processes associated with virtual boundaries late 2017/early 2018.

- ### What was done?

United States Forest Service Forest Products Modernization Team ID's the need for a pilot project regarding virtual boundary to outline process, cost savings, ID potential lessons learned in summer 2018.

Representatives from WO Forest and Range Management and Vegetation Ecology, RO Forest Management, 4FRI, and the Kaibab National Forests convene in Fort Collins June 18-22, 2018.

- Outlined process to establish and check virtual boundaries, manual updates needed, and draft contract language

- ID'ed pilot project—Parks West in TNC's Future Forest project

- Kaibab National Forest and TNC created and signed a Challenge Cost Share agreement to implement a virtual boundary pilot along with other sale prep innovations on July 19, 2018.

- ### What was the process?

Updating Manual Direction FSH 2409.12 Chapter 70 added in glossary to define virtual boundaries, geo-fence and discernible boundaries. Multiple edits of language adding sale and project area rather than just sale area and major edit to 71.22 Designating Boundaries.

- FSH 2409.12b Chapter 10—edited 11.1 and 11.2 in reference to storing boundary files and utilizing vector file for presale theft prevention

- 2409.15 Chapter 10 14.1 Timber Sale Contract Files—added in need to store vector file

- FSH 2409.18 Chapter 50---created a map symbol for virtual boundary geo fence in 53.54 exhibit 04, added in sections 55.21 cutting unit boundary and 55.21a– Cutting Unit Boundary: Virtual Boundary Geo-Fence that defines need for risk assessment, vector files and procedures when satellites fail.

- Virtual Boundary Desk Guide Draft

Timber Theft Plan

Where to find the updated:

- Timber Theft Plan on the R3 Forestry, Forest Health and Cooperative Forestry Share Point site

- Timber Sale Prep and Admin Page

- Section called Sale Administration Library

- Folder Timber Theft Plan

• Jason Eakins, Harvest Inspector, Kaibab National Forest

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What was the process?

Contract Language/ Provision

An official digital vector/shape file will need to be developed that shows the formal designation of all virtual boundary locations for the sale or project. This file will need to be kept in a secure location and will be the official file of record for sale or project boundaries. The contract will need to name this file. Copies of this file will need to be provided to the marking crews and timber cruisers, purchasers and contractors, and sale administrators.

The Contract Defined Distance should not be too narrow as to create unnecessary hardship or expense in relocating the boundary but also not so wide that it offers little protection from unintentional resource damage beyond the scope of the sale or project area management plan. The Contract Defined Distance should take into account value of resources, impact of treatments occurring outside of planned unit boundaries, impact of treatments not occurring up to the planned unit boundaries, and other social/economic factors that may apply.

The contract does not specify what equipment the purchaser will use, only the Contract Defined Distance. The purchaser is free to operate using whatever equipment or procedure that will keep them within the Contract Defined Distance.

Example of contract language can be found in the Virtual Boundaries Desk Guide

- Regional provision created for Stewardship contracts/Agreements R3-K-C-3.0.1# Cutting Unit Boundaries

- ID's name and date of official digital vector file

- Cutting unit boundary designation table

- ID's what the acceptable distance from the digital geo fence line Forest Service will accept

- ID's data accuracy standards that contractor may use and outlines procedures for what happens during disputes and failures of satellites

- Need to ensure long term data file storage method for vector file

• Jason Eakins, Harvest Inspector, Kaibab National Forest

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What was the process?

Defining Virtual Boundaries

Virtual boundaries are considered to be clearly identified cutting unit boundaries that are unpainted or otherwise unmarked. There are two types of virtual boundaries:

Discernable: A natural or constructive feature so conspicuous it can be identified from a sale area map and using that feature will not cause mistakes to be made when trees are cut. Examples of discernable boundaries are roads, meadows, and rock outcrops.

Geo-fence: A virtual perimeter for a real-world geographic area. A geo-fence can be dynamically generated, as in a radius around a point location, or a geo-fence can be a predefined set of boundaries. The geo-fence is paired with a hardware/software application that responds to the boundary in some fashion as dictated by the parameters of the program.

Painted Boundaries:

Boundaries must be marked when the risk of unintentional resource damage will effect non-Forest Service land, impact the economic concerns of other partners, or impact sensitive or protected areas. Boundaries must therefore be marked with Forest Service tracer paint when:

- Units from different sales or project areas have a common boundary.
- Units abut non-National Forest System lands or wilderness boundaries.
- Units are adjacent to cultural sites, federally listed species habitat, or other resources that require protection as defined in site-specific NEPA decision and contract provisions.
- Where NEPA is not in place, such as beyond the sale or contract area boundary.

• Jason Eakins, Harvest Inspector, Kaibab National Forest

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Virtual Boundaries FACT SHEET

What was the process?

Develop procedures for establishing a virtual boundary:

1. **Prework (stay organized!)**

   - Risk Assessment

   - Determine the boundary type

   - Determine allowable accuracies

   - Convert units to line segments

Parks_West_Line_Segments

OBJECTID *	Shape *	Line_ID	Shape_Length	Line_Type
1	Polyline	1	262.405685	GPS Geo Fence
2	Polyline	2	1053.892491	GPS Geo Fence
3	Polyline	3	1077.739685	GPS Geo Fence
4	Polyline	4	901.553631	GPS Geo Fence
5	Polyline	5	637.808278	Discernible Digitized
6	Polyline	6	1527.522554	Discernible Digitized
7	Polyline	7	574.365941	Discernible Digitized
8	Polyline	8	834.477472	Discernible Digitized
9	Polyline	9	669.348382	Discernible Digitized
10	Polyline	10	111.609813	Discernible Digitized
11	Polyline	11	1251.964684	Digitized Geo-Fence
12	Polyline	12	765.566279	GPS Geo Fence
13	Polyline	13	1421.602112	GPS Geo Fence

Establishing Virtual Boundaries

The techniques used to survey the boundary lines will not change from using a painted boundary to using a virtual boundary. Area determination errors will still need to be met, so appropriate equipment and techniques will still need to be used (2409.12 chap 50). There are some specific issues to be aware of when establishing virtual boundaries however.

- Jason Eakins, Harvest Inspector, Kaibab National Forest
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What was the process?

Risk Assessment:

Before utilizing a virtual boundary, a risk assessment should be completed for each boundary that is to be designated with a virtual boundary. The risk assessment should describe the boundary line location, resource protection risks, and any other considerations that may need to be taken into account. Doing the risk assessment will help to identify boundaries that have a discernable feature, boundaries that will need to be painted, and boundaries where a geo-fence is applicable.

Boundary Location	Policy	Considerations	GEO-fence	Discernible	ID #
Land Ownership Boundaries (e.g. private and other public organizations)	Current Policy (FSH 2409.12 Chapter 71.22)	Avoid trespass.	NO	NO, unless have agreement with adjacent landowner for all lands project and is documented in risk assessment and agreement	A
Where NEPA is not in place at the sale area boundary	Current Policy (FSH 2409.12 Chapter 71.22)	Ensure environmental compliance.	NO	YES	B
Cultural sites, federally listed species habitat, or other resources that require protection (e.g. specific soils)	Current Policy (FSH 2409.12 Chapter 71.22)	Avoid damage or unintended impact to important resources that could be outside the effects of a biological opinion or other legal requirement.	NO	NO	C
Separation between different awarded timber sale contracts	Current Policy (FSH 2409.12 Chapter 71.22)	Ensure compliance with timber sale contracts such as differing timber rates or removal of another purchaser's volume. Minimize opportunities for claim.	NO	YES	D
Obvious visible features such as roads, meadow edges, previous harvest units, rock rims, distinct ridges, and streams	Current Policy (FSH 2409.12 Chapter 71.22)	These obvious visible features are discernable on the ground, through orthophoto imagery, and/or remotely-sensed data. Current handbook policy allows for these areas to be unmarked.	N/A	YES	E
Identifiable areas but not discernible	no current direction for geo-fence	Internal and external boundaries to clarify identifiable features.	YES-needs documentation in risk assessment	N/A	F
Shared cutting unit boundaries within the sale area	no current direction for geo-fence	Where shared cutting unit boundaries are within the sale area.	YES-needs documentation in risk assessment	YES	G
External cutting unit boundaries all FS land and does not have adjoining approved NEPA	no current direction for geo-fence	Avoid trespass and resource damage.	NO	YES	H
External cutting unit boundary where product is low value and NEPA coverage extends beyond the sale area and all FS land	no current direction for geo-fence	Avoid trespass and resource damage.	POSSIBLE-needs documentation in risk assessment to utilize	YES	I
GNSS observation conditions are poor (HDOP > 6) or influenced by errors such as blockage or multi-pathing	Current Policy (FSH 2409.12 Chapter 71.22)	Operator cannot implement and FS can't administer.	NO	YES	J
Cut tree mark	no current direction for geo-fence	All trees to be removed are designated.	YES-needs documentation in risk assessment	YES	K
High value product is being removed – not cut tree marked	Current Policy (FSH 2409.12 Chapter 71.22)	Avoid trespass of high value product.	NO	YES	L

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What was the process?

Procedures for implementing a geo-fence

2) Collect and Digitize lines via the following methods

- Field surveys

- Digitizing off remote sensing sources

- Combination methods
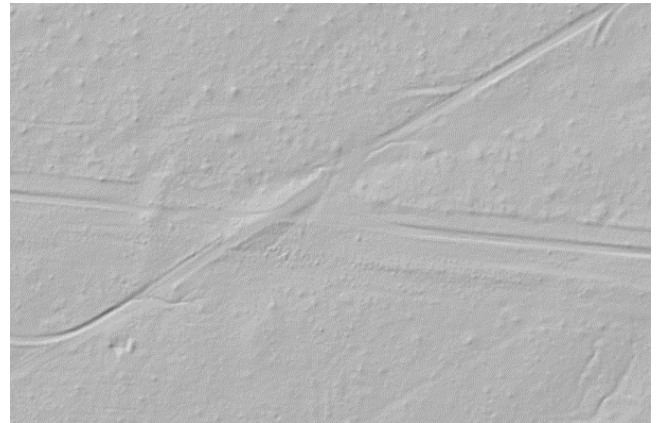
3) Procedures for implementing a geo-fence

- Determining accuracy

  - GPS Accuracy

  - Remote Sensing Data Accuracy

- Re-locating the geo-fence

  - Make sure there are no gaps between line intersections

- Jason Eakins, Harvest Inspector, Kaibab National Forest
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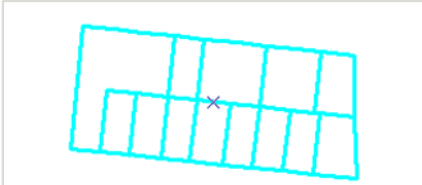
What was the process?

4) Finalize geo-fence boundaries:

1. Construct polygons from final GPS and digitized lines

2. Document procedure in cruise plan

3. Secure final unit Feature Class

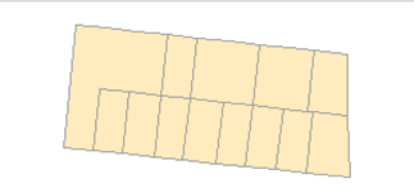### Constructing polygons from the shapes of other features

ArcGIS 10.5

Locate topic

This topic applies to ArcGIS Desktop Standard and ArcGIS Desktop Advanced only.

You can use Construct Polygons to create new polygons from the shapes of existing lines or polygons. For example, you might need to create new parcel features from some parcel boundary lines.

Parcel lot lines used to create new polygons   *New polygons created from the selected lines*

Table 5. Boundary Info Table

Boundary Segment Number	Boundary Type	Accuracy	Risk Category
1	GPS Geo-Fence	5.57	G
2	GPS Geo-Fence	5.57	G
3	GPS Geo-Fence	5.57	G
4	GPS Geo-Fence	5.57	G
5	Discernible Digitized	4	E
6	Discernible Digitized	4	E

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What worked well?

Use of ESRI ARC GIS Online to:

- Identify risk of each boundary

- Label boundary types

- Coordinate field surveys using Two Trails

☑ Virtual Boundary Lines

——— Discernible

——— Painted

——— GPS Geofence

——— Heads Up Digitize Geofence

- **Approximately 52 miles of virtual boundaries — 89% of the project area boundaries!**

- **Discernable boundary type**

  - 26 miles digitized

- **GEO-fence boundary type**

  - 18 miles of GPS'

  - 8 miles digitized

- **Painted boundary type**

  - 6 miles GPS'

- **Saved 110 gallons of paint**

Collaboration:

- Between the sale prep team, sale administrator, silviculturist, and other resource specialists during the risk assessment phase is important. Input from the purchasers in the area will also be necessary.

- "Fire team" approach to working out all steps of the process

- Partners resources in technology/planning

- Partner working well with logger to implement technology

- In-cab mapping software on GPS enabled tablets mounted in operating equipment

- Willingness from everybody to try something different

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Key points for implementation

Timber Marking and Cruising

Any crew going into units with a geo-fence will need to have a decent GNSS receiver and software that can relocate the boundary. Relying on internal cell phone GPS accuracy with a navigation software package like Avenza will not be accurate enough to locate these boundaries with any real precision. Marking crews will need to check their maps repeatedly as they approach a geo-fence, which will slow the crew down and add additional time to complete the marking. Both cut tree and leave tree marking can be considered a visual cue that purchasers and contractors will rely on to help relocate the boundary so care needs to be taken when marking trees along a geo-fence. To help speed up marking crews, survey crews should consider flagging the geo-fence line if they are using GPS to establish those boundaries.

In general, cruising in a unit with a geo-fence will not be different than cruising in any other stand except more care will need to be taken to ensure all samples are within the unit boundary. When plot cruising, plot locations that occur near a geo-fence, where a portion of the plot may fall outside of the cutting unit boundary, will need be handled using the half-plot method instead of using mirage plots or the walk through method (2409.12 chap 34.23).
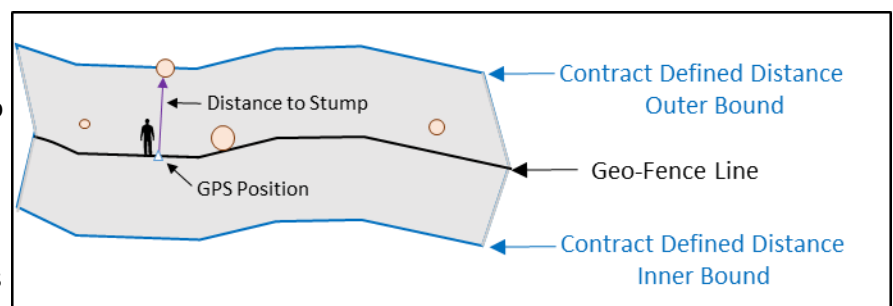
Sale Administration and Contract Compliance

To check the boundary for compliance, the Sale Administrator (SA) will use the final geo-fence vector file (specified in Regional C provision) uploaded into an approved device (tablet/cell phone/mobile device) connected to the contract specified GNSS receiver and running approved software (e.g., Two-Trails or Arc Collector). The software will need to able to collect and store waypoints as a way of documenting stump locations.

As noted above, the SA compliance check will use the Contract Defined Distance plus the GNSS accuracy error to determine if the resource treatment stayed with the required geo-fence boundaries. A two-phase procedure is recommended for this check; a quick check in the field and a compliance check from the office.

Quick Check

The quick check is a procedure for the SA to make a quick estimate of the stump (or uncut tree) distance from the geo-fence to determine compliance. The SA will use the GPS receiver to locate the geo-fence perpendicular to the stump being checked. The SA will use the average of 60 positions collected to determine the location of the geo-fence line. Once the SA is reasonably sure they are on the geo-fence line, the horizontal distance between the stump and the geo-fence line is measured. A rangefinder laser device will be the most efficient way to determine horizontal distance to the stump. If the stump is within the tolerance (Contract Defined Distance plus the GNSS accuracy error), the SA can move to the next stump to be checked. If the stump is out of tolerance or borderline out of tolerance, move to the compliance check.
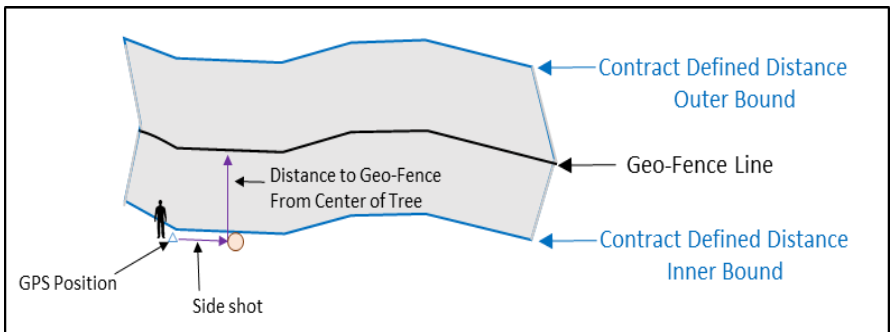
Key points for implementation

Compliance Check

The compliance check will be the legal check for any stump or standing tree that may be out of compliance. Because it is difficult for the SA to determine where the exact geo-fence line is on the ground, the compliance check reverses the process. The SA will record the GPS position of the stump using the average of 60 positions. The SA will need to place the GNSS receiver directly over the center of the stump when determining the location.
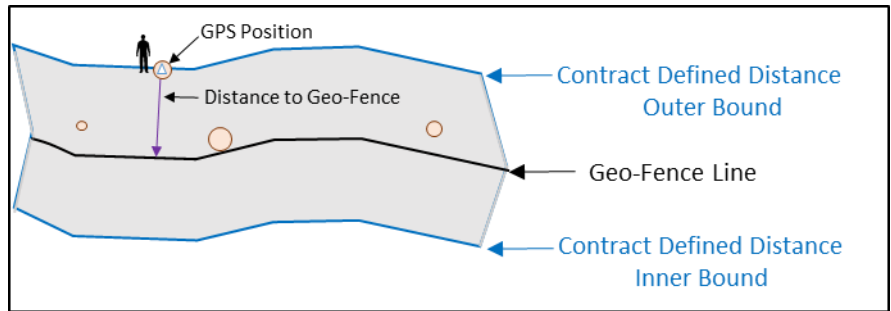
For standing trees, a GPS location taken close to the tree under open sky with a side-shot to the tree will work. Try to use a side shot to the face of the tree that is parallel to the geo-fence boundary. This will result in a distance from the center of the tree to the geo-fence line. The GPS locations of possible noncompliance stumps or trees are placed on the official digital shapefile/vector file and the distance to the geo-fence is determined. If the stump or tree location is outside of the tolerance, the stump or tree is in non-compliance. The SA has a record of the stump or tree location (so it can be easily relocated) and its proximity to the legal geo-fence line.

Recommendations

The technology and hardware for implementing virtual boundaries already exist and are in use by the Forest Service. Discernable boundaries are permitted under current Forest Service regulations and their use is encouraged. Forest Service policy and contract language concerning geo-fence implementation are currently under development. Education for both Forest Service personnel and contractors will be necessary to successfully incorporate geo-fences into resource management projects. Consult with your Regional Office specialists when looking at implementing geo-fences on your project

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