

Grounded Fuel Mapping: Measured, Modelled, and Grounded

Foundation essay on the three basis classes that make physical fuel data auditable

Public Cut

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Executive Summary

Every wildfire risk model that feeds an underwriting decision, a wildfire mitigation plan (WMP) docket, or an infrastructure rate case starts with a **fuel number**. The question that determines whether that number can survive audit is not resolution or color ramp — it is **basis**: *where did the number come from, and is that origin declared?*

Grounded Fuel Mapping is the intellectual foundation that answers that question with three mutually exclusive basis classes:

Basis	Public meaning
Measured	Value derived strictly from physical, direct empirical observation at a known place and time
Modelled	Value derived from spectral proxies, satellite classifications, spatial interpolations, or machine-learning inferences where no biomass was physically weighed on site
Grounded	Spatial fuel surface initiated as a model and mathematically constrained by local, temporally co-located measured anchors , validated against held-out ground observation

Mixing unlabeled bases — treating a landscape-scale spectral estimate as if it were a clipped quadrat, or letting a single field clip “sponsor” cells hundreds of meters away — breaks underwriting, WMP defense, and third-party audit. The remedy is not to ban models. It is to **tag every cell, bound every measured influence, and seal which basis was claimed** so that provenance travels with the value.

GFMS-1.0 is the open **standard** that turns the foundation into normative interface rules. **CFI** is the enterprise technology **category**. **PlotSeal** names the **registry / system of record** concept for sealed observations. **GFHL** is the **spatial expression** of grounded fuel at hazard-layer scale. **RiskWise** is a **commercial vehicle** — not the thesis of this document.

Soft next step only: read GFMS-1.0 Public; ask of any fuel layer whether every feature declares basis, carries support and uncertainty context, and seals offline-verifiably which basis was used.

1. Problem — Why Unlabeled Fuel Bases Fail Audit

Wildfire exposure decisions for utilities, insurers, reinsurers, model vendors, and infrastructure operators increasingly rest on spatial fuel layers. Two practices dominate — and both leave a structural gap when used alone:

Practice	Typical origin	Structural gap
Remote sensing / spectral models	Statistical inference from above-canopy reflectance and related proxies	Cannot weigh sub-canopy surface fuel; audit trail is a model pipeline, not a physical condition
Traditional field notes	Paper logs, photos, unverified spreadsheets	High local knowledge, but records are easily altered and rarely carry offline-cryptographic proof of <i>what was claimed</i>

Claim (foundation thesis): High-consequence environments need an explicit basis taxonomy — Measured / Modelled / Grounded — before they need another model. Without that taxonomy, “ground truth,” “high resolution,” and “AI fuel map” compete on marketing language rather than on auditable properties.

Illustration (non-normative): A cell labeled 4.1 tons per acre tells an underwriter nothing about whether someone clipped biomass at that location, whether a satellite class was interpolated, or whether a model was constrained by nearby measured anchors. Without a basis tag, the number is unclassifiable for docket defense.

Asset-level risk is a **localized** problem. The fuel load at the base of a substation fence, within a treated buffer around a battery energy storage system, or along the first meters of a transmission corridor is poorly represented by a regional average. The zones that matter most to asset protection are exactly the zones where landscape-scale remote sensing is least reliable — and where unlabeled blending of field clips and spectral surfaces creates the greatest audit risk.

Modeled data is not wrong. Field data is not automatically trustworthy. **What breaks underwriting, WMP review, and opposing-counsel challenge is the silent mixture of the two without disclosure.**

2. Framework — The Three Basis Classes

2.1 Measured

Measured (basis: measured) means the value is derived strictly from physical, direct empirical observation — for example, a quadrat of clipped fuel dry-mass or a point-count curing observation — traced to a field collection event with attributable place, date, method class, recorder (or role), and evidence handle.

A spatial cell or attribute **does not** inherit measured merely because a measurement occurred somewhere in the same county, the same parcel, or the same remote-sensing tile. Measured is reserved for the direct observation location (and its declared geometry), not for speculative inheritance.

2.2 Modelled

Modelled (basis: modelled) means the value is derived from spectral proxies, satellite classifications, spatial interpolations, machine-learning inferences, or other algorithmic surfaces where **zero biomass was physically weighed on site** for that cell.

Modelled is an honest and necessary class for landscape coverage. The failure mode is not the existence of modelled cells — it is presenting them as if they were measured, or letting them silently inherit measured status from distant anchors.

2.3 Grounded

Grounded (basis: grounded) means a spatial fuel surface that was **initiated as a model** and then **mathematically constrained by local, temporally co-located measured anchors**, with validation against held-out ground observation.

Grounded is not a marketing synonym for “better model.” It is a third class with a different claim: the surface remains model-initiated, but its local behavior is bound by measured evidence within declared support limits. Outside those limits — or across a stratum (ecological / vegetation / management) boundary — influence terminates and cells revert to modelled.

Naming lock reminder: *Grounded Fuel Mapping* names the intellectual foundation and the practice of declaring these three classes. **GFMS-1.0** is the open **standard** that makes the foundation normative. **CFI** is the **category**. Do not collapse these names.

2.4 Support bounds (conceptual)

A measured anchor must not be allowed to “sponsor” fuel values at arbitrary distances. **Claim (conceptual):** spatial influence of a physical measurement is finite; beyond a declared support radius, or upon crossing a stratum boundary, cells must not retain measured or grounded status by inheritance.

Normative maxima, adequacy rules, and conformance classes are published in **GFMS-1.0** (Document ID HPS-09-MAP-01). This essay does not restate normative thresholds as requirements; it teaches why bounds exist. Readers who need the interface rulebook should consult GFMS-1.0 Public directly (including the published support-radius maximum and reversion rules).

2.5 Cryptographic seal as provenance of *which basis*

A cryptographic seal on a fuel record is not primarily a marketing badge. In the grounded-fuel stack, the seal's public job is to prove **which basis was claimed**, for **which payload**, at **collection time**, in a form that remains **offline-verifiable** without vendor intervention.

Under the open interface (GFMS-1.0): payloads are canonicalized (e.g., RFC 8785) so digests are reproducible; dual digests (SHA-256 / SHA3-256) provide tamper-evident integrity; legal and regulatory lookup codes ride in the record envelope **outside** the physical-measurement seal, so rule updates do not invalidate historical physical proofs.

Claim: Without sealing the basis declaration into an offline-verifiable payload, basis tags can be rewritten after the fact. The seal is provenance of *which basis* — not a substitute for measurement itself.

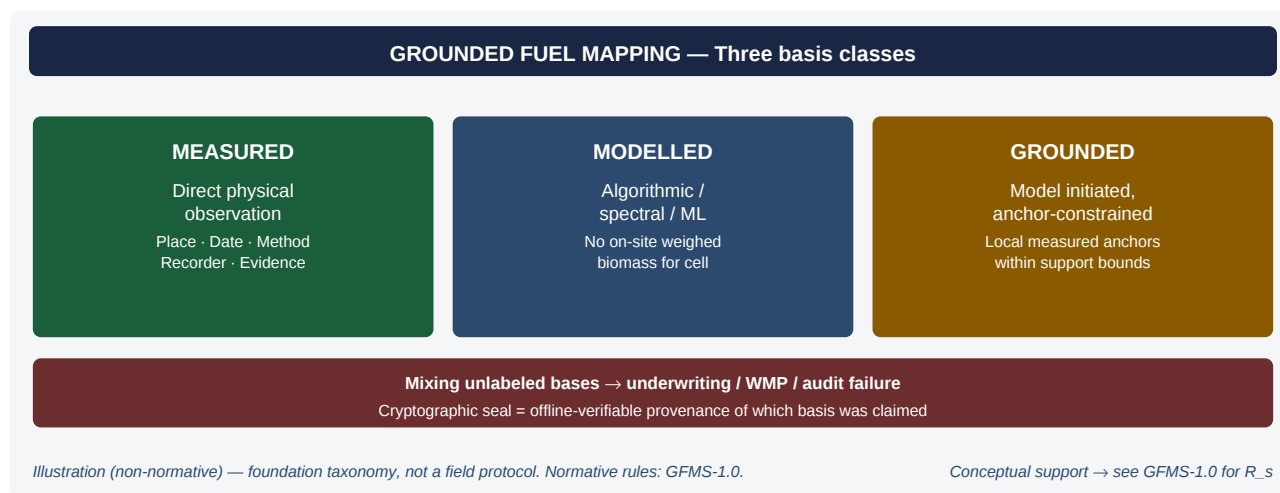


Figure 1 — Basis taxonomy (Measured / Modelled / Grounded). Illustration (non-normative).

3. Proof — Why the Taxonomy Holds

3.1 Comparative standing (informative)

Existing spatial and fuel standards address file structures, exposure schemas, or remote-sensing classifications. None of them, by themselves, force the three-way basis distinction, hard spatial support termination, and cryptographic proof of which basis was claimed.

Property	Typical unlabeled fuel layer	Grounded Fuel Mapping foundation
Basis declared per cell/feature	Often absent or implied	Mandatory Measured / Modelled / Grounded
Sub-canopy surface fuel mass	Optical/spectral blind under dense canopy	Requires physical observation for Measured; Grounded only where anchors constrain
Spatial sponsorship limits	Continuous interpolation common	Finite support; stratum termination; reversion to Modelled
Audit question answerable offline	Usually no	Yes when sealed payloads carry basis + provenance
Docket / underwriting defense	Narrative report + model story	Basis-tagged, support-bounded, seal-verifiable record

Structural note (claim, physics — not product pitch): Reflected light above the canopy cannot reveal sub-canopy surface fuel mass at any optical resolution. Higher-resolution imagery and AI post-processing refine estimates of what the sensor can see; they do not convert reflectance into weighed biomass under dense canopy. Grounded Fuel Mapping does not “beat AI at imagery.” It answers a different question: *what class of evidence is this cell, under what support, with what sealed claim?*

3.2 Failure modes of silent mixing

Illustration (non-normative) — four failure modes:

- **False measured inheritance** — A single quadrat is used to recolor an entire treatment buffer as “ground truth.”
- **Unbounded sponsorship** — A clip in shrub-steppe calibrates cells across a gravel pad or managed turf as if stratum did not matter.
- **Resolution cosplay** — A high-resolution spectral product is presented as asset-level physical condition.
- **Post-hoc basis rewrite** — Tags or accompanying PDFs are edited after submission without a seal that breaks on change.

Each failure mode is preventable by the foundation: explicit tags, bounded support, and sealed provenance of which basis was claimed.

3.3 Stack linkage (naming locks)

Name	Role	Public classification
Grounded Fuel Mapping (this essay)	Intellectual foundation — three basis classes + why they matter	F1 foundation essay
GFMS-1.0	Open interface standard (schemas, basis, spatial support, uncertainty, seal format)	Technical Public open standard
GFHL	Spatial expression of grounded fuel at hazard-layer scale	Named spatial expression; internals not this essay
PlotSeal	Registry / system of record concept for sealed observations	Named SoR concept; implementation internals not public
CFI	Enterprise technology category (physical + open rules + seal + custody)	Category doctrine

Name	Role	Public classification
RiskWise	Commercial vehicle that may deliver conformant workflows	Commercial packaging — outside this essay's thesis

Open vs. proprietary boundary (public-safe):

- **Open (interface):** Three-tier basis taxonomy; support and reversion concepts as published in GFMS-1.0; RFC 8785 canonicalization and dual-digest structure; conformance checklist for claiming GFMS-1.0 compliance.
- **Not disclosed here:** Proprietary field-collection execution engines, registry implementation architecture, device-binding or key-management internals, commercial scoring or exposure engines, calibration weight tables, and internal go-to-market programs.

Allowed public phrase: Proprietary field-collection protocols may produce GFMS-1.0-conformant payloads; they are not required for external conformance.

4. Implication — Who Uses the Foundation and How

Grounded Fuel Mapping matters wherever a fuel number must survive third-party challenge:

- **Utility wildfire mitigation plans (WMPs)** and related regulatory dockets that must defend fuel inputs.
- **Insurance and reinsurance** analytics that underwrite or price wildfire exposure using fuel assumptions.
- **Catastrophe and wildfire model vendors** (and their utility / insurer clients) that need basis-honest fuel inputs rather than unlabeled blends.
- **GIS and spatial-platform operators** that publish or consume fuel layers and need a shared vocabulary for provenance.
- **Infrastructure asset owners** (renewables, substations, corridors, oil & gas surface facilities) that need defensible-space and fuel documentation.
- **Field service and data intermediaries** that want to publish or consume an open, conformant interface rather than a vendor-locked fuel story.

Implication for adopters: Adopt the **foundation language** first (Measured / Modelled / Grounded; support-bounded; seal as basis provenance). Then adopt the **open standard** (GFMS-1.0). Evaluate commercial vehicles — including RiskWise — only after the interface and evidence properties are clear. Category and standard growth do not require exclusive use of any one vendor; they require shared rules and verifiable properties.

Soft next step (teach, don't sell)

1. Read **GFMS-1.0** (Public cut) — Document ID HPS-09-MAP-01 — for normative interface requirements (including support radius and conformance classes).
2. Ask of any fuel layer in your stack: *Does every feature declare basis? Is measured influence spatially bounded? Is uncertainty present where claimed? Does a seal prove offline which basis was claimed?*
3. Contact High Plains Shield, LLC at info@highplainshield.com for standards clarification or conformant-implementation questions — not a product hard sell.

5. Limitations — What This Document Is Not

This Public cut:

- **Is not** an open standard (see GFMS-1.0).
- **Is not** a product datasheet, SKU list, or pricing document.
- **Is not** a disclosure of proprietary field-collection protocols, registry architecture, key-management, device attestation, scoring engines, calibration weights, or trade-secret thresholds.
- **Does not** claim that every remote-sensing product is unfit for all uses; it claims remote sensing alone cannot substitute for physical sub-canopy fuel mass where that mass is the decision-critical input — and that unlabeled mixing of bases breaks audit.
- **Does not** restate GFMS-1.0 normative thresholds as if this essay were the rulebook; normative values live in GFMS-1.0.
- **Does not** guarantee regulatory acceptance in any specific jurisdiction; acceptance depends on local rules and docket practice.
- **Does not** describe PlotSeal, GFHL, or commercial-vehicle internals beyond public naming-lock roles.

Quantitative performance claims for any commercial implementation are **out of scope** here and must be labeled separately as claim, requirement, or illustration in those materials.

6. Glossary

Term	Public meaning
Grounded Fuel Mapping	Intellectual foundation and practice of declaring Measured / Modelled / Grounded fuel bases with bounded support and sealed provenance.
Measured	Basis class: direct physical empirical observation at a known place and time.
Modelled	Basis class: algorithmic / spectral / ML inference without on-site weighed biomass for that cell.

Term	Public meaning
Grounded	Basis class: model-initiated surface constrained by local, temporally co-located measured anchors within support limits.
GFMS-1.0	Grounded Fuel Mapping Standard — open interface standard for representation, spatial support, uncertainty, and cryptographic provenance of physical fuel data.
Support radius (R_s)	Maximum distance a measured anchor may influence adjacent cells; normative maximum published in GFMS-1.0.
Stratum boundary	Ecological, vegetation, or management zone transition beyond which measured influence terminates.
CFI	Enterprise technology category for physical, cryptographically proven fuel intelligence. Not “the standard.”
GFHL	Spatial expression of grounded fuel at hazard-layer scale.
PlotSeal	Registry / system of record concept for sealed fuel measurement records. Not “Wildfire Data Center.”
RiskWise	Commercial vehicle that may implement CFI-conformant workflows. Not the category; not the open standard.
Dual-hash / dual-digest	Concurrent SHA-256 and SHA3-256 digests over a canonical payload for tamper-evident integrity.
RFC 8785 canonicalization	Deterministic JSON canonicalization so digests are reproducible across systems.
Offline verification	Ability to check digests without proprietary API authentication or vendor intervention.

Document Control

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Contact	info@highplainshield.com

Revision History

Version	Effective	Summary	Gates
Public v1.0	2026-09-24	First dedicated public foundation essay: three basis classes; unlabeled-mixing failure modes; Grounded = model constrained by measured anchors; support bounds conceptual (normative $R_s \rightarrow$ GFMS-1.0); seal as provenance of which basis; stack linkage with naming locks; Figure 1 visual proof; Limitations + Glossary; soft CTA; §4 scrub; clean Markdown $\rightarrow$ PDF.	Author $\rightarrow$ Technical Review $\rightarrow$ Publication Review $\rightarrow$ Release (HPS process)

Pre-Publish Checklist (Hard Gate) — Recorded Pass

- Format F1 selected; Problem $\rightarrow$ Framework $\rightarrow$ Proof $\rightarrow$ Implication spine complete
- Author = High Plains Shield, LLC everywhere (including metadata)
- Face block complete: Document ID · Version ID · Effective Date · Supersedes · Classification · Author
- Naming locks: CFI = category · GFMS-1.0 = standard · RiskWise = commercial vehicle · PlotSeal = registry/SoR · Method 1.1 / forbidden internals absent
- Claims vs illustrations labeled; Limitations present; Glossary present
- IP gate cleared (§4 scrub): FMES, HPFS thresholds, Method 1.1, Structural MVE, PlotSeal implementation, calibration weights, Field Gauge / TrueFuel / WROS / VALOR engines absent
- Visual proof: Figure 1 basis taxonomy (Measured / Modelled / Grounded)
- Production clean from Markdown (no DOCX artifacts)
- Technical Review + Publication Review recorded (HPS process)
- Minimum credibility length met; teach-don't-sell tone verified
- No Netlify publish (held to T19); parent attaches PDF only for peer review

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