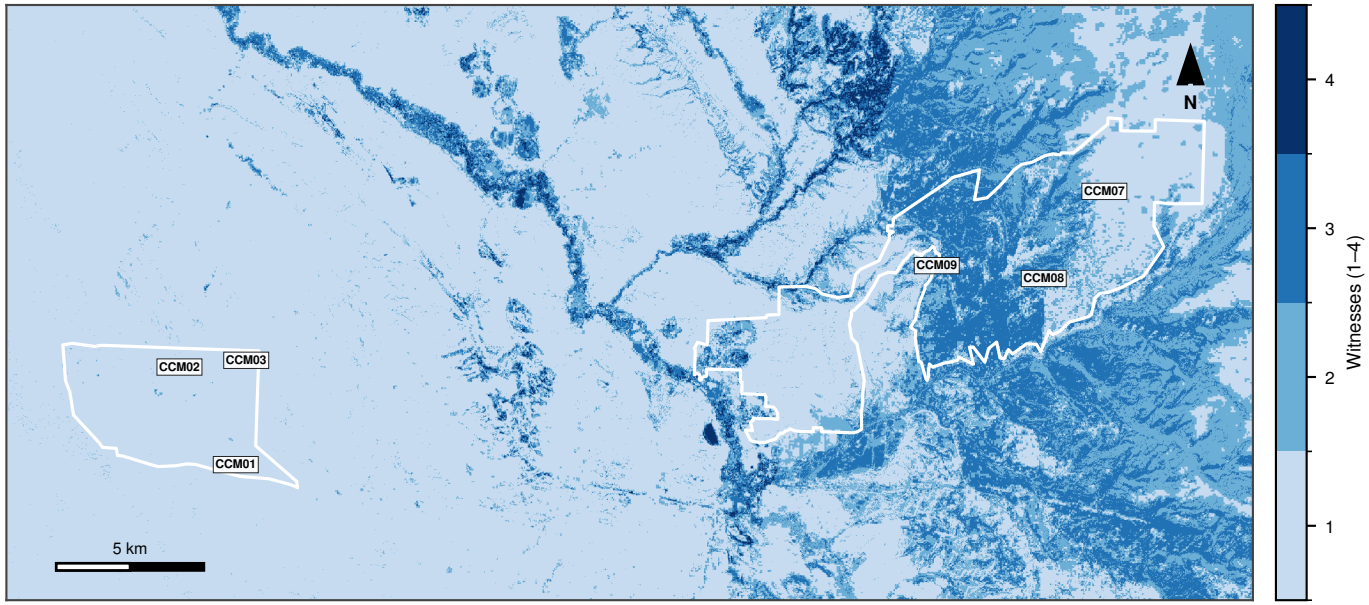
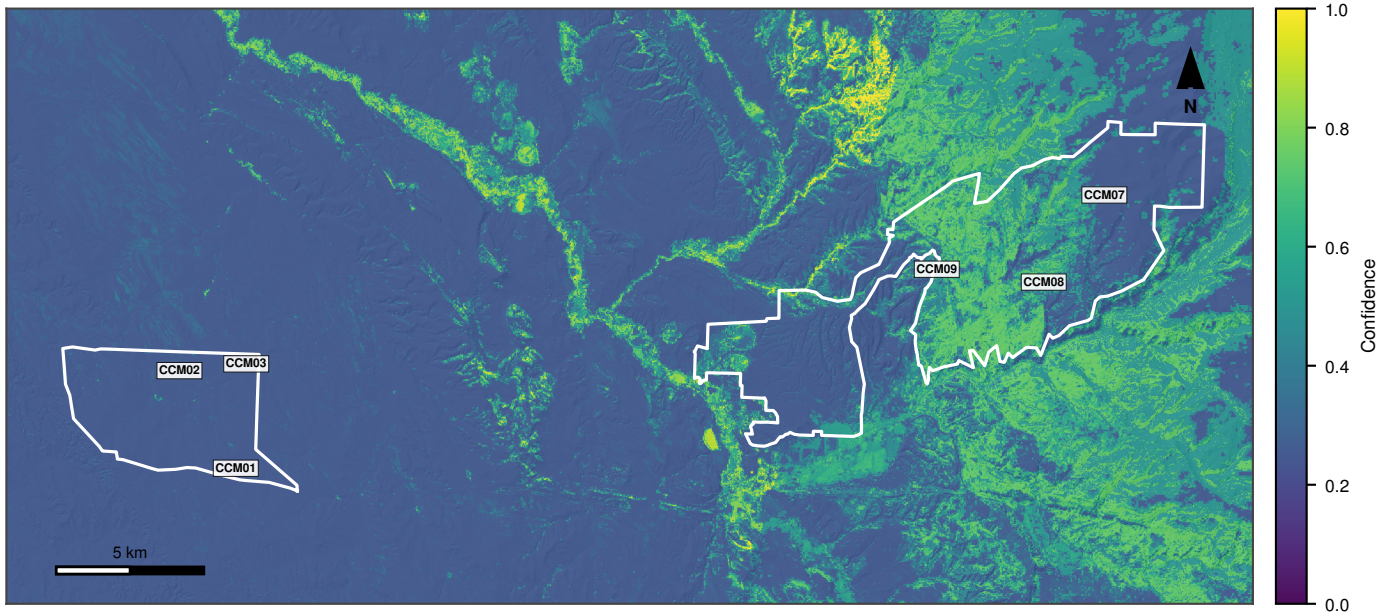
Four independent witnesses for juniper — EMIT, EnMAP, HLS winter-evergreen, GEDI structure

Juniper presence = at least two witnesses and confidence ≥ 0.25

Witness count



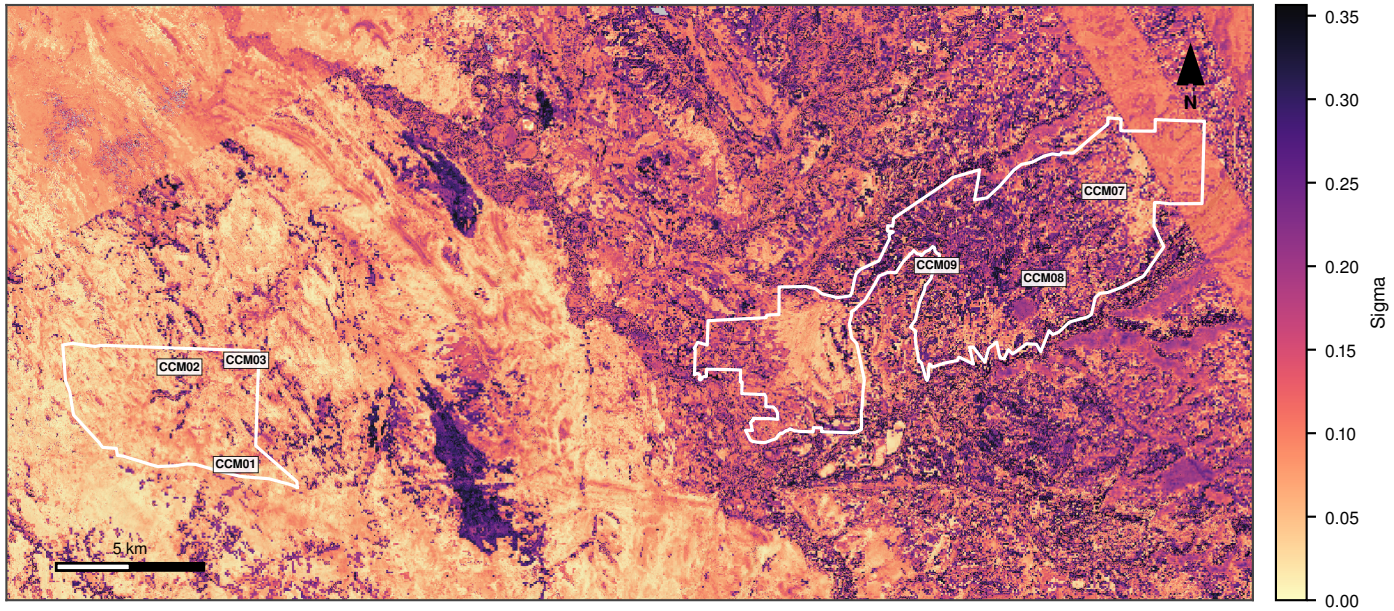
Confidence (0–1)



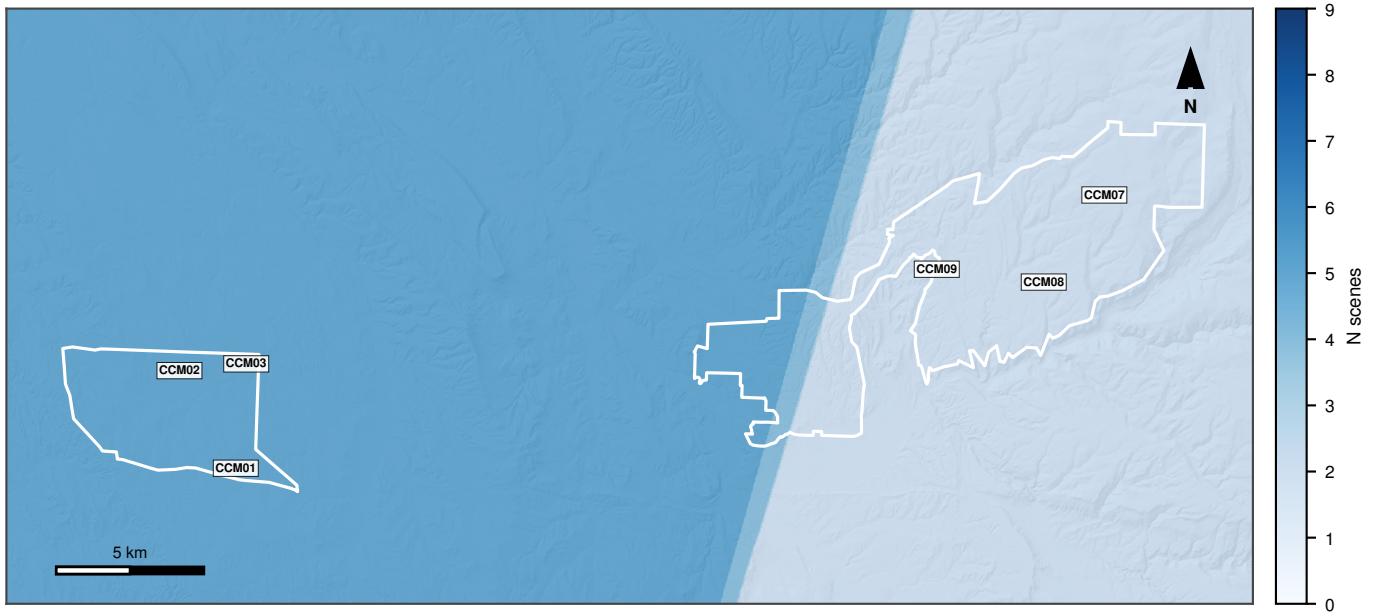
Uncertainty — total propagated sigma and scene support, summer2026

Summer2026: 5 admitted scenes (2026-06-01, 2026-06-05, 2026-06-16, 2026-07-13, 2026-08-01)

Total sigma (root-sum-square over classes)

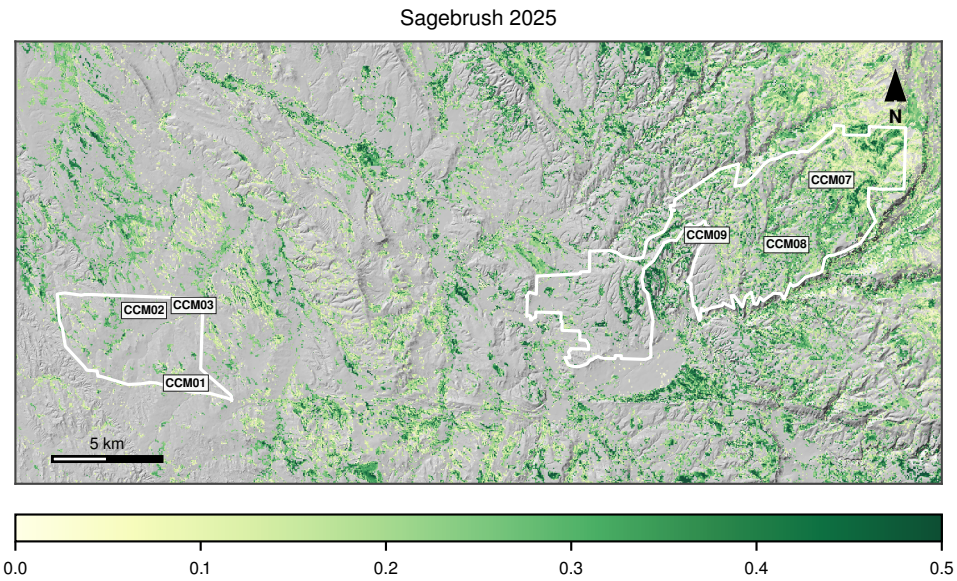


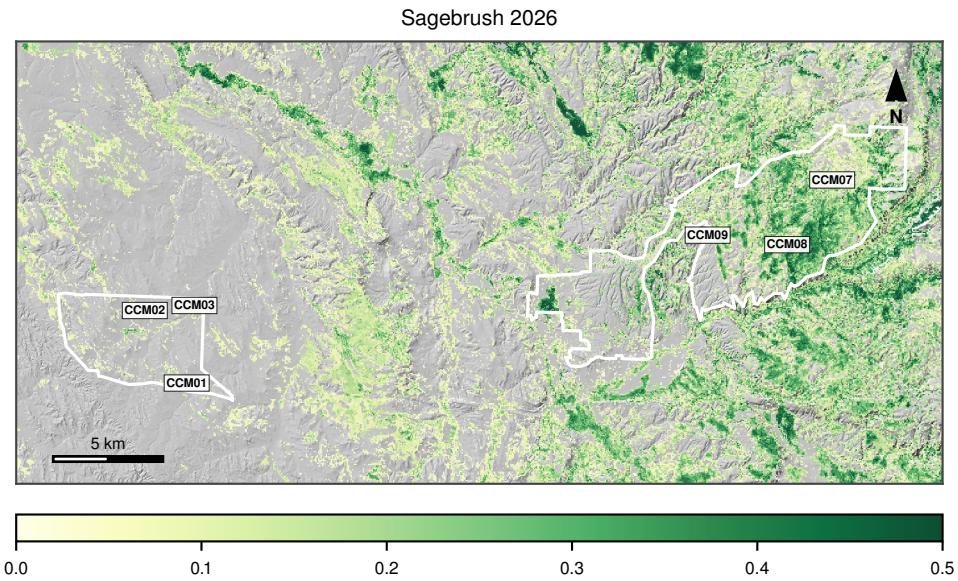
Admitted scenes per cell

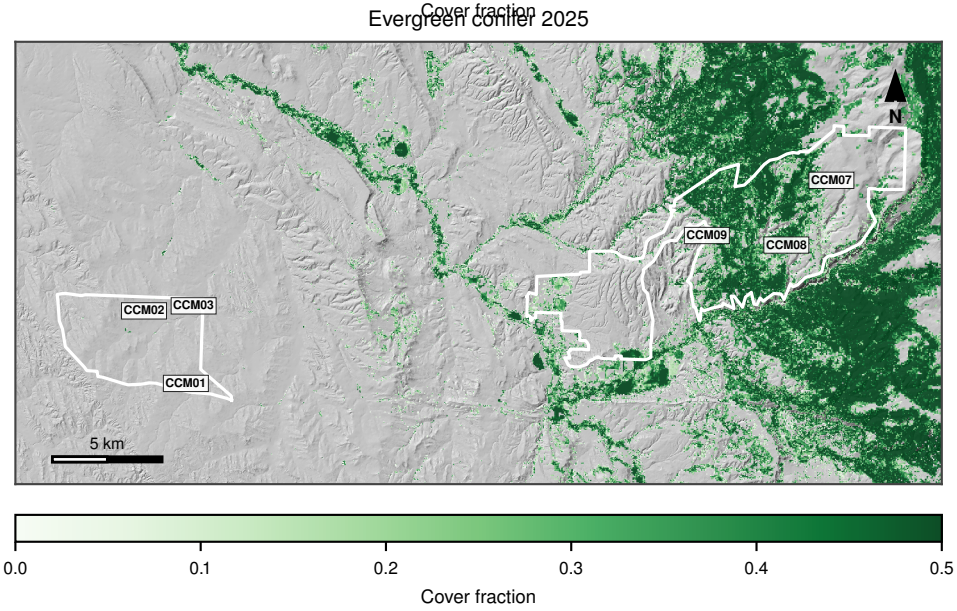


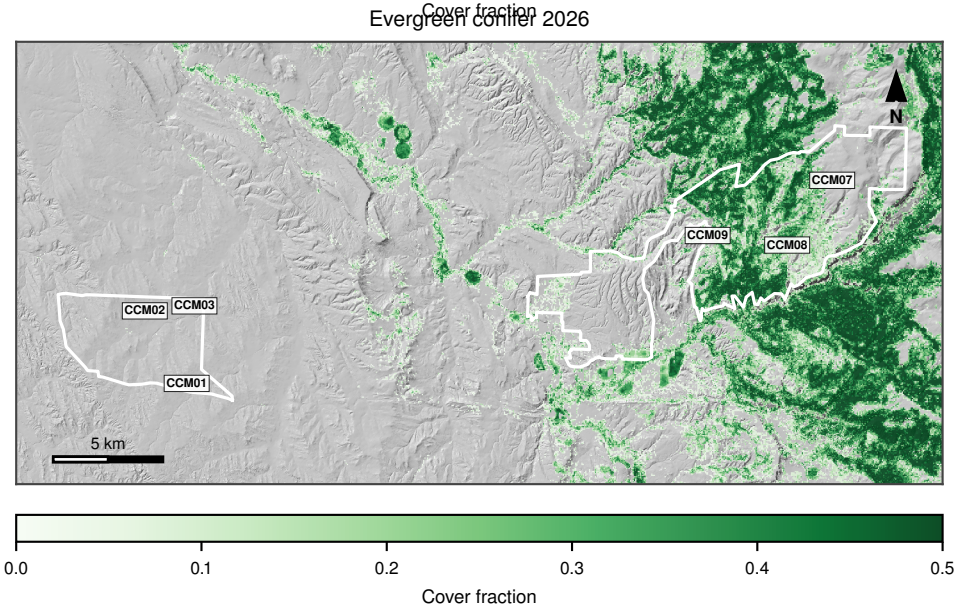
Sagebrush and evergreen conifer, 2025 to 2026 (2024 context only: two scenes, April and October)

Annual composites year2025 (2 scenes) and year2026 (9 scenes)

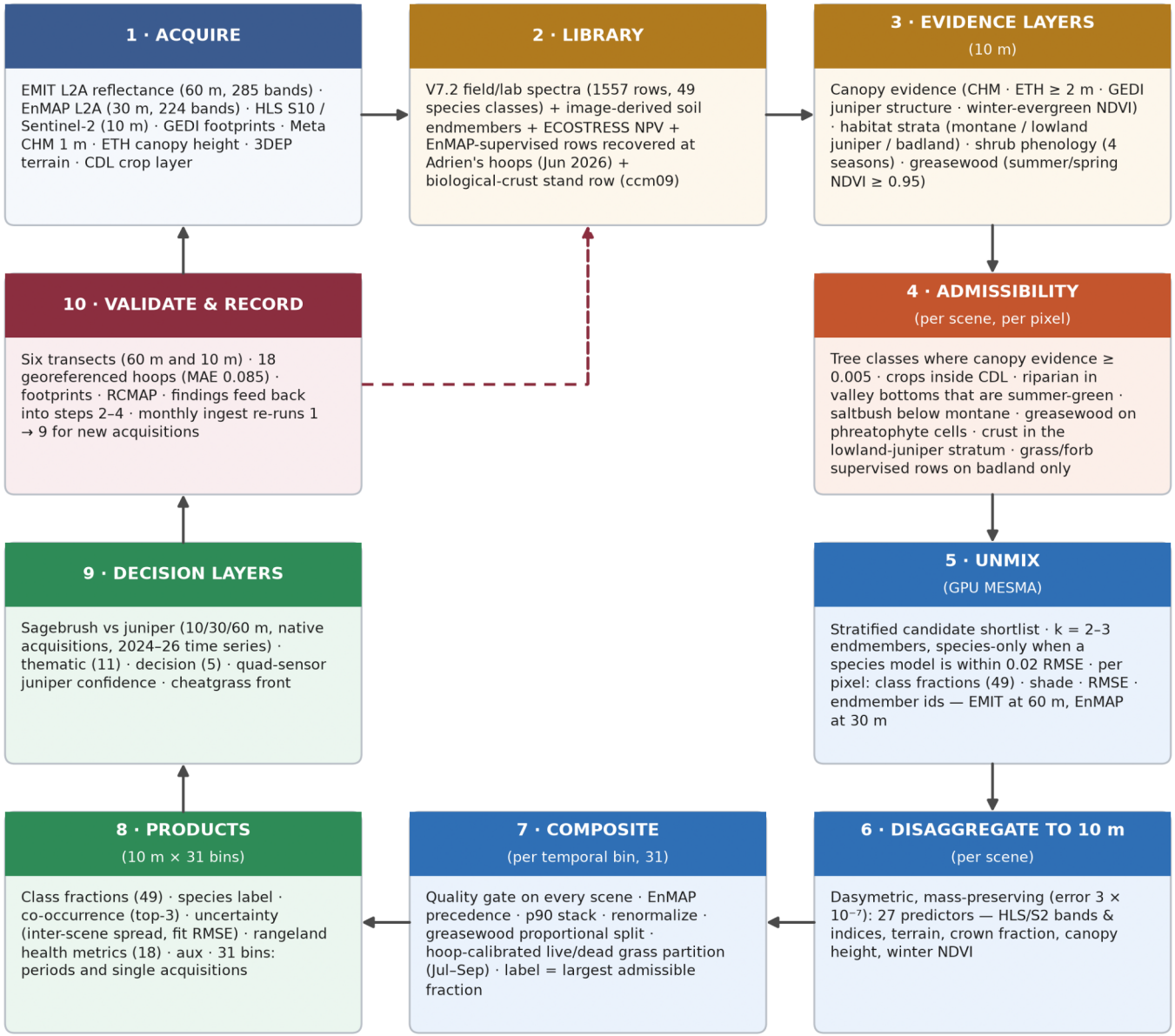








Data-to-map flow



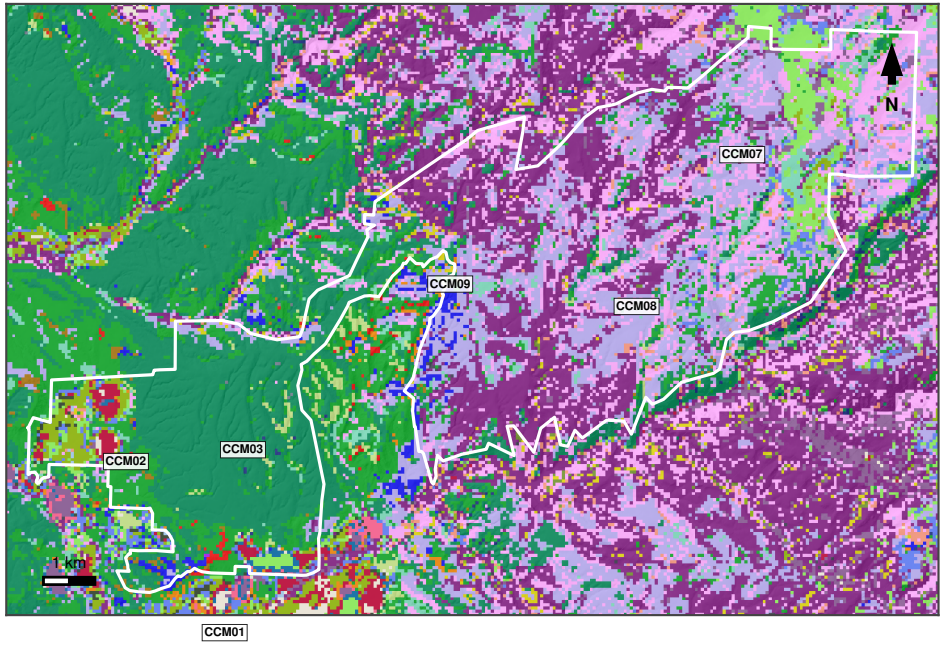
Solid arrows: the monthly cycle, steps 1 → 10 → 1 with each new acquisition. Dashed arrow: validation findings revise the library and rules (steps 2 – 4).

Input data · Knowledge · Rules · Compute · Output · Ground truth

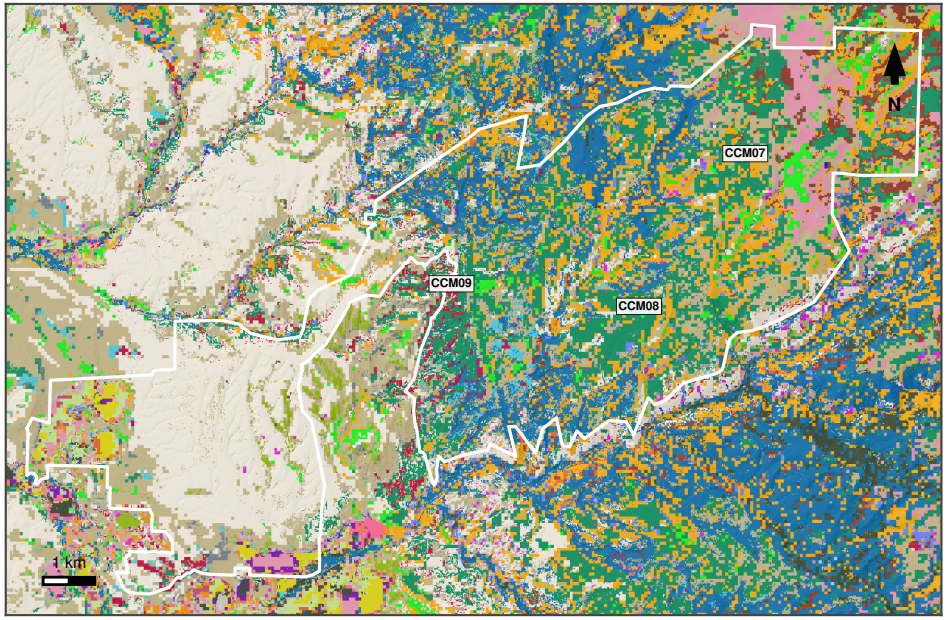
Pipeline progression — species label on the 4 Aug 2025 scene, steps 1 and 2 of 6, plateau parcel

Each configuration adds one data source; frames identical

1. EMIT spectra only (60 m)



2. + HLS 10 m disaggregation

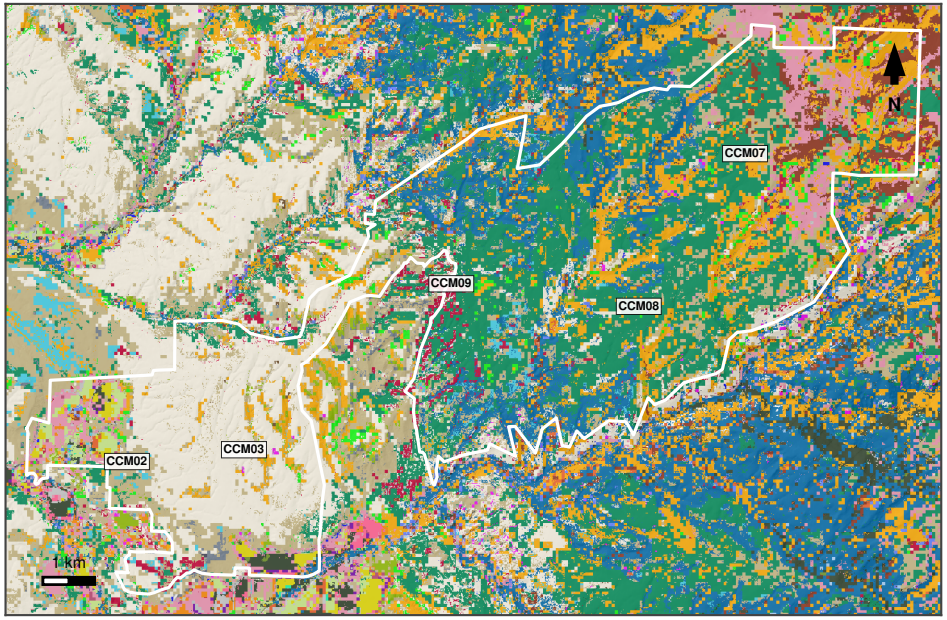


22 · BARE — bare soil (exposed soil) 23.5%
17 · NPV_GRASS — standing dead and cured grass (grass litter) 18.2%
9 · PIED — Pinus ponderosa / P. flexilis (ponderosa and limber pine; library Pinus edulis rows) 15.7%
8 · PFG — perennial graminoids (perennial grasses, live share) 12.7%
1 · ARTR — Artemisia tridentata (big sagebrush) 12.1%
16 · NWFRB — native perennial forbs (wildflowers and perennial forbs) 3.0%
11 · CONI — other conifers (mixed conifer) 2.2%
47 · SARVE — Sarcobatus vermiculatus (greasewood) 2.1%
20 · NPV_NEEDLE — needle litter (conifer needle litter) 2.1%
5 · CHE — Bromus tectorum (cheatgrass) 1.2%
3 · ATCA — Atriplex canescens (fourwing saltbush) 1.0%
19 · NPV_LEAF — leaf litter (fallen leaves) 0.9%
4 · SATR — Salsola tragus (Russian thistle) 0.9%
40 · ALFALFA_SENESCENT — Medicago sativa (alfalfa, senescent) 0.8%
39 · ALFALFA_VEG — Medicago sativa (alfalfa, vegetative) 0.7%
21 · NPV_BRANCH — woody debris (branches and stems) 0.5%
2 · CHRY — Chrysothamnus viscidiflorus (green rabbitbrush) 0.5%
38 · ALFALFA_EMERGENT — Medicago sativa (alfalfa, emergent) 0.4%
25 · ROCK_MET — metamorphic rock (exposed metamorphic rock) 0.4%
41 · BARLEY_EMERGENT — Hordeum vulgare (barley, emergent) 0.2%
44 · SUGARBEET_VEG — Beta vulgaris (sugar beet, vegetative) 0.2%
42 · BARLEY_VEG — Hordeum vulgare (barley, vegetative) 0.2%
18 · NPV_BARK — bark (woody bark) 0.1%
10 · JUOS — Juniperus osteosperma / J. scopulorum (juniper) 0.1%
13 · SALI — Salix spp. (willow) 0.1%
14 · DECI — other deciduous broadleaf (deciduous shrubs and trees) 0.1%
15 · LICH — lichen and cyanobacteria (biological soil crust) 0.0%
43 · BARLEY_SENESCENT — Hordeum vulgare (barley, senescent) 0.0%
7 · AFG_BD — annual bromes, Bromus spp. (Japanese brome and other annual bromes) 0.0%
23 · ROCK_IG — igneous rock (exposed igneous rock) 0.0%
6 · AFG_AF — annual forbs, e.g. Bassia scoparia (kochia and other annual forbs) 0.0%
12 · POPU — Populus spp. (cottonwood and aspen) 0.0%
24 · ROCK_SED — sedimentary rock (exposed sandstone / shale) 0.0%
26 · CORN_VEG — Zea mays (corn, vegetative) 0.0%
27 · CORN_SENESCENT — Zea mays (corn, senescent) 0.0%
28 · CORN_HARVESTED — Zea mays (corn, harvested) 0.0%
29 · SOYBEAN_VEG — Glycine max (soybean, vegetative) 0.0%
30 · SOYBEAN_SENESCENT — Glycine max (soybean, senescent) 0.0%
31 · SOYBEAN_HARVESTED — Glycine max (soybean, harvested) 0.0%
32 · COTTON_VEG — Gossypium hirsutum (cotton, vegetative) 0.0%
35 · WHEAT_VEG — Triticum aestivum (wheat, vegetative) 0.0%
36 · WHEAT_SENESCENT — Triticum aestivum (wheat, senescent) 0.0%

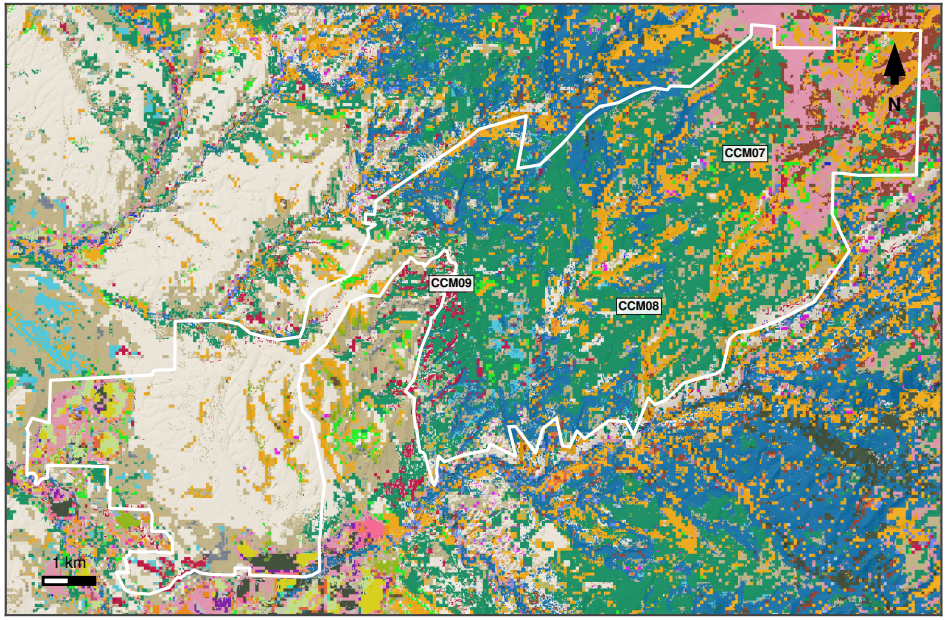
Pipeline progression — species label on the 4 Aug 2025 scene, steps 3 and 4 of 6, plateau parcel

Each configuration adds one data source; frames identical

3. + EnMAP-supervised rows



4. + GEDI / CHM canopy evidence

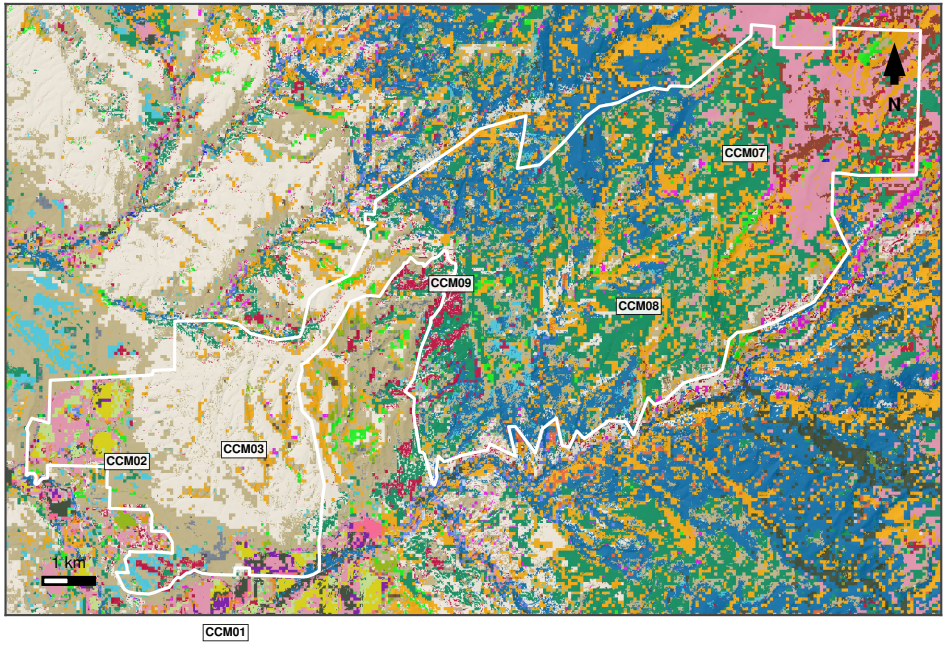


22 · BARE — bare soil (exposed soil) 20.6%
8 · PFG — perennial graminoids (perennial grasses, live share) 19.8%
9 · PIED — Pinus ponderosa / P. flexilis (ponderosa and limber pine; library Pinus edulis rows) 15.2%
17 · NPV_GRASS — standing dead and cured grass (grass litter) 14.3%
1 · ARTR — Artemisia tridentata (big sagebrush) 12.6%
16 · NWFRB — native perennial forbs (wildflowers and perennial forbs) 4.3%
47 · SARVE — Sarcobatus vermiculatus (greasewood) 2.3%
11 · CONI — other conifers (mixed conifer) 2.1%
5 · CHE — Bromus tectorum (cheatgrass) 1.4%
19 · NPV_LEAF — leaf litter (fallen leaves) 1.4%
20 · NPV_NEEDLE — needle litter (conifer needle litter) 1.1%
3 · ATCA — Atriplex canescens (fourwing saltbush) 0.7%
40 · ALFALFA_SENESCENT — Medicago sativa (alfalfa, senescent) 0.7%
4 · SATR — Salsola tragus (Russian thistle) 0.6%
39 · ALFALFA_VEG — Medicago sativa (alfalfa, vegetative) 0.5%
2 · CHRY — Chrysothamnus viscidiflorus (green rabbitbrush) 0.5%
21 · NPV_BRANCH — woody debris (branches and stems) 0.4%
25 · ROCK_MET — metamorphic rock (exposed metamorphic rock) 0.3%
38 · ALFALFA_EMERGENT — Medicago sativa (alfalfa, emergent) 0.3%
44 · SUGARBEET_VEG — Beta vulgaris (sugar beet, vegetative) 0.2%
41 · BARLEY_EMERGENT — Hordeum vulgare (barley, emergent) 0.1%
18 · NPV_BARK — bark (woody bark) 0.1%
10 · JUOS — Juniperus osteosperma / J. scopulorum (juniper) 0.1%
42 · BARLEY_VEG — Hordeum vulgare (barley, vegetative) 0.1%
14 · DECI — other deciduous broadleaf (deciduous shrubs and trees) 0.1%
13 · SALI — Salix spp. (willow) 0.1%
43 · BARLEY_SENESCENT — Hordeum vulgare (barley, senescent) 0.0%
15 · LICH — lichen and cyanobacteria (biological soil crust) 0.0%
23 · ROCK_IG — igneous rock (exposed igneous rock) 0.0%
6 · AFG_AF — annual forbs, e.g. Bassia scoparia (kochia and other annual forbs) 0.0%
7 · AFG_BD — annual bromes, Bromus spp. (Japanese brome and other annual bromes) 0.0%
12 · POPU — Populus spp. (cottonwood and aspen) 0.0%
24 · ROCK_SED — sedimentary rock (exposed sandstone / shale) 0.0%

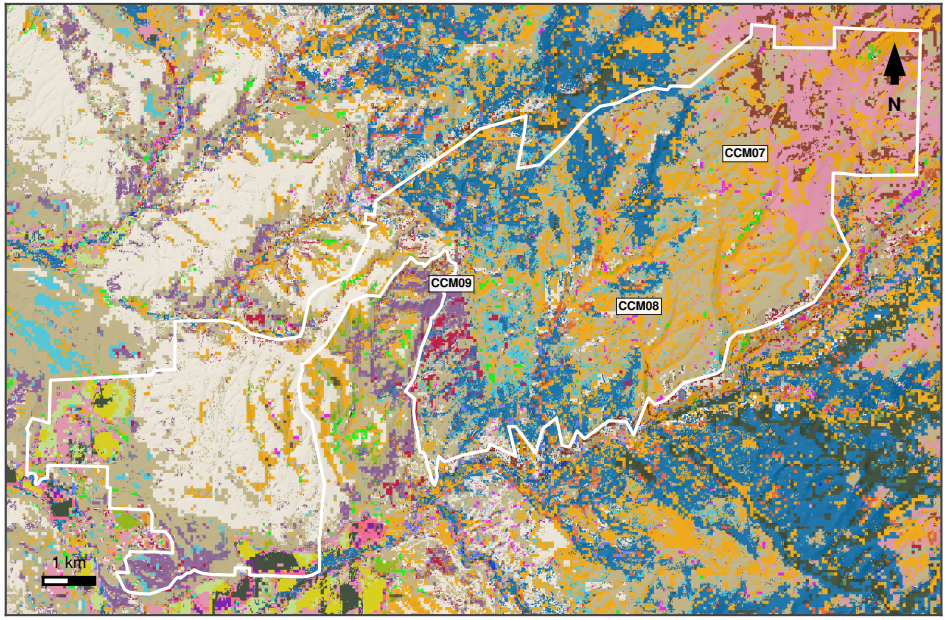
Pipeline progression — species label on the 4 Aug 2025 scene, steps 5 and 6 of 6, plateau parcel

Each configuration adds one data source; frames identical

5. + terrain and habitat strata



6. + ground observations (current)

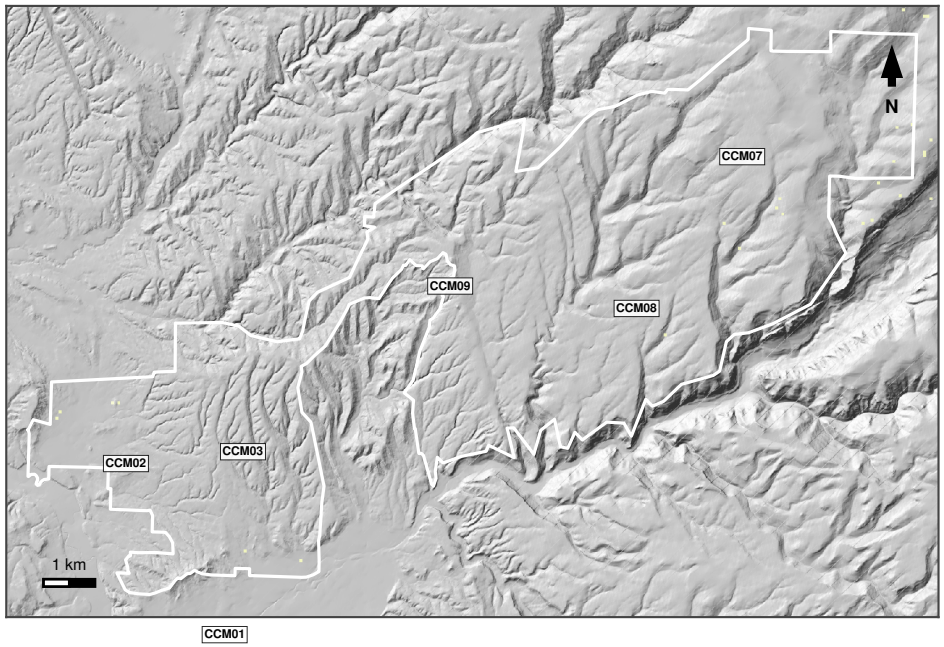


17 · NPV_GRASS — standing dead and cured grass (grass litter) 26.7%
22 · BARE — bare soil (exposed soil) 17.5%
1 · ARTR — Artemisia tridentata (big sagebrush) 16.0%
9 · PIED — Pinus ponderosa / P. flexilis (ponderosa and limber pine; library Pinus edulis rows) 14.7%
16 · NWFRB — native perennial forbs (wildflowers and perennial forbs) 5.7%
11 · CONI — other conifers (mixed conifer) 3.8%
15 · LICH — lichen and cyanobacteria (biological soil crust) 3.2%
19 · NPV_LEAF — leaf litter (fallen leaves) 2.4%
2 · CHRY — Chrysothamnus viscidiflorus (green rabbitbrush) 1.8%
47 · SARVE — Sarcobatus vermiculatus (greasewood) 1.6%
5 · CHE — Bromus tectorum (cheatgrass) 0.9%
39 · ALFALFA_VEG — Medicago sativa (alfalfa, vegetative) 0.9%
40 · ALFALFA_SENESCENT — Medicago sativa (alfalfa, senescent) 0.8%
3 · ATCA — Atriplex canescens (fourwing saltbush) 0.7%
21 · NPV_BRANCH — woody debris (branches and stems) 0.7%
20 · NPV_NEEDLE — needle litter (conifer needle litter) 0.6%
4 · SATR — Salsola tragus (Russian thistle) 0.6%
18 · NPV_BARK — bark (woody bark) 0.3%
25 · ROCK_MET — metamorphic rock (exposed metamorphic rock) 0.3%
44 · SUGARBEET_VEG — Beta vulgaris (sugar beet, vegetative) 0.2%
10 · JUOS — Juniperus osteosperma / J. scopulorum (juniper) 0.2%
14 · DECI — other deciduous broadleaf (deciduous shrubs and trees) 0.2%
41 · BARLEY_EMERGENT — Hordeum vulgare (barley, emergent) 0.1%
38 · ALFALFA_EMERGENT — Medicago sativa (alfalfa, emergent) 0.1%
42 · BARLEY_VEG — Hordeum vulgare (barley, vegetative) 0.1%
43 · BARLEY_SENESCENT — Hordeum vulgare (barley, senescent) 0.1%
13 · SALI — Salix spp. (willow) 0.1%
46 · URBAN_BUILT — built surfaces (roads, structures) 0.0%
45 · WATER_CLEAR — open water (clear water) 0.0%
24 · ROCK_SED — sedimentary rock (exposed sandstone / shale) 0.0%
23 · ROCK_IG — igneous rock (exposed igneous rock) 0.0%
7 · AFG_BD — annual bromes, Bromus spp. (Japanese brome and other annual bromes) 0.0%
6 · AFG_AF — annual forbs, e.g. Bassia scoparia (kochia and other annual forbs) 0.0%
48 · BURN — burned surface (char and ash) 0.0%
12 · POPU — Populus spp. (cottonwood and aspen) 0.0%
8 · PFG — perennial graminoids (perennial grasses, live share) 0.0%

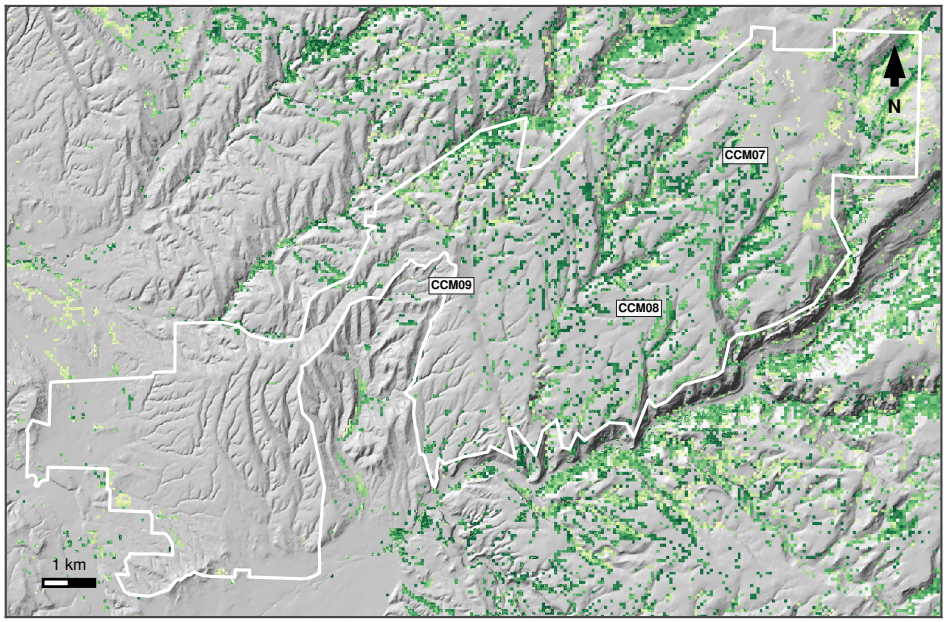
Pipeline progression — sagebrush (ARTR) cover on the 4 Aug 2025 scene, steps 1 and 2 of 6, plateau parcel

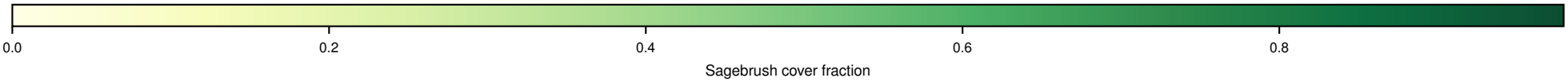
Each configuration adds one data source; frames identical; shared scale

1. EMIT spectra only (60 m) (mean 0.000)



2. + HLS 10 m disaggregation (mean 0.102)

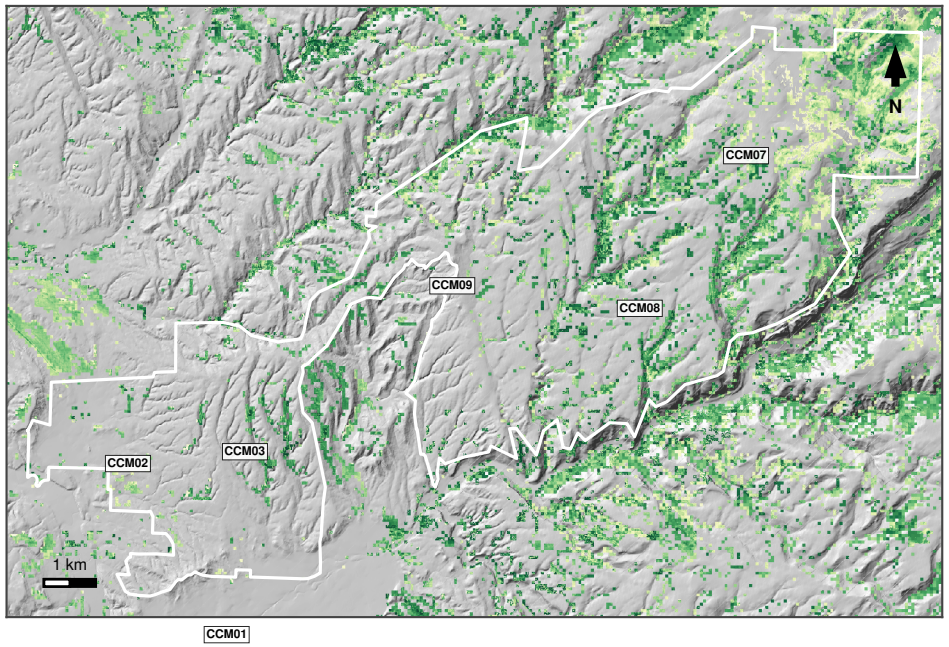




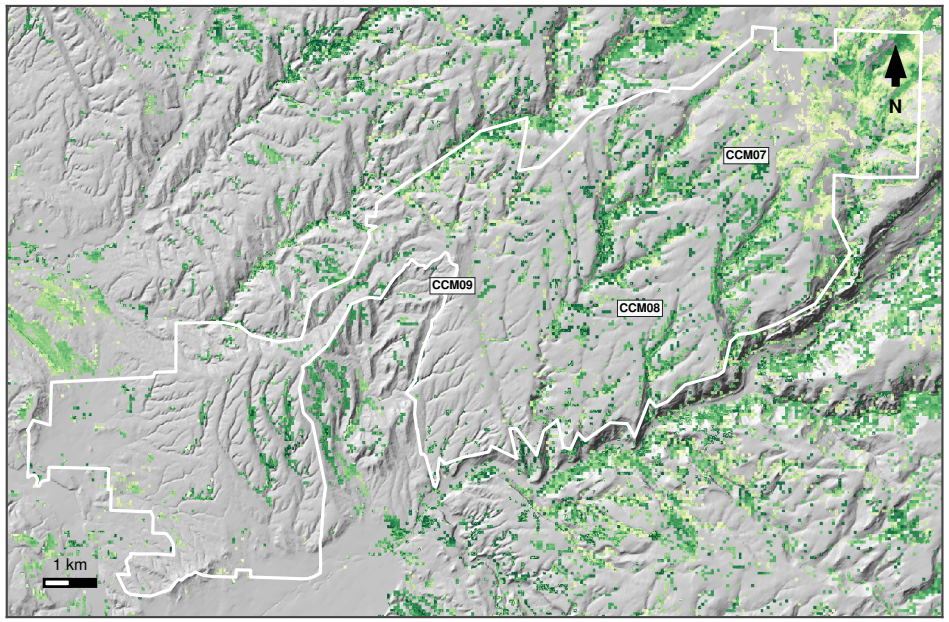
Pipeline progression — sagebrush (ARTR) cover on the 4 Aug 2025 scene, steps 3 and 4 of 6, plateau parcel

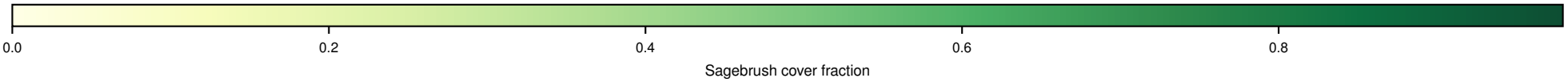
Each configuration adds one data source; frames identical; shared scale

3. + EnMAP-supervised rows (mean 0.111)



4. + GEDI / CHM canopy evidence (mean 0.109)

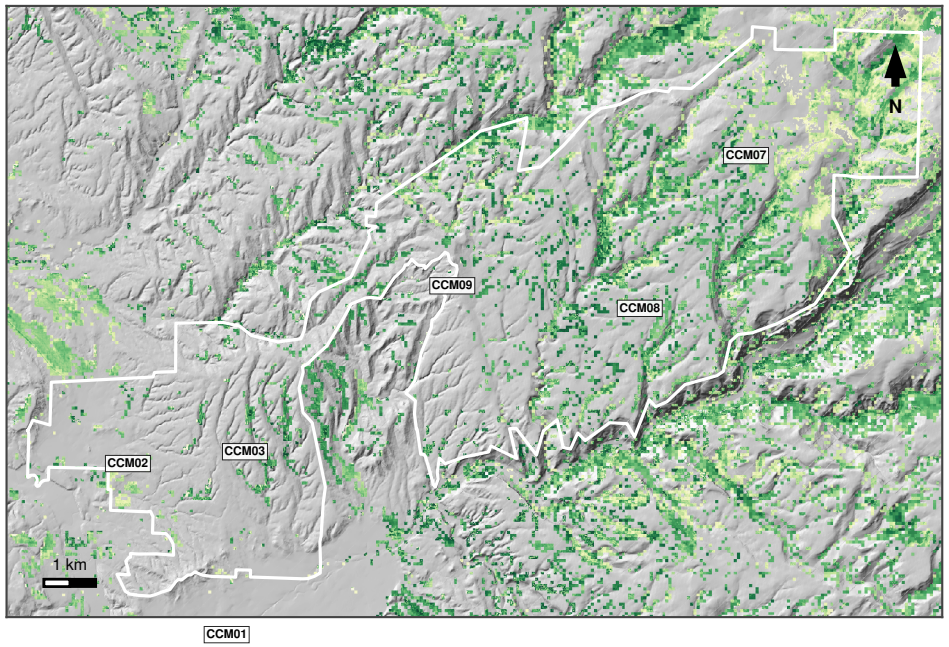




Pipeline progression — sagebrush (ARTR) cover on the 4 Aug 2025 scene, steps 5 and 6 of 6, plateau parcel

Each configuration adds one data source; frames identical; shared scale

5. + terrain and habitat strata (mean 0.122)



6. + ground observations (current) (mean 0.135)

