Animal MoveLab — Incremental Roadmap

> Compact, modular plan to build a local-first Shiny/Golem platform for animal movement ecology. Each phase ends with clear deliverables and a definition of done (DoD). Work Packages (WPs) can run in parallel when dependencies allow.

Phase 0 — Bootstrap & Project Scaffolding (Week 0)

Goal: Stand up a reproducible app skeleton scientists can run locally.

Deliverables - `MoveLabApp/` golem package created via bootstrap script - `inst/runtime/projects/DemoProject/` with WP1 - `renv.lock` and install notes

Key Tasks - [ ] Run bootstrap R script - [ ] Pin dependencies with `renv` - [ ] Basic tabs: Project, Import, Env, HomeRange, Habitat

DoD - App launches with demo project; navigation works end-to-end; no errors on fresh machine

WP Mapping: WP-OPS-01

Phase 1 — Foundation & Data Management

Goal: Robust local install, project structure, provenance, CRS hygiene.

Deliverables - Standard folders: `RAW/`, `GPS/`, `DEM/`, `Vegetation/`, `LandscapeMetrics/`, `ANALYSES/`, `OUTPUT/` - Import wizard with CRS detect/reproject - Metadata & provenance log (YAML/JSON per project)

Key Tasks - [ ] Enforce read-only `RAW/` - [ ] Import CSV/GPX/shp/Movebank (v1: CSV) - [ ] CRS detection & transform to analysis CRS - [ ] Minimal metadata schema (project.yml)

DoD - 10k-point CSV ingested → `GPS/cleaned_tracks.gpkg` with correct CRS & metadata

Dependencies: Phase 0

WP Mapping: WP1-Data

Phase 2 — Environmental Layers Integration

Goal: Bring DEM/vegetation rasters into the pipeline; align with GPS.

Deliverables - Raster import (GeoTIFF) - Reproject/crop/overview build; cached aligned rasters

Key Tasks - [ ] Import UI (DEM/Vegetation/LandscapeMetrics) - [ ] Reproject to analysis CRS; save as COG/GeoTIFF - [ ] Batch `terra::extract()` helper (chunked)

DoD - DEM & landcover visible on map and extractable for locations

Dependencies: Phase 1

WP Mapping: WP2-Env

Phase 3 — Core Space-Use Analyses

Goal: Area use via AKDE (ctmm) + classics (MCP/KDE/LoCoH).

Deliverables - AKDE workflow (variogram → model fit → UD export) - MCP/KDE (adehabitatHR) baseline - Export UD contours to `OUTPUT/`

Key Tasks - [ ] ctmm telemetry conversion & fitting - [ ] UD raster/shapes export (levels: 50/95) - [ ] Compare estimators (table + plots)

DoD - For a demo track, AKDE 95% area computed & saved; comparison table rendered

Dependencies: Phases 1–2

WP Mapping: WP3-SpaceUse

Phase 4 — Habitat Use & Selection (RSF/SSF/iSSF)

Goal: Model selection with environmental covariates at steps/points.

Deliverables - RSF (used-available points) - SSF/iSSF (steps with random alternatives) - Simulation of space-use from SSF/iSSF

Key Tasks - [ ] Covariate extraction pipeline (batched) - [ ] Model fit UI (formula builder, scaling) - [ ] Maps of predicted use & partial effects

DoD - RSF/SSF model fits; predictions rasterized and saved; report stub

Dependencies: Phases 1–3

WP Mapping: WP4-Selection

Phase 5 — Advanced Movement & Connectivity

Goal: Multi-scale metrics, corridors, restrictions, first-mover patterns.

Deliverables - Temporal aggregation (daily/seasonal/yearly) - Corridor/path density maps; optional circuit/least-cost - Fences/barriers mask support; simple first-mover heuristics

Key Tasks - [ ] Step metrics & NSD timelines - [ ] Density/corridor surfaces (kernel/track density) - [ ] Barrier-aware availability & path summaries

DoD - Corridor heatmap exported; barrier-aware analyses run without errors

Dependencies: Phases 2–4

WP Mapping: WP5-Advanced

Phase 6 — Theory Integration (e.g., Ideal Free Distribution)

Goal: Test empirical distributions vs. theory.

Deliverables - Patch/resource definition tool - IFD checklist & diagnostics panel (assumptions/fit)

Key Tasks - [ ] Patch delineation & resource quantification - [ ] Observed vs. expected occupancy comparison

DoD - IFD dashboard produces summary & exportable figures

Dependencies: Phases 3–5

WP Mapping: WP6-Theory

Phase 7 — UX, Agentic Tools & Workflow Orchestration

Goal: Streamlined tram-line wizard + expert mode; agentic helper.

Deliverables - Wizard flow (Beginner) & Full control (Expert) - Agentic assistant: suggests next step, checks data integrity

Key Tasks - [ ] Progress tracker + validations per step - [ ] Background jobs (`future/promises`) & cache (`targets/memoise`) - [ ] Agent prompts for common operations & QA checks

DoD - Beginner can complete import→UD→RSF in wizard without code; assistant gives actionable hints

Dependencies: Phases 1–5

WP Mapping: WP7-UX

Phase 8 — Reporting, Export & Reproducibility

Goal: Push-button reports and packaged study bundles.

Deliverables - HTML/PDF report templates per module - Project export (.zip): config, data subsets, outputs, metadata

Key Tasks - [ ] R Markdown/Quarto templates - [ ] Provenance summary & model registry

DoD - One-click report runs on demo and user data; zip export reopens reproducibly elsewhere

Dependencies: Phases 1–4 (min), expands with advanced modules

WP Mapping: WP8-Reporting

Phase 9 — Deployment & Ops

Goal: Smooth local usage and optional server deploy.

Deliverables - Local install guide; Windows/macOS/Linux notes - Optional: Dockerfile & Compose; Posit Connect manifest

Key Tasks - [ ] Hardening: timeouts, error banners, inputs validation - [ ] Backups for `runtime/projects` volume - [ ] Telemetry-free usage; opt-in logs only

DoD - Cold machine → app running in under 10 min with documented steps

Dependencies: Phase 0+

WP Mapping: WP-OPS-02

Cross-Cutting Concerns

- **Data Governance:** ID anonymization, read-only RAW, metadata completeness checks
- **Performance:** Chunked extraction, spatial indexing, raster overviews, caching

- **Testing:** Module unit tests; golden files for outputs; sample datasets
- **Docs:** Inline help, tooltips, quickstart, FAQ

Milestones & Checkpoints

1. **M0 (Boot):** App starts; demo project visible
2. **M1 (Data Ready):** Import + CRS + metadata complete
3. **M2 (UD Core):** AKDE/MCP working; exports OK
4. **M3 (Selection):** RSF/SSF with predictions
5. **M4 (Advanced):** Corridors/barriers; time aggregation
6. **M5 (Theory):** IFD module beta
7. **M6 (UX+Agent):** Wizard + assistant complete
8. **M7 (Reports):** One-click Quarto
9. **M8 (Ops):** Docker/Connect ready, docs done

Risks & Mitigations

- **Large rasters:** Pre-tile/COG, lazy extracts, cache
- **CRS mismatch:** Enforce analysis CRS per project; clear warnings
- **Long-running jobs:** Background futures; progress + cancel
- **Package churn:** Lock with `renv`; pin critical versions

Backlog (Future Epics)

- HMM/SSM behavior state classification
- Diarization of group tracks & leader–follower dynamics
- Circuit theory integration (Circuitscape) and empirical validation
- Batch Movebank import + schedules

Quick Start (for scientists)

1) Run bootstrap script → open app 2) Create/select project & WP 3) Import GPS CSV (set CRS) 4) Add DEM/vegetation 5) Run AKDE (Phase 3) → RSF/SSF (Phase 4) 6) Export maps & report