

Supporting Information for

Integer Linear programming outperforms simulated annealing for solving conservation planning problems

Richard Schuster, Jeffrey O. Hanson, Matt Strimas-Mackey, Joseph R. Bennett

Table S1

Table S1: List of species that were used as features in our analysis.

Species Code	Common Name	Scientific Name
amegfi	American Goldfinch	<i>Spinus tristis</i>
amekes	American Kestrel	<i>Falco sparverius</i>
amerob	American Robin	<i>Turdus migratorius</i>
annhum	Anna's Hummingbird	<i>Calypte anna</i>
baleag	Bald Eagle	<i>Haliaeetus leucocephalus</i>
barswa	Barn Swallow	<i>Hirundo rustica</i>
brdowl	Barred Owl	<i>Strix varia</i>
belkin1	Belted Kingfisher	<i>Megaceryle alcyon</i>
bewwre	Bewick's Wren	<i>Thryomanes bewickii</i>
bnhcow	Brown-headed Cowbird	<i>Molothrus ater</i>
bkhgro	Black-headed Grosbeak	<i>Pheucticus melanocephalus</i>
brebla	Brewer's Blackbird	<i>Euphagus cyanocephalus</i>
brncre	Brown Creeper	<i>Certhia americana</i>
batpig1	Band-tailed Pigeon	<i>Patagioenas fasciata</i>
bushti	Bushtit	<i>Psaltiriparus minimus</i>
cangoo	Canada Goose	<i>Branta canadensis</i>
chbchi	Chestnut-backed Chickadee	<i>Poecile rufescens</i>
cedwax	Cedar Waxwing	<i>Bombycilla cedrorum</i>
chispa	Chipping Sparrow	<i>Spizella passerina</i>
coohaw	Cooper's Hawk	<i>Accipiter cooperii</i>
comrav	Common Raven	<i>Corvus corax</i>
amecro	American Crow	<i>Corvus brachyrhynchos</i>
dowwoo	Downy Woodpecker	<i>Dryobates pubescens</i>
eucdov	Eurasian Collared-Dove	<i>Streptopelia decaocto</i>
eursta	European Starling	<i>Sturnus vulgaris</i>
evegro	Evening Grosbeak	<i>Coccothraustes vespertinus</i>
norfli	Northern Flicker	<i>Colaptes auratus</i>
foxspa	Fox Sparrow	<i>Passerella iliaca</i>
gockin	Golden-crowned Kinglet	<i>Regulus satrapa</i>
haiwoo	Hairy Woodpecker	<i>Dryobates villosus</i>
houfin	House Finch	<i>Haemorhous mexicanus</i>
houspa	House Sparrow	<i>Passer domesticus</i>
houwre	House Wren	<i>Troglodytes aedon</i>
hutvir	Hutton's Vireo	<i>Vireo huttoni</i>
macwar	MacGillivray's Warbler	<i>Geothlypis tolmiei</i>
moudov	Mourning Dove	<i>Zenaida macroura</i>
norhar1	Hen Harrier	<i>Circus cyaneus</i>
orcwar	Orange-crowned Warbler	<i>Oreothlypis celata</i>
olsfly	Olive-sided Flycatcher	<i>Contopus cooperi</i>
osprey	Osprey	<i>Pandion haliaetus</i>
pacwre1	Pacific Wren	<i>Troglodytes pacificus</i>
pinsis	Pine Siskin	<i>Spinus pinus</i>
pilwoo	Pileated Woodpecker	<i>Dryocopus pileatus</i>
pasfly	Pacific-slope Flycatcher	<i>Empidonax difficilis</i>
purfin	Purple Finch	<i>Haemorhous purpureus</i>
purmar	Purple Martin	<i>Progne subis</i>
rebnut	Red-breasted Nuthatch	<i>Sitta canadensis</i>
rebsap	Red-breasted Sapsucker	<i>Sphyrapicus ruber</i>
redcro	Red Crossbill	<i>Loxia curvirostra</i>

Species Code	Common Name	Scientific Name
rocpig	Rock Pigeon	<i>Columba livia</i>
rethaw	Red-tailed Hawk	<i>Buteo jamaicensis</i>
rufhum	Rufous Hummingbird	<i>Selasphorus rufus</i>
rewbla	Red-winged Blackbird	<i>Agelaius phoeniceus</i>
savspa	Savannah Sparrow	<i>Passerculus sandwichensis</i>
sora	Sora	<i>Porzana carolina</i>
sonspa	Song Sparrow	<i>Melospiza melodia</i>
spotow	Spotted Towhee	<i>Pipilo maculatus</i>
stejay	Steller's Jay	<i>Cyanocitta stelleri</i>
swathr	Swainson's Thrush	<i>Catharus ustulatus</i>
towwar	Townsend's Warbler	<i>Setophaga townsendi</i>
treswa	Tree Swallow	<i>Tachycineta bicolor</i>
daejun	Dark-eyed Junco	<i>Junco hyemalis</i>
yerwar	Yellow-rumped Warbler	<i>Setophaga coronata</i>
varthr	Varied Thrush	<i>Ixoreus naevius</i>
vigswa	Violet-green Swallow	<i>Tachycineta thalassina</i>
warvir	Warbling Vireo	<i>Vireo gilvus</i>
whcspa	White-crowned Sparrow	<i>Zonotrichia leucophrys</i>
westan	Western Tanager	<i>Piranga ludoviciana</i>
wilsni1	Wilson's Snipe	<i>Gallinago delicata</i>
wlswar	Wilson's Warbler	<i>Cardellina pusilla</i>
wooduc	Wood Duck	<i>Aix sponsa</i>
yelwar	Yellow Warbler	<i>Setophaga petechia</i>

Figure S1

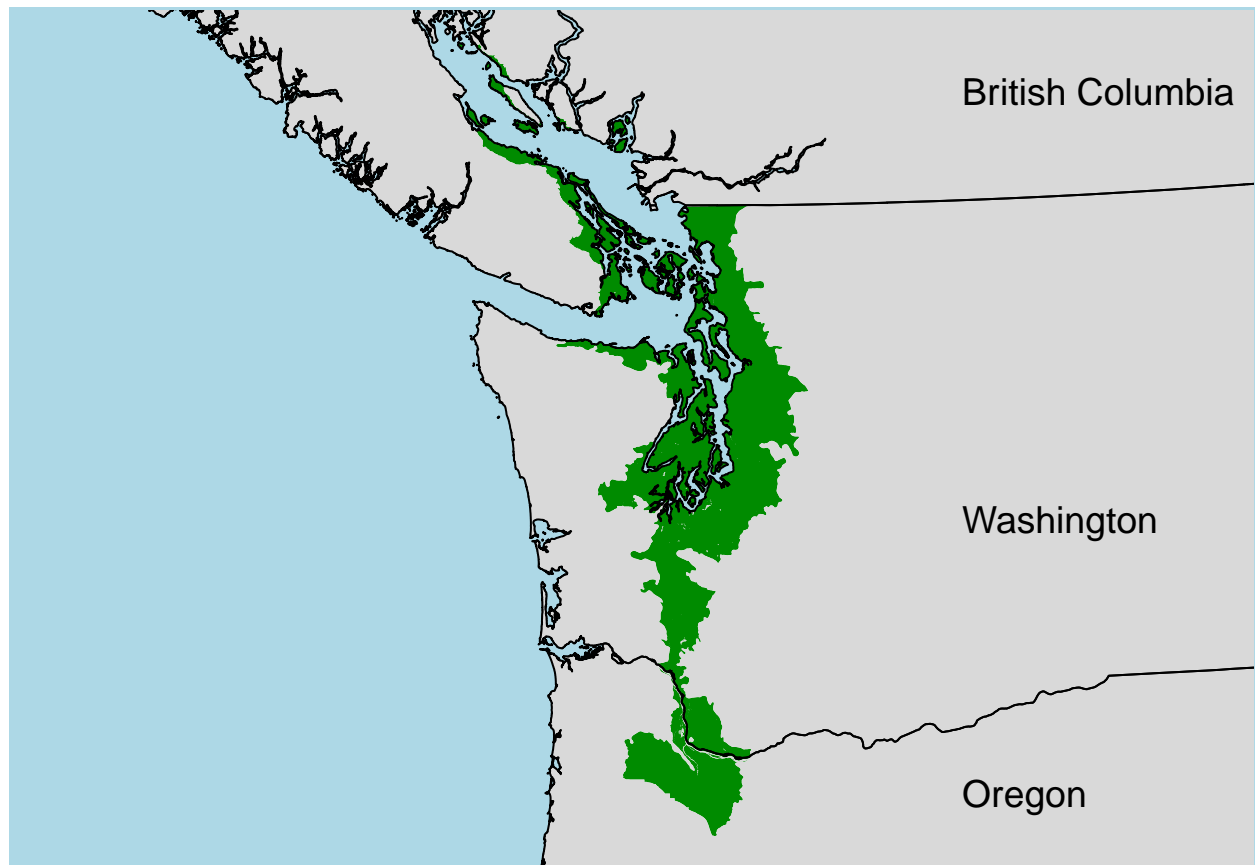


Figure S1: Study area.

Figure S2

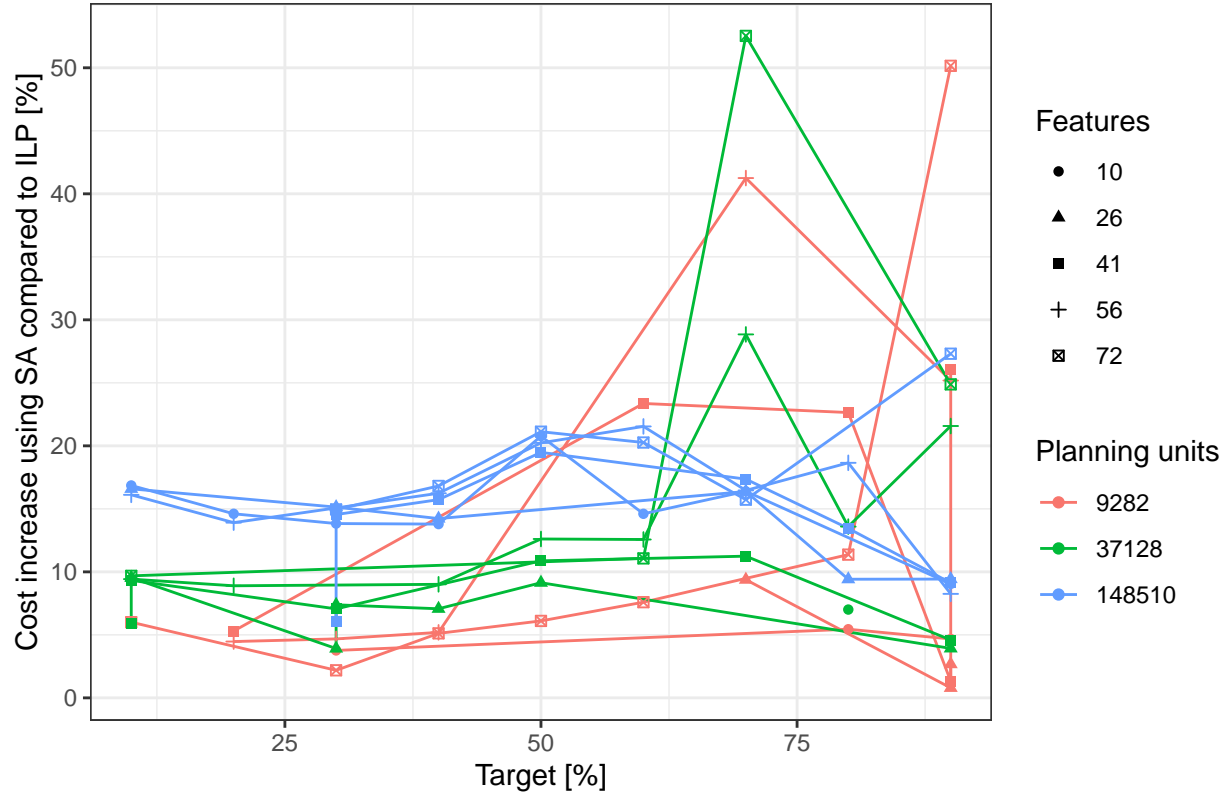


Figure S2: Percent cost increase of SA solutions compared to ILP solutions, across targets, number of features and number of planning units. Simulated annealing (i.e. Marxan) parameters used are: number of iterations > 100,000; species penalty factor 5 or 25. Not all Marxan scenarios generated yielded feasible solutions (where all targets were met), which is why e.g. there is only one observation for 37,128 planning units and 10 features.

Figure S3

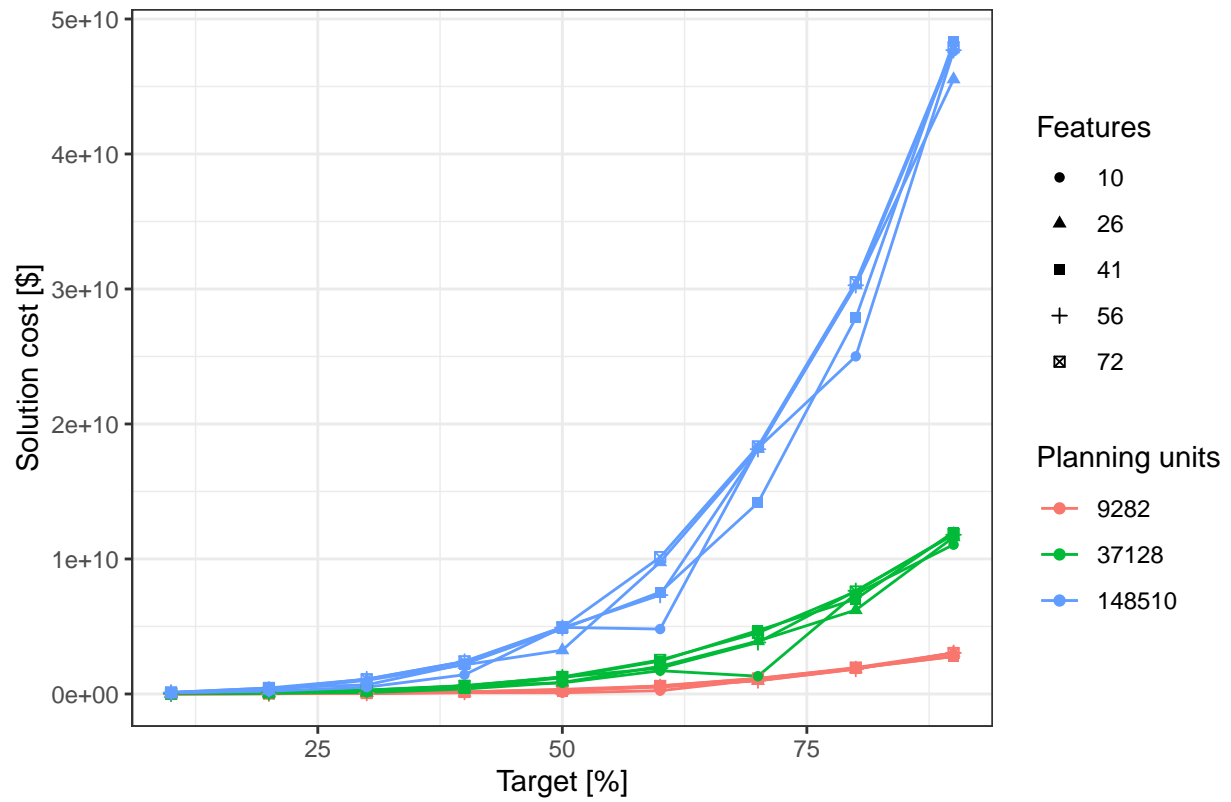


Figure S3: Cost profile for Gurobi solver across targets, number of features and number of planning units.

Figure S4

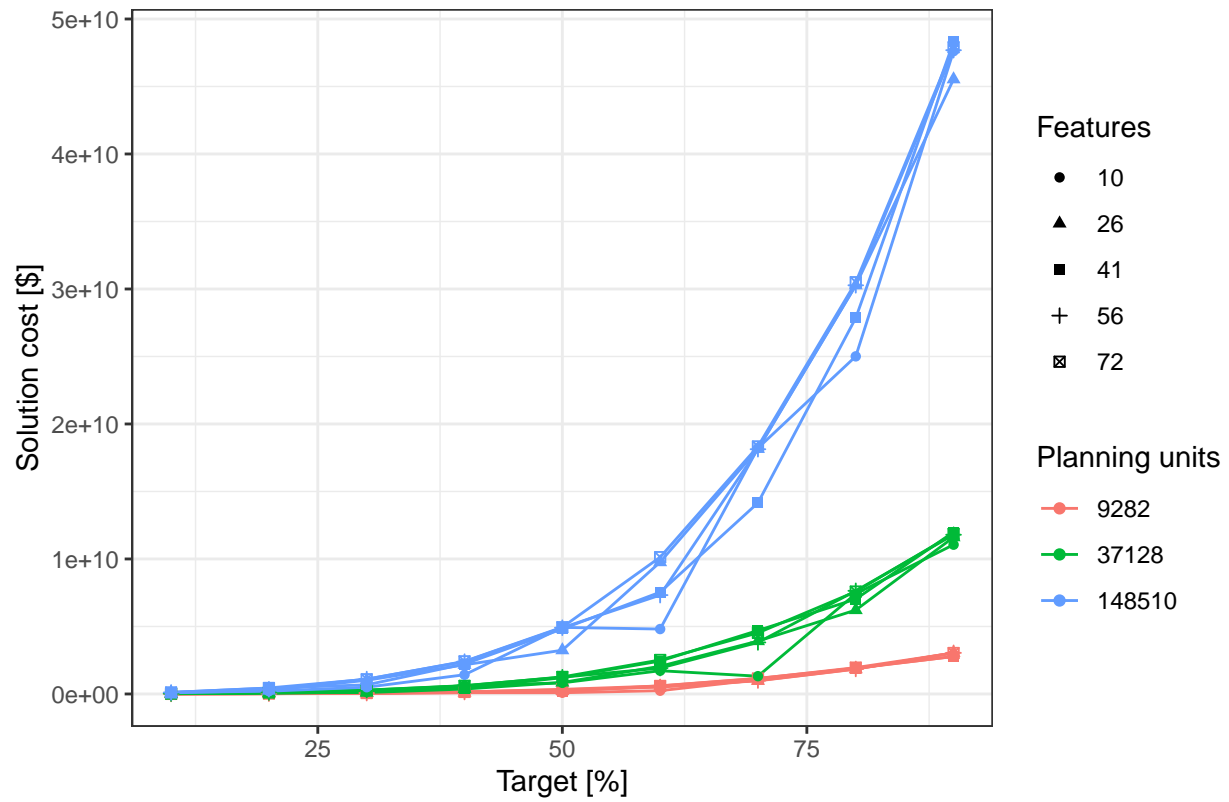


Figure S4: Cost profile for SYMPHONY solver across targets, number of features and number of planning units.

Figure S5

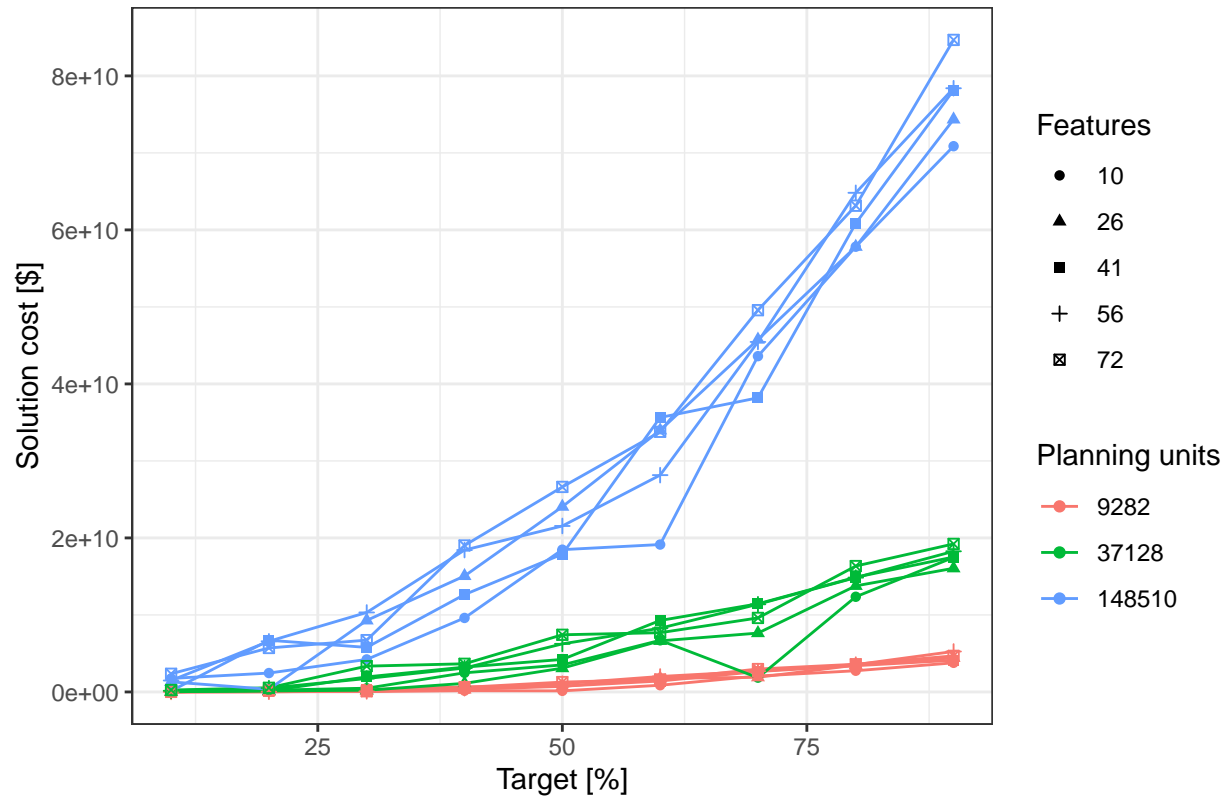


Figure S5: Cost profile for Marxan using Simulated Annealing across targets, number of features and number of planning units.

Figure S6

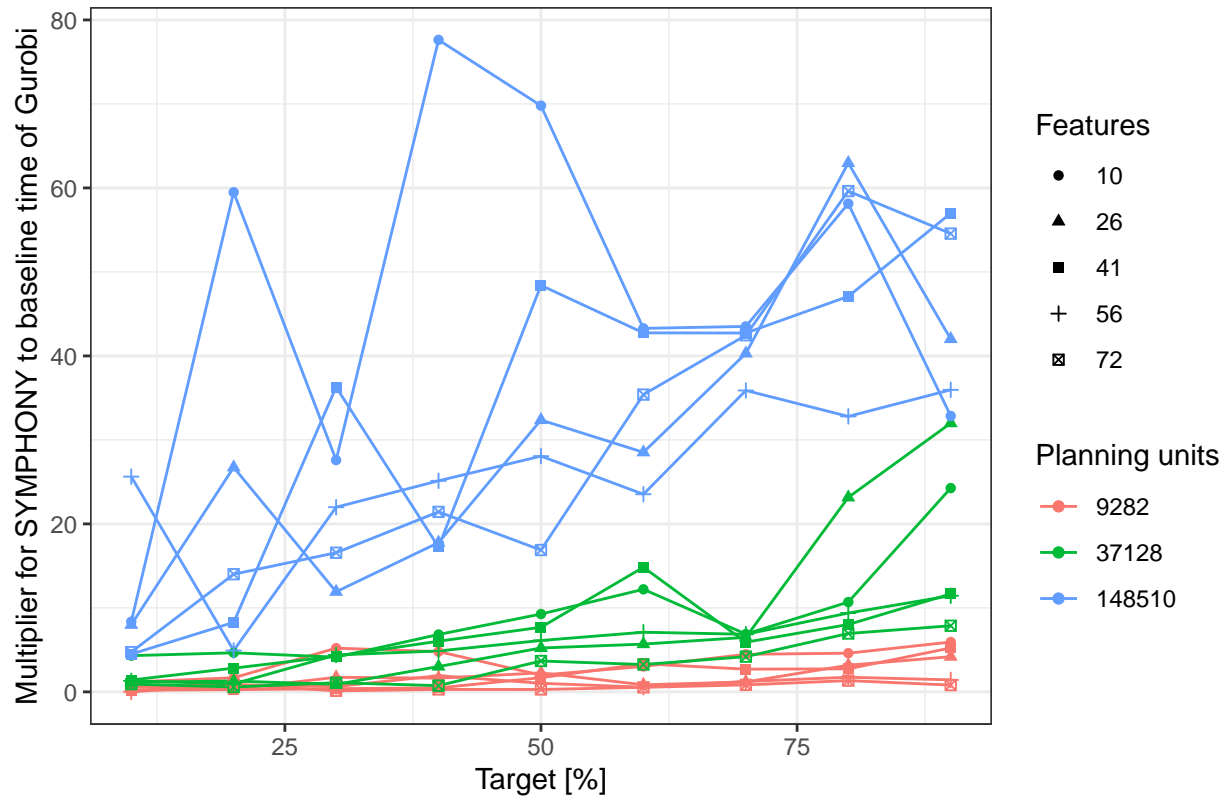


Figure S6: Time to solution comparisons between SYMPHONY and Gurobi across targets, number of features and number of planning units.

Figure S7

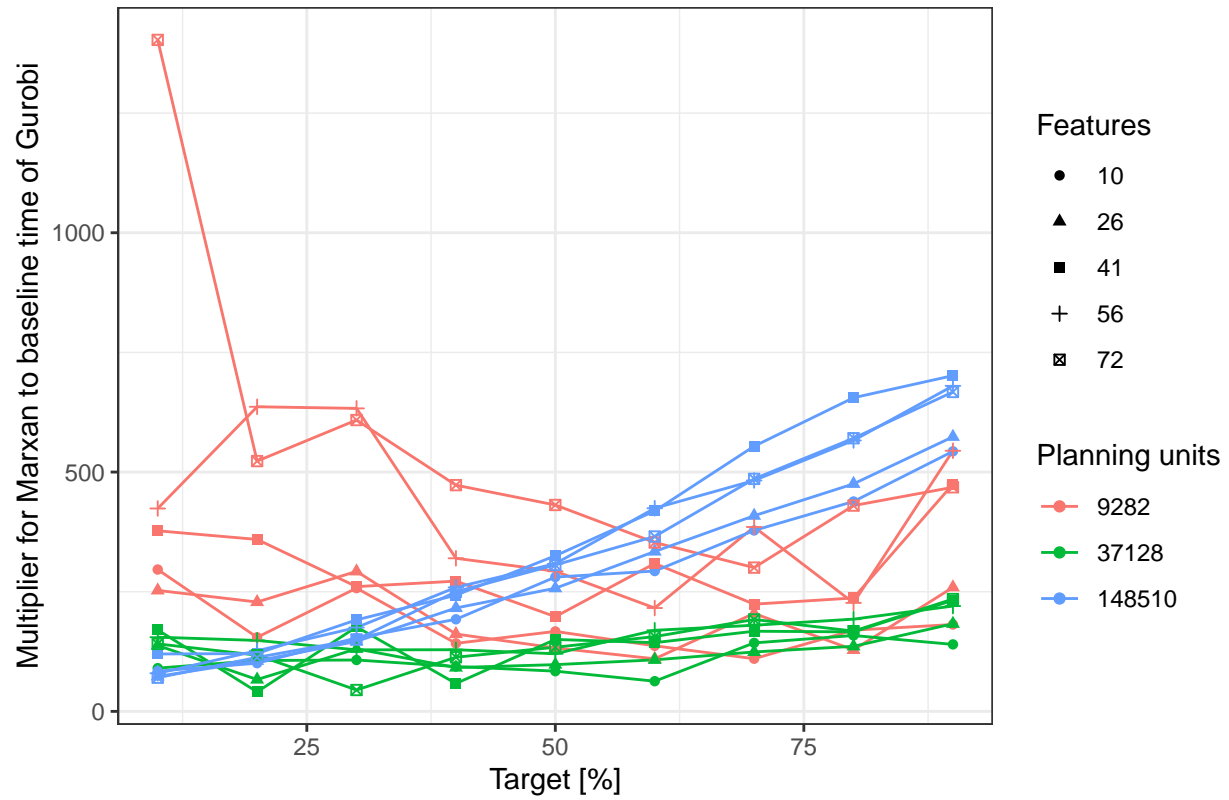


Figure S7: Time to solution comparisons between Marxan using Simulated Annealing and Gurobi across targets, number of features and number of planning units.

Figure S8

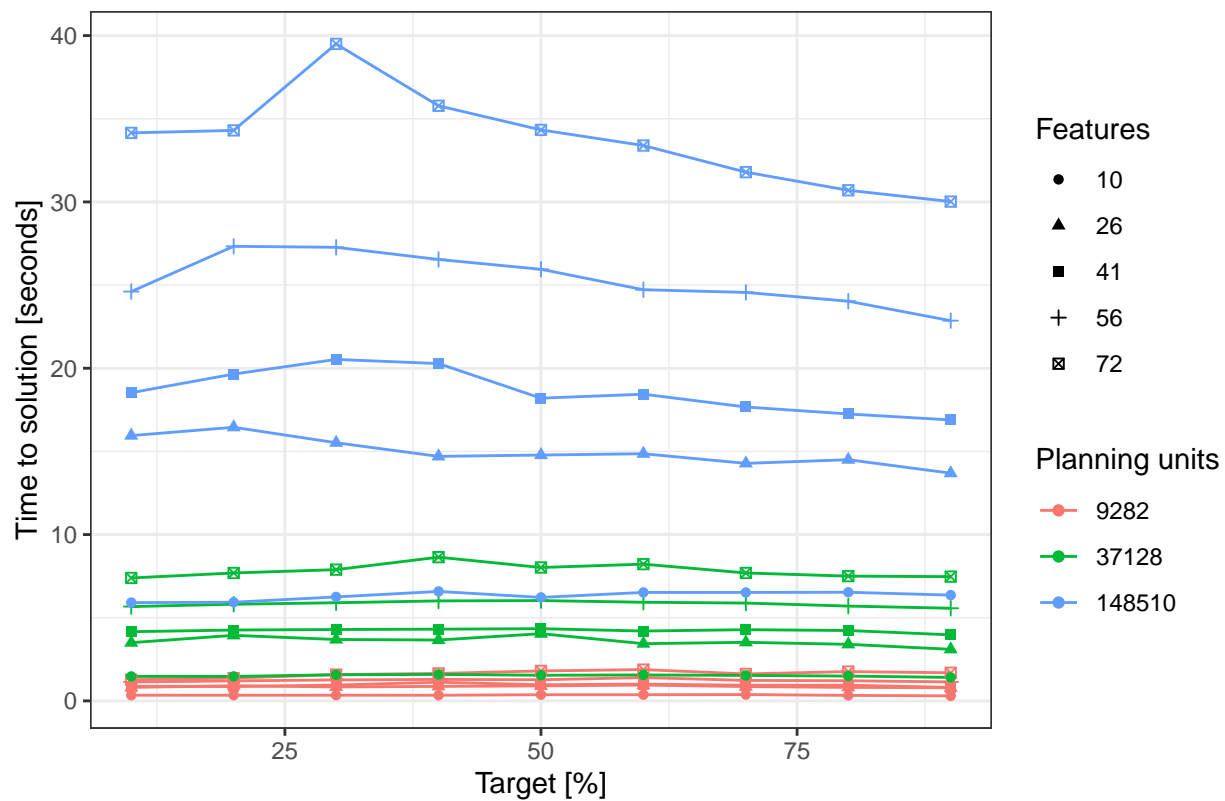


Figure S8: Time to solution profile for Gurobi solver across targets, number of features and number of planning units.

Figure S9

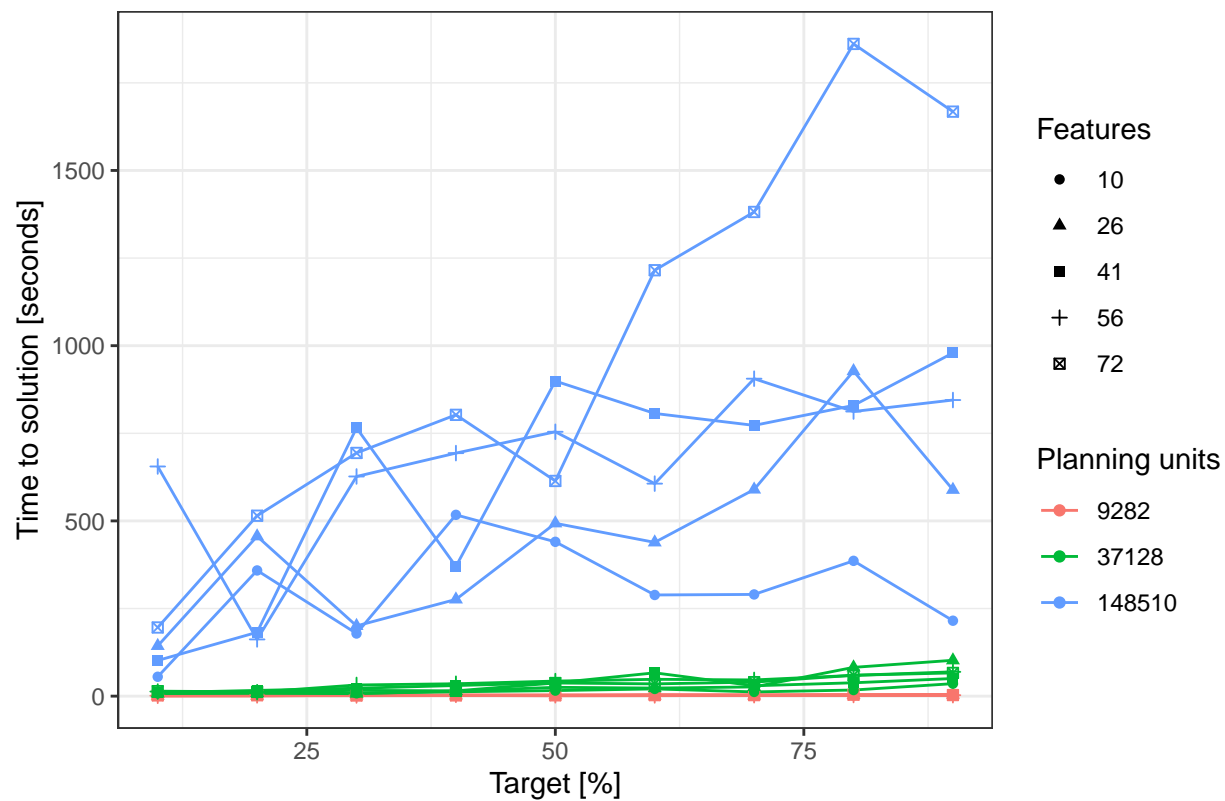


Figure S9: Time to solution profile for SYMPHONY solver across targets, number of features and number of planning units.

Figure S10

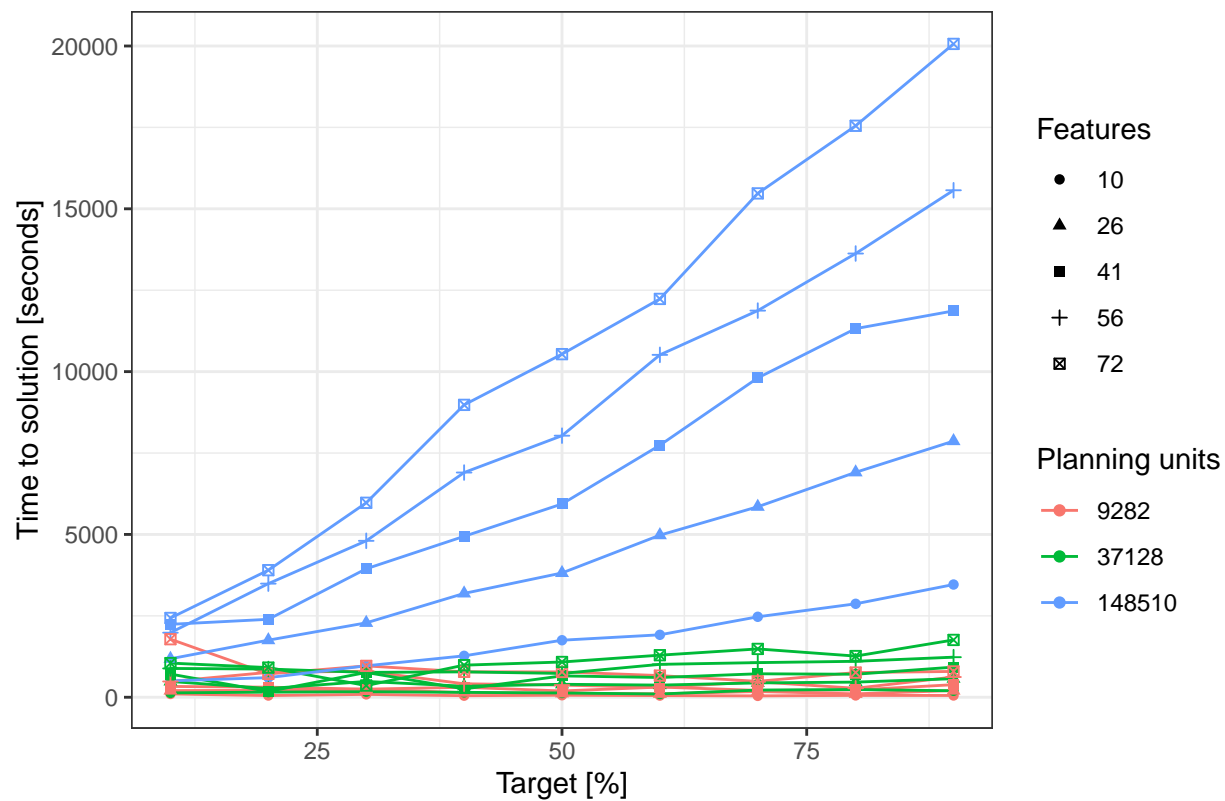
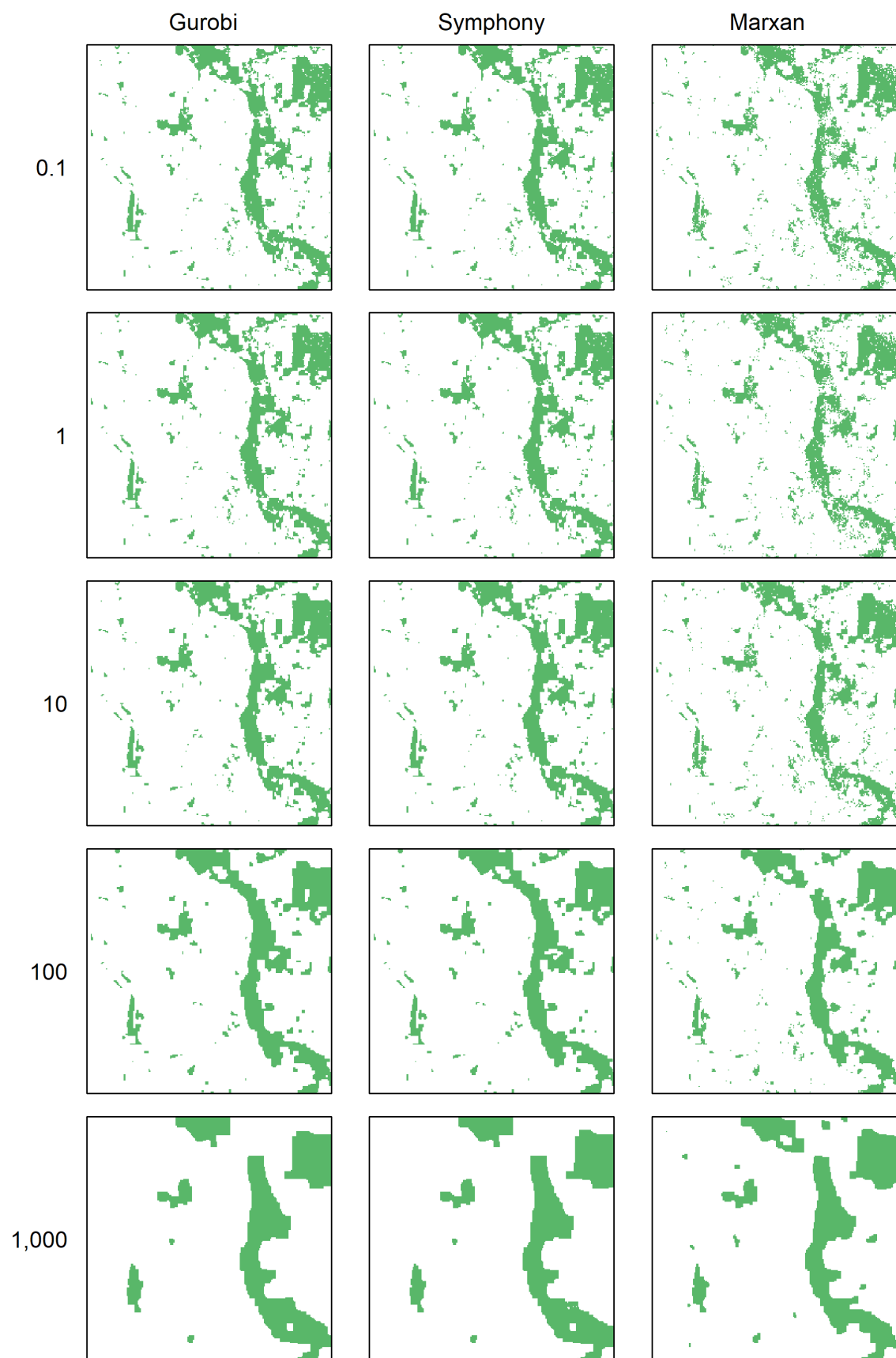


Figure S10: Time to solution profile for Marxan using Simulated Annealing across targets, number of features and number of planning units.

Figure S11



S11: Compactness of solutions. Shown are the solutions for a 10% target. The numbers represent BLM

values.