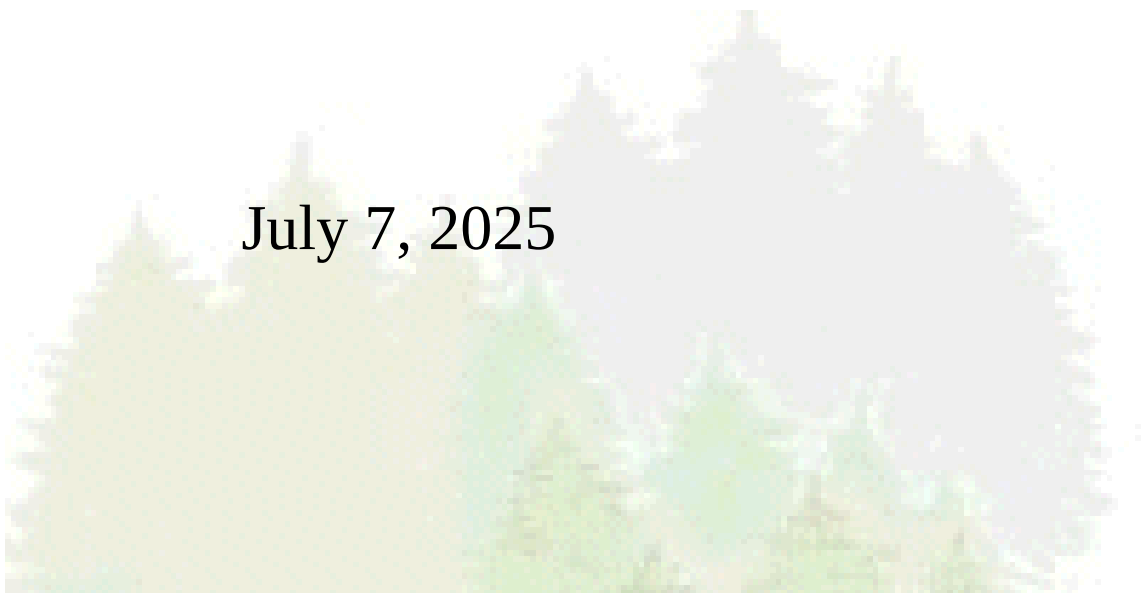




Virtual Boundary Desk Guide

July 7, 2025



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Introduction

Cutting unit boundaries define where timber harvest or other resource management activities will take place. It is important for the locations of these boundaries to be clearly identified to ensure activities only occur in the designated areas and do not spill over onto private lands or ecologically sensitive areas. Typically, all timber sale contract cutting unit boundaries are designated, or marked, with special paint, known as tracer paint, and augmented with paper or plastic signs. Painting boundaries can be one of the more costly practices associated with timber sale preparation. This sale preparation cost can be reduced by using virtual boundary designation methods including “discernable” and geofence methods as part of boundary designation.

Virtual boundaries

Virtual boundaries are clearly identified cutting unit boundaries that are unpainted or otherwise unmarked on the ground. There are two types of virtual boundaries:

Discernable: A natural or constructed feature apparent on the ground and identifiable from a sale area map; users can distinguish the unit boundary location without the assistance of tracer paint. Examples of discernable boundaries are roads (Figure 1), distinct breaks in vegetation, and rock outcrops. Discernable boundaries are easily located on the ground using the sale area map alone and should have little risk from unintentional resource damage outside of the cutting unit boundary.

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 specific hardware/software application that responds to the boundary in some fashion as dictated by the parameters of the program.



Figure 1. Forest Service road.

Benefits

The benefits to using virtual boundaries over painted boundaries include:

- Lower paint costs.

- Lower crew costs.

- Decreased timeframe needed in sale preparation schedules to conduct field work associated with some, or all, of the boundary designation process.

- Increased flexibility as to time of year some phases of sale preparation can be completed.

- Lack of visible marks if used in areas with visual quality objectives like along a roadside or ski trail.

- Keeping crews out of or reducing crew time in potentially dangerous areas like blow down.

- Negates the need for additional leave trees along roads or between two cutting units with shared boundaries.

- Negates the need to repaint boundaries in areas where boundary paint is known to fade before treatment begins or areas with frequent prescribed burns that can obscure boundary paint.

Costs

There are several costs associated with using virtual boundaries

Geo-fences may require expensive global positioning system (GPS) receivers to relocate the boundary accurately.

Administering Geo-Fences may require additional training, take more time to administer, and increase sale administration costs.

More risk of not treating up to or treating areas over the designated boundary line.

Increased risk of disputes over boundary locations and possible claims.

Requires purchasers/contractors to invest in GPS receivers and appropriate software, provide training to employees, and work with non-traditional oversight of logging operations.

Increased time and costs to purchasers/contractors in locating boundary lines which can result in reduced stumpage values or no-bid sales.

Sale Prep Planning

Painted boundary designations offer little risk of unintentional resource damage beyond the designated unit boundaries when done appropriately with inter-visible painted trees (Figure 2). The same is true when using discernable boundary designations. For this reason, boundaries must be marked if a discernable boundary is not present when the risk of unintentional resource damage will affect 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 if not designated with a discernable boundary when:

- Units from different sales or project areas have a common boundary.
- Units abut non-National Forest System lands or wilderness, designated natural, or roadless area boundaries (FSM 7150.3).
- Units are adjacent to heritage resource sites or other resources that require protection as defined in site-specific NEPA decision and contract provisions.
- The risk of using a geo-fence could result in cutting outside the activity area analyzed in NEPA is high.



Figure 2. Boundary marked with tracer paint and unit tag.

Except as described above, the District Ranger may authorize cutting unit boundaries designated without paint marks using geo-fences providing these boundary designations will meet the objectives of the resource management plan (FSM2404.17b). Restrict geo-fences to scaled sales to reduce risk to purchasers unless every tree to be removed is to be clearly identified with tracer paint.

Risk Assessment – the potential for resource damage or trespass if a virtual boundary is used.

A risk assessment shall be completed for each boundary segment to be designated with a geo-fence to evaluate risk factors like high timber values and resource protection. The risk assessment will describe the boundary line location, resource risks, and other factors to be considered like availability of GPS signals, accuracy of surveyed boundaries, and availability of appropriate technology (see Table 1). Doing the risk

Table 1: Example of Risk Assessment Table

Risk Assessment for JavaBean Timber Sale

Boundary Location Type	Unit Numbers	Risk & Value			Total	Recommended Boundary Type						GPS signal verified ¹
		Low	Med	High	Miles	Painted	Miles	Discernable	Miles	Geo-fence	Miles	
Adjacent to Other Land Ownership	N/A											
Shares Boundary with External NEPA Boundary	71,74,79,80			X	1.92	X	0.39	X	1.53			
External Boundary within NEPA Boundary												
High quality timber adjacent to external boundary	48, 52, 53, 58, 71, 80			X	3.27	X	0.87	X	2.4			
Low quality timber adjacent to external boundary or identifiable feature present (slope change/fence line/etc)	10, 11, 12, 15, 18, 22, 23, 24, 25, 32, 38, 74, 79	X			12.57			X	9.04	X	3.53	x
Shared Boundary with Other Cutting Units												
Different Treatment Prescriptions - Similar Forest Products	10:11, 10:12, 11:12, 15:18, 23:24, 52:53, 53:58, 71:74	X			8.62					X	8.62	x
Different Treatment Prescriptions - Different Forest Products	12:15, 25:32, 24:38, 48:52, 58:71,		X		7.12					X	7.12	x
Same Treatment Prescriptions - Different Logging Methods	48:52, 79:80	X			0.35					X	0.35	x
Natural Resource Protection Boundary												
Stream Course/Riparian Protection	22, 23, 24, 25, 32			X	2.69	X	2.69					
Cultural/Heitage Resources	58			X	0.07	X	0.07					
Other exclusions (Known nest sites/Threatened and Endangered species)	N/A											
Wildlife Corridor	10, 11, 15, 18, 38			X	2.41	X	2.41					
Totals					39.02	Painted	6.43	Discernable	12.97	Geo-fence	19.62	

Allowable Contract Tolerance

30 feet

¹Field check confirmed a GPS signal is available along boundary.

Signature:

X

Title:

assessment will identify boundaries with a discernable feature, boundaries to be painted, and boundaries where a geo-fence is applicable.

A geo-fence will affect more than just sale preparation so collaboration between the sale prep team, sale administration, law enforcement, silviculturist, and other resource specialists during the risk assessment phase is important. Engaging the local purchasing and contracting community about the use of virtual boundaries, GPS receivers, accuracy errors, and receiver costs should be part of the risk analysis process. The local purchasing and contracting community need to be fully aware of how all boundaries will be identified. Potential bidders unaccustomed to the use of geo-fences may decrease the rate they are willing to pay for the stumpage or decide not to submit a bid.

Although a geo-fence is a distinct line that describes the cutting unit boundary in a precise location, relocating that boundary is not exact. All GPS receivers contain some level of accuracy error. The level of acceptable accuracy error needs to be determined based on the risk the CO and the NEPA Deciding Officer is willing to accept around any geo-fence boundary and needs to consider the accuracy levels of readily available GPS receivers. This acceptable level of risk should be defined during the risk assessment. Factors such as the value of the product to be removed and the level of resource protection needed for adjacent stands should be taken into account.

This acceptable accuracy error will be known as the Allowable Contract Tolerance and all work along a geo-fence boundary will need to be implemented using GPS receivers meeting this accuracy tolerance.

Note: adding in an additional buffer next to geo-fence equal to or greater than the Allowable Contract Tolerance to ensure the adjacent stand is not encroached upon signifies the boundary is high risk and a geo-fence shall not be used in these locations.

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 (FSH 2409.12 chap 50). There are some specific issues to be aware of when establishing the different virtual boundaries however.

Discernable Boundaries:

When surveying a discernable boundary, whether by GPS or digitizing off of a geo-referenced map or photo, make sure the boundary is placed along the edge of the unit and not in the middle of the discernable feature. For example, if a road is being used as the discernable feature, the boundary line will need to be surveyed along the edge of the road closest to the unit and not down the middle of the road. You can take GPS measurements along the center of the road, but side shots to the unit boundary will need to be taken or an off-set will need to be applied to position the boundary correctly. Failure to do so will add additional area to the unit acreage that is not part of the unit description which will impact volume estimates if plot based cruising is used in the unit.

Geo-Fences:

Because GPS and geo-referenced maps and photos contain some level of accuracy error, the boundary locations will also have some level of error associated with them (FSH 2409.12 chap 51). For painted and discernable boundaries, these accuracy errors are mitigated by visual cues on the ground, either from paint or from the discernable feature. For a geo-fence, there may or may not be any visual cues.



Figure 3. Example of a smooth boundary.

Care should be taken to establish the best possible boundary line when establishing a geo-fence. GPS receivers that have low accuracy errors for the type of canopy closure that occurs along the boundary line will provide the best results. The estimated accuracy for different GPS receivers can be determined by using the [National Technology and Development Center \(NTDC\) Accuracy Matrix](#).

Geo-fences placed along smooth boundaries with few sharp angles (Figure 3) will be easier to implement than boundaries with many sharp angles or units with small corridors or narrow fingers (Figure 4).

Units with shared boundaries within the same sale should have a single geo-fence describing the shared boundary. Creating a geo-fence for each unit can cause discrepancies in boundary locations leading to overlaps or skips which can cause confusion in the field when implementing and checking the boundary for contract compliance.

Digitizing boundaries will require Regional Forester approval (FSH 2409.12 chap 50.4). Make sure any map or photo errors are within an acceptable tolerance before using them to digitize a geo-fence boundary. If digitizing a geo-fence boundary from a photo or map, make sure you are digitizing across an area that has an acceptable GPS signal strength. Avoid placing geo-fences down steep slopes, in draws, or under heavy canopy where a GPS signal maybe weak, blocked, or be affected by multi-pathing. Digitized boundaries should have GPS signals verified in the field if there is any doubt about the quality of the signal strength. If the operator cannot establish a good GPS signal, those boundaries will need to be resurveyed and painted before the area can be treated.



Figure 4. . Example of a boundary with many sharp angles.

Once a geo-fence has been established, the coordinates defining that boundary will be considered the exact boundary line for the purposes of the timber sale, stewardship contract, or service contract. All errors associated with establishing the geo-fence will be incorporated into the legal boundary definition. This includes GPS receiver errors and any uncorrected remote sensed imagery errors.

Make sure the start of a geo-fence is clearly identified on the ground. If a geo-fence shares a corner with a painted boundary, a special boundary mark will need to be identified to designate the start and end of a geo-fence line. The recommended mark is to add two painted circles above the designated boundary mark.

In addition to locating these boundaries on the sale area map, an official digital vector/shape file will need to be developed that shows the formal designation of all geo-fence locations for the sale or project. This digital vector/shape file can be imported into GIS and survey applications to be used as an overlay on either a sale map or other remote sensed data.

Timber Marking and Cruising

Any crew going into units with a geo-fence will need to have a reliable GPS receiver and software that can relocate the boundary with at least the same accuracy as it was established. Marking crews will need to check the digital vector/shape file repeatedly as they approach a geo-fence, which will slow the crew down and add additional time to complete marking (Figure 5). Trees will need to be marked up to and not past the geo-fence boundary shown on the digital vector file/shapefile.

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

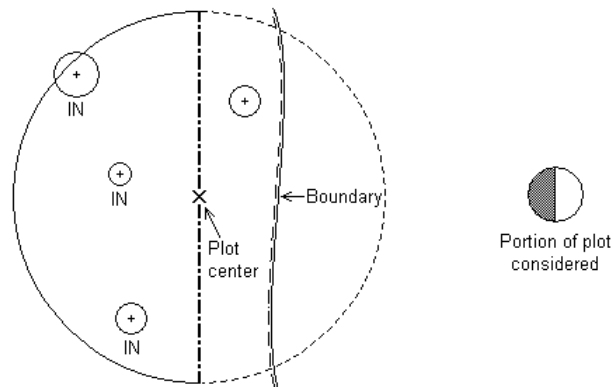


Figure 5. Cruiser using GPS in forest setting.

locations that occur near a geo-fence, where a portion of the plot may fall outside of the cutting unit boundary, will need to be handled using the half-plot or quarter plot method instead of using mirage plots or the walk-through method (FSH 2409.12 chap 34.23). For fixed plots, use the plot radius to determine if the plot extends beyond the geo-fence boundary. For variable plots, use the expected maximum limiting distance for the cut trees within the stratum as the plot radius for determining if a half or quarter plot is needed.

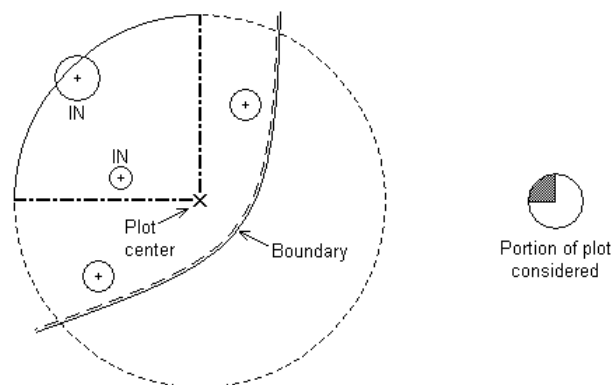
Half Plots and Quarter Plots. For half plots, an imaginary line is drawn through the center of the plot parallel to the tract boundary in such a way it does not cross the boundary (exhibit 01). A 180-degree sweep is made of the half plot falling within the unit boundary using the normal limiting distance calculations to determine if a tree is in the half plot. Since this plot represents only half the area of a regular plot, the “in” trees in are recorded twice. For two-stage methods, each “in” tree is tallied twice so it is possible for an “in” tree to be recorded as both a count and a measure tree depending on the selection frequency.

**Exhibit 01
Implementing a Half Plot**



If a sample plot falls in a corner or where the boundary forms an angle such that a half plot cannot be used, then a quarter plot should be used. For a quarter plot, two imaginary lines are placed through the center of the plot, so the lines form a 90-degree angle (exhibit 02). A 90-degree sweep is made on the quadrant existing entirely within the unit boundary using the normal limiting distance calculations to determine if a tree is in the quarter plot. As a quarter plot contains one fourth the area of a regular plot, each “in” tree is recorded four times.

**Exhibit 02
Implementing a Quarter Plot**



Data Management for Contract Administration

The official digital vector/shape file showing the formal designation of all geo-fence locations for the sale or project will need to be kept in a secure location (in a restricted folder on Pinyon for example) and will be the official file of record for sale or project geo-fence boundaries. The name and date of the file will need to be specified in the contract. Use contract provision WO-C2.30# - Cutting Unit Boundaries (7/22) if geo-fences are being used (see Appendix A). The official file of record should contain the contract name in the file name. Copies of this file will need to be provided to the marking crews, timber cruisers, and sale administrator. Copies of the file will be provided at sale advertisement for prospective bidders to accurately assess the sale. The purchaser/contractor awarded the sale will need to be provided with a copy of this file to locate all geo-fence boundaries.

Discernable Boundaries

Written descriptions of features used as discernable boundaries should be in the sale file and/or in a written logging plan document and clearly shown on the Sale/Contract Area Map.

Geo-Fence

The Allowable Contract Tolerance defines the level of accuracy error permitted in the contract and in the General Section of the timber sale prospectus. The operator will be required to select GPS receivers that meet the level of accuracy error selected. Although the [National Technology and Development Center \(NTDC\) Accuracy Matrix](#) can assist operators in determining appropriate receivers, the Accuracy Matrix should not be considered a list of approved receivers or devices. The operator will be required to cut trees up to and not past the geo-fence boundary shown on the digital vector file/shapefile using a GPS receiver that meets the Allowable Contract Tolerance (Figure 6).



Figure 6. Example of GPS receiver used in forest setting.

Area of Risk or Uncertainty

We use the term “risk” to mean there is the possibility the location showing on the GPS device is not the true location on the earth. “Error” is a measure of risk, as is “accuracy” and “precision”. We measure error in terms of “uncertainty.” The GPS recorder used by the operator is expected to keep any management activities within the area risk. The Sale Administrator (SA) is expected to validate the management activities stayed within the area of risk.

The level of Allowable Contract Tolerance defines the Area of Risk. Even though the GPS position might show as being on the geo-fence line, the real world position could be anywhere with the circle defined by the GPS accuracy error. By defining the maximum acceptable GPS accuracy error, the Area of Risk is also defined (Figure 7). Within this area of risk, the resource treatment may be applied inconsistently, sometimes not reaching the geo-fence line while sometimes going over the geo-fence line, even though the operator, according to the GPS readings, is cutting up to and not over the geo-fence line.

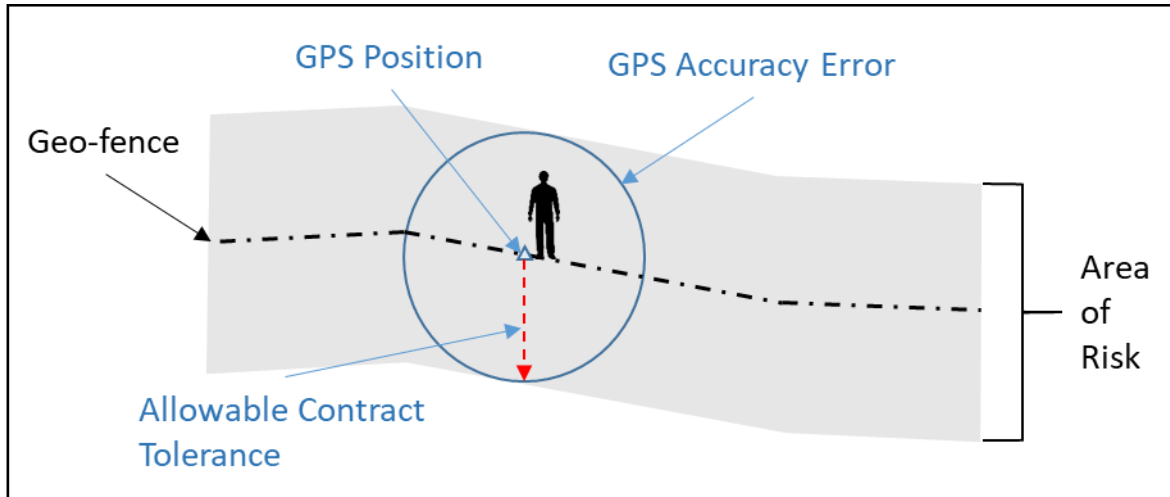


Figure 7. Area of Risk Defined by Allowable Contract Tolerance

However, there is an additional source of error needing consideration. When the geo-fence is checked by the SA, the GPS receiver used by the SA will have an accuracy error associated with the device as well. Because the SA is checking to see if the operator stayed with the Allowable Contract Tolerance, the SA will need to check the work against the area of risk and not just the geo-fence boundary. The accuracy error of the GPS receiver used by the SA will therefore be additive to the Allowable Contract Tolerance.

When the SA locates the geo-fence line, the GPS accuracy error creates an area of uncertainty around the SA's position. Because the real-world position of the SA can be anywhere within the area defined by the GPS accuracy error, the maximum GPS accuracy error, or worst-case scenario, will need to be added to the Allowable Contract Tolerance to determine if the operator is in compliance (Figure 8). Otherwise, the SA could call stumps or trees outside of compliance when they were actually in compliance due to the SA GPS accuracy error.

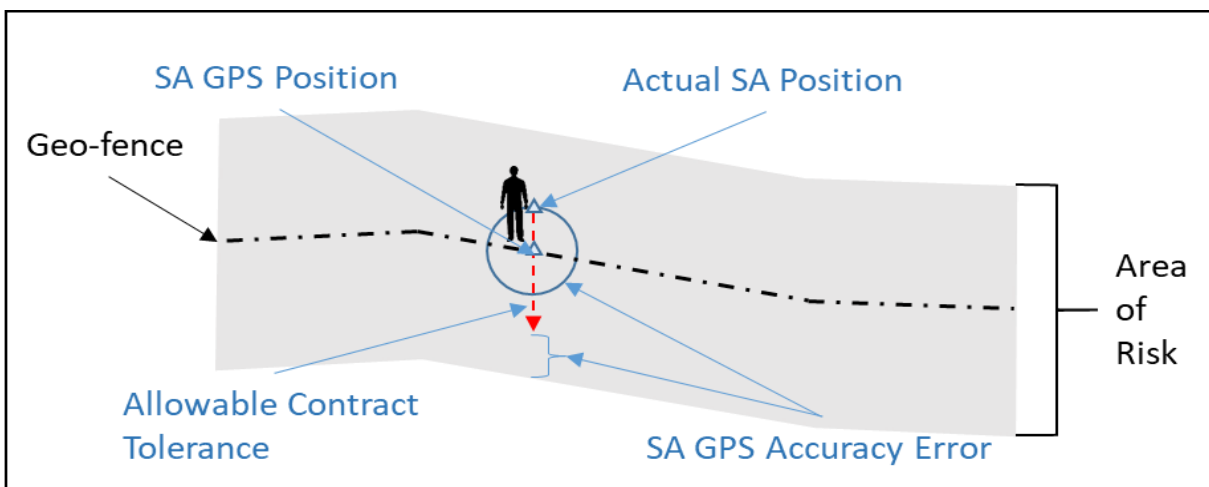


Figure 8. Worst-case SA GPS Accuracy Error combines with Allowable Contract Tolerance.

If the worst-case scenario happens in the direction closest to the Allowable Contract Tolerance boundary checked, the additional area of risk is double the SA GPS accuracy error. The definition of the Actual Area of Risk is the Allowable Contract Tolerance plus twice the GPS accuracy error from the receiver used by the Sale Administrator (Figure 9).

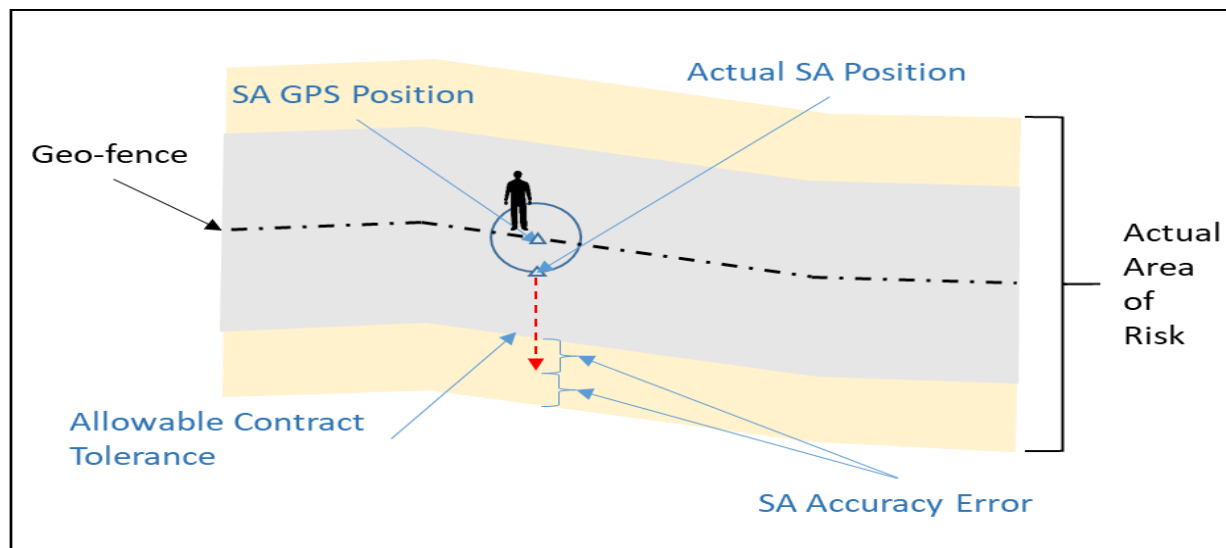


Figure 9. Actual Area of Risk includes twice SA GPS Accuracy Error Assuming Worst-Case Scenario.

To minimize this actual area of risk, the GPS receiver used by the Sale Administrator should have low accuracy errors.

Sale Administration and Contract Compliance

To check the boundary for compliance, the SA will need:

- The final geo-fence vector file/shapfile (named in the contract provision WO-C2.30# - Cutting Unit Boundaries (7/22)).
- An appropriate device (tablet/cell phone/mobile device) connected to a GPS receiver with a minimum, tested accuracy error that meets the contract specifications.
- Appropriate software (e.g. Two-Trails or Field Maps) displaying the geo-fence as a vector line (as opposed to a raster line) and able to collect and store waypoints as a way of documenting stump locations.
- Knowledge of basic GPS collection requirements (see Appendix B).

The compliance check will use the SA Compliance Distance defined as the Allowable Contract Tolerance plus the GPS accuracy error from the SA's receiver to determine if the resource treatment stayed with the geo-fence boundary. The Allowable Contract Tolerance is defined in the contract provision WO-C2.30# - Cutting Unit Boundaries (7/22).

There are two methods available for checking contract compliance: a manual method and a digital method.

Manual Method for Contract Compliance Checks

A two-phase procedure is recommended for the manual method; a quick check and a compliance check.

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. 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 (Figure. 10). A rangefinder laser device will be the most efficient way to determine horizontal distance to the stump. If the stump is within the tolerance (Allowable Contract Tolerance plus the SA GPS 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.

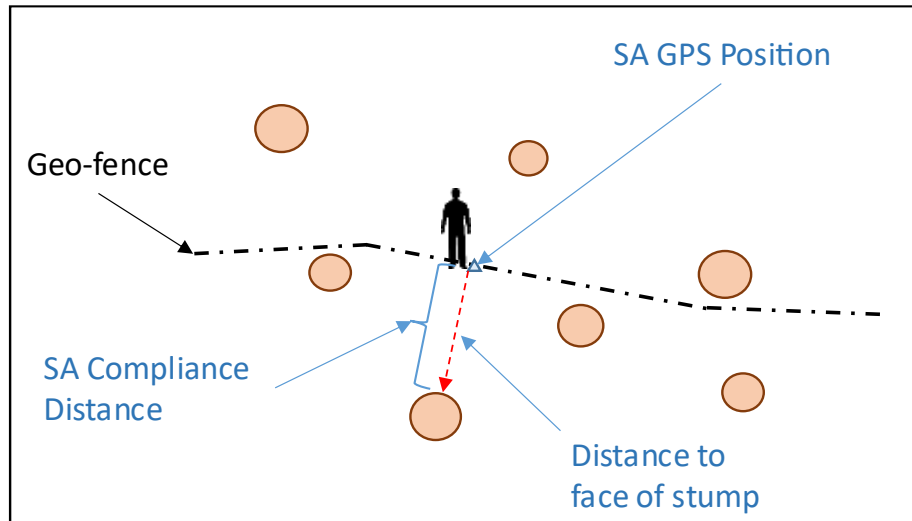


Figure 10. Quick Check Procedure.

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 GPS receiver on the stump edge closest to the geo-fence when determining the location (Figure 11).

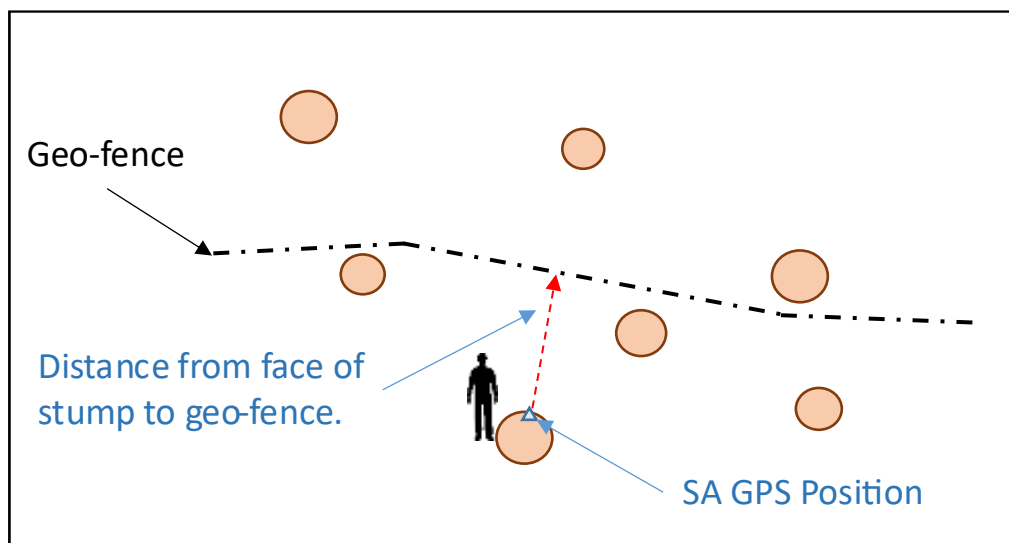


Figure 11. Collect Stump Position and Compare to Geo-Fence Line for Compliance Check.

Record the GPS locations of possible noncompliance stumps on the digital shapefile/vector file and the distance to the geo-fence is determined. If the stump location is outside of the tolerance, the stump is in non-compliance. This can be determined in the field if the software used by the SA has the capability to do this calculation. Otherwise, the calculation will have to be done in the office. The SA will have a record of the stump location (so it can be easily relocated) and its proximity to the legal geo-fence line. For standing trees, a GPS location (using the average of 60 positions) taken close to the tree under open sky with a side-shot to the tree will give the best possible location. Use a side shot to the face of the tree that is perpendicular or in-line to the geo-fence boundary (Figure 12). This will remove possible Azimuth error. If the back side of the tree is located, the tree DBH will need to be added to the side shot distance to determine a distance from the tree to the geo-fence line. As with stumps, record the GPS locations of possible noncompliance standing trees on the digital shapefile/vector file and the distance to the geo-fence is determined.

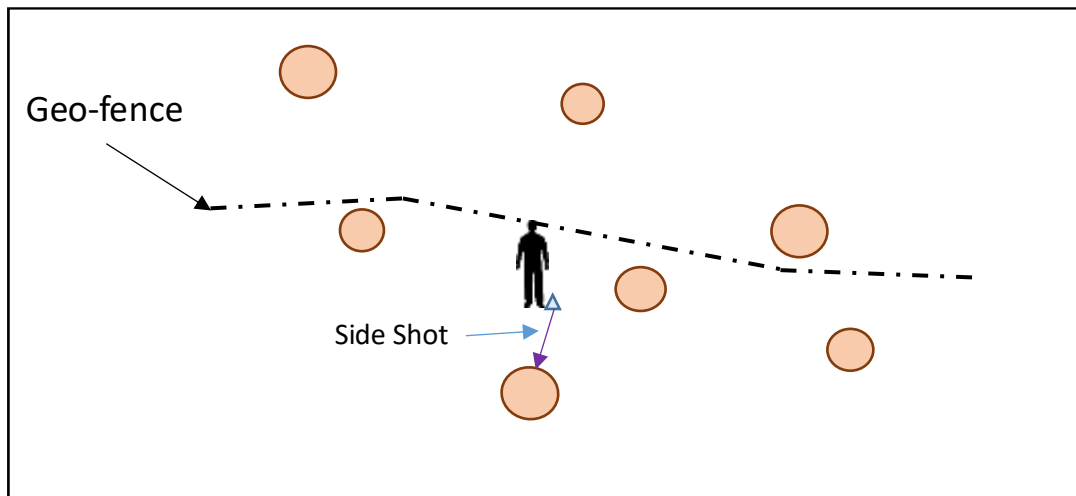


Figure 12. Collect standing tree position with an in-line side shot for compliance check.

Digital Method for Contract Compliance Checks

The Forest Service Application TwoTrails has been updated with a feature to assist the SA with contract compliance checks along geo-fences. TwoTrails can determine the distance between the GPS receiver location and the closest boundary location in real time. The SA enters the SA Compliance Distance (Allowable Contract Tolerance plus the GPS accuracy error from the SA's receiver) into TwoTrails and the application can assist with checking compliance along the geo-fence boundary. This is also a twostep process: the quick check and the compliance check.

Quick Check

The SA walks along the stump line left by the operator quickly checking each stump to see if it is within the SA Compliance Distance. If the dashed line indicating the distance to the geo-fence is black, the stump or tree checked is within the SA Compliance Distance and SA continues along the stump line (Figure 13).

If the stump or uncut tree is out of tolerance, the dashed line indicating the distance to the geo-fence will change to red (Figure 14). Once this occurs, the SA will move to the compliance check.

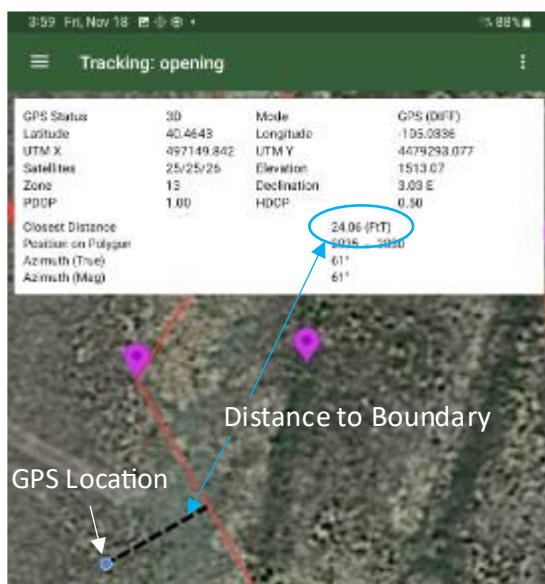


Figure 13. Digital Quick Check using TwoTrails where stump is within SA Compliance Distance.

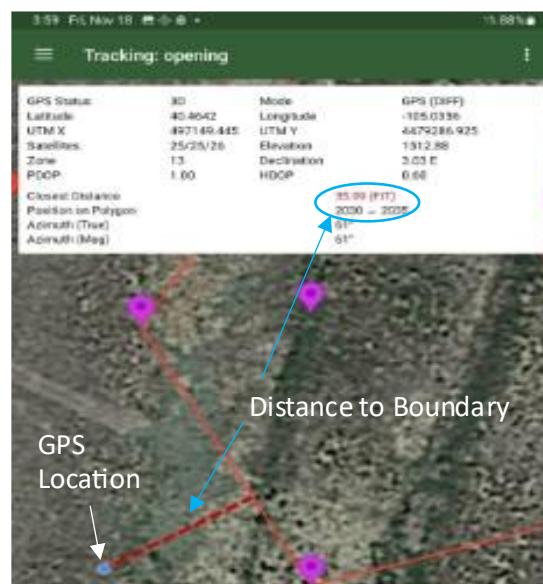


Figure 14. Digital Quick Check using TwoTrails where stump is outside SA Compliance Distance.

Compliance Check

The SA will need to place the GPS receiver on the stump edge or face of the uncut tree closest to the geo-fence when determining the location of the stump or uncut tree. The TwoTrails application will take average of 60 GPS measurements to determine this position. If the stump or uncut tree is determined to be outside of the compliance distance, the SA will log this information and TwoTrails will create a geospatial point for the stump or uncut tree.

Boundary Inspections

Prior to cutting operations commencing on a sale, Sale Administrators should demonstrate to the Purchaser how cutting along a geo-fence boundary will be inspected. Sale Administrators should perform an inspection of cutting along a geo-fence boundary as soon as safely possible when cutting first begins on the sale. It's recommended the results of the initial inspection be reviewed with the Field Supervisor or Purchaser Representative. After initial inspection, inspections should be performed at a frequency based on the results of previous inspections. Factors such as the number of trees observed cut past or not up to the allowable contract tolerance will determine the frequency of inspections. Sale Administrators should increase boundary inspections as the occurrence of trees cut past the SA compliance distance increases. As part of final acceptance, portions of boundaries should be inspected uniformly across the cutting unit boundary.

Law Enforcement will need to be aware of how Geo-Fence boundary locations are determined, and what hardware and software are required for use, along with the new geo-fence contract requirements. Law Enforcement should be invited to accompany inspections to become familiar with the inspection process. The Timber Theft Plan may need to be updated for geo-fence inspections.

Conclusion

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. For geo-fences to

work efficiently in the field, proper sale administration procedures need to be followed and frequent communication between all parties throughout the process will be essential.

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Appendix A: Contract Provision

C2.30# - CUTTING UNIT BOUNDARIES. (7/22) Notwithstanding BT2.3, the boundaries of cutting units, or portions of cutting units, are identified as shown on the Cutting Unit Boundary Designation Table below and the Sale Area Map.

Cutting Unit Boundary Designation Table

Cutting Unit(s) ^{1/}	Paint Color ^{2/}	Designation Method ^{3/}	Description ^{4/}

Marked boundary trees shall not be cut.

Discernable Boundaries are boundary locations that are readily identifiable features on the ground in locations shown on the Sale Area Map.

A Geo-Fence is a location on the ground corresponding to the boundary location shown on a mobile mapping device using a Global Positioning System (GPS) Receiver using the digital vector file/shapefile named 5/_____ and dated 6/_____. The digital vector file/shapefile will be provided to the Purchaser by the Forest Service. A digital list of the coordinates can be provided upon request.

Included Timber is located within and not past the boundary as shown on the mobile mapping device using the digital vector file/shapefile listed above. Purchaser is responsible for obtaining a GPS receiver(s) that is capable of determining the location of the true Geo-Fence within the contract tolerance. Allowable contract tolerance is 7/_____feet.

Forest Service inspection of cutting Included Timber to determine if cutting is within allowable contract tolerance, shall use the digital vector file/shapefile named and dated above using a GPS Receiver with a minimum, tested accuracy in a 8/_____ canopy of 9/_____feet.

National Technology Development Program GPS Receiver accuracy reports by GPS manufacturer and model are available at: <https://www.fs.fed.us/database/gps/mtdcrept/accuracy/index.htm>. Forest Service determination of boundary location will be final.

As an operational convenience and subject to written agreement by the Forest Service, in advance of marking, Purchaser may mark Geo-Fence boundaries on the ground with Purchaser's non-tracer paint. Boundary trees shall not be identified with paint applied below stump height. Purchaser shall bear all costs associated with painting used to visually identify boundaries. Forest Service will not approve or accept the boundaries identified on the ground by the Purchaser in advance of cutting.

In case of a major disruption in GPS service, or lack of GPS coverage on the Sale Area beyond the control of the Purchaser, as determined by the Contracting Officer, the Purchaser's only remedy shall be Contract Term Adjustment under BT8.21. Qualification requirements are described in BT8.21. To resolve major disruption of GPS service, or lack of GPS coverage on the Sale Area, the Forest Service may elect to Mark Geo-Fence boundaries on the ground, in which case the Forest Service's determination of boundary location will be final.

Purchaser may request Forest Service Marking of Geo-Fence boundaries on the ground with paint at Purchaser's expense. Approval by the Contracting Officer is subject to agreement on cost under BT4.218 Cooperative Deposits and the availability of Forest Service personnel. If Purchaser's request is approved, Forest Service determination of boundary location will be final.

WO-2400-6T-C2.30#

INSTRUCTIONS: For use in 2400-6T contracts. Geo-Fence boundary designation is only approved for use where the timber designation method is cut tree marking. Geo-Fence boundary designation methods should be described in the timber sale Prospectus general section, include a list of Cutting Units with Geo-Fence boundaries.

- 1/ List cutting unit number(s).
- 2/ Include the paint color (for example orange, pink or white).
- 3/ List the designation method as Marked, Discernable or Geo-Fence.
- 4/ For Marked designation method describe how the boundary trees are marked above and below stump height. For Discernable designation method list the discernable feature(s). For Geo-Fence designation method list as "See description below". Example:

Cutting Unit(s)	Paint Color	Designation Method	Description
1, 2, 3, 4, 5	Orange	Marked	Boundary trees are marked with three vertical stripes on three sides of the tree. Two stripes face the direction of adjacent boundary marked trees and extend from ground level to approximately eye level in height. A shorter stripe faces the area of cutting. Unit numbers are painted on approximately every 5th boundary tree.
4, 6		Discernable	Fence
5		Discernable	Fence and Road
2		Geo-Fence	See Description below

5/ List the electronic file name of the digital vector file or shapefile to be provided to the Purchaser.

6/ Modified date shown in the file properties for the digital vector file or shapefile shown in 5/.

7/ Allowable distance cutting may occur up to and past Forest Service determined boundary location. Distance listed is the allowable GPS accuracy error. Allowable distances should take into account value of resources at risk, impacts of treatments that may occur outside planned boundaries, impacts of treatments not occurring up to planned boundaries, social/economic factors and level of risk the responsible official is willing to take. Generally, the fill in tolerance should not exceed 30 feet or be less than 15 Feet. Enter whole numbers only. GPS accuracy errors by receiver type as established by Missoula Technology & Development Center. 8/ List open, light-medium or heavy-closed for manufacturer and receiver type used as shown at

<https://www.fs.usda.gov/database/gps/mtdcrept/accuracy/index.htm> 9/ List tested accuracy in feet for canopy type shown in meters at

<https://www.fs.usda.gov/database/gps/mtdcrept/accuracy/index.htm>

Appendix B: Basic GPS Collection Requirements

The Global Positioning System (GPS) utilizes signals transmitted from satellites to determine the coordinate location (X, Y, and Z) of points on the ground. Before taking measurements, allow the GPS receiver to “warm up” for a sufficient amount of time to download a current GPS ephemeris. This may take as long as ten minutes and may be done while walking to the site if the antenna is kept in view of the satellites (avoid heavy canopy closure and obstacles). Use only three-dimensional GPS measurements. This requires a minimum of four satellites. SBAS (Satellite Based Augmentation Systems) should be used where available, such as WAAS (Wide Area Augmentation System) for GPS.

Only filtered information from a GPS receiver is adequate for area-determination measurements. Filtered information means satellite information that has been inspected, ordinarily by software, before acceptance into a position calculation. The filtering process checks whether criteria such as HDOP limits and 3D mode are being met. Signals not meeting defined criteria are rejected for measurement. Some GPS receivers can filter satellite information as it is collected: this type of information does not need further filtering. For GPS receivers that do not do this, software to filter GPS information data or similar procedures can be used. This second situation usually requires that the GPS receiver have an internal operating system or be connected to a data recorder with an operating system that can run filtering software. Programs like TwoTrails© and ArcPad© can be configured to meet this requirement.

GPS receivers calculate a position when they receive signals from satellites. Any interference with these signals can cause errors in positioning. The optimal observing environment is a clear, open sky with little or no canopy closure. During measurements, position the antenna of the GPS receiver above local obstacles (including the body) as much as possible. Take care to avoid situations that could cause multipath errors (reflected, redirected, or bounced signals) such as proximity to cliffs, large rocks, buildings, trucks, signs, power lines, and nearby large tree boles.

Coordinates for determining position may be calculated in any appropriate coordinate system, datum, and projection. The mapping projection, coordinate system, and datum used must always be associated with the coordinates. The process used must be clearly identified for each and every operation, such as data collection, calculations, mapping values, and any conversions or translations performed. Methods of conversion or translations between different systems must be documented. The USDA Forest Service presently requires data be reported in the NAD 83 datum for official mapping operations.