Assessment of tahr survival during aerial 1080 applications in the Perth River valley, South Westland

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May 2020

Contents

Background

Zero Invasive Predators (ZIP), in collaboration with DOC and Predator Free 2050 Ltd, is undertaking a research and development programme of work in the Perth River valley, South Westland (43.2616° S, 170.3590° E) seeking to develop the technologies to enable the complete removal of possums, ship rats, and stoats; and then defend the site from re-establishment of these species. The initial removal stage of the programme included undertaking two aerial 1080 operations (each using a different bait type and lure) over the course of four months, aiming to remove all target individuals of those species.

From the outset, ZIP recognised the potential for Himalayan tahr (*Hemitragus jemlahicus*) to be killed by eating aerially sown 1080 (sodium fluoroacetate) cereal bait intended for possums and rats. Tahr are a game animal under the Game Animal Council Act 2013 and are a valued species for recreational and commercial hunters. The Himalayan Thar Control Plan 1993 (DOC, 1993) seeks to manage their impact on conservation values. Further to hunting impacts, tahr by-kill could be problematic if they were a vector for secondary poisoning for non-target native species such as kea; although evidence to date suggests that is not the case (DOC 2020). In the Perth River valley site, any potential risk to kea from scavenging carcasses was reinforced by ZIP utilising kea proclivity to feed on tahr carcasses to attract kea to specific sites outside of the operational areas temporarily, and to develop 1080 bait aversion in kea by exposing them to anthraquinone-laced cereal baits at those tahr carcass sites (Nichols & Bell 2019). Recognising this risk of tahr bykill, ZIP invited the Game Animal Council (GAC) to collaborate on a research programme to assess the survival rate for tahr exposed to aerially sown 1080 cereal bait.

There is ample evidence of unintentional deer mortality from aerially sown 1080 bait when it is used for broadscale pest control, and in some instances mortality rates can be extremely high (Morriss & Yockney, 2019). Historic research with carrot baits with 1080 applied at 0.16% has shown that tahr can be susceptible to 1080 poison and that the level of kill increased with increased amount of non-toxic pre feeding (Douglas 1967). Douglas did not report bait application rates. Contemporary aerial 1080 operations use cereal pellet baits with 0.15% 1080, typically applied at densities of 1–4 kg ha^{-1}. Deer repellent added to 1080 bait reduces deer mortality during aerial 1080 pest control operations (Morriss, 2007; Morriss & Nugent 2008; Morriss & Nugent 2017; Morriss et al., 2005; Nugent et al., 2012). However, deer repellent was not used for the Perth Valley operations due to its unknown influence on bait consumption rates by kea, and to maintain consistency in appearance and smell of operational bait as part of the kea mitigation strategy.

The most direct assessment of incidental mortality of tahr is to monitor a sample of animals and assess their survival through a 1080 operation. In this case, we monitored animals via radio collars. Provided there is no major correlation between how easily animals can be captured and radio-collared and their susceptibility to 1080 poisoning, the percentage of radio-collared animals killed provides a simple, direct, and rapid indication of lethality that does not require adjustment for other factors such as seasonality that affect indices of animal abundance.

A key decision point entailed deciding the preferred tahr demographic for collar deployment. Recreational hunters and professional hunting guides are most interested in trophy bull (mature male) tahr and preferred to monitor bulls. However, several factors favoured deployment on nannies (mature females) and juveniles (either sex).

1. Larger animals are less susceptible to poisoning because they need to eat more baits. This is a particularly relevant point for tahr, which display significant sexual dimorphism. Douglas

(1967) found higher mortality rates in juveniles than in adult tahr.

2. Bulls are highly mobile during the rut, the time of planned toxin applications, and therefore would have had a high probability of moving from the study area, and non-exposure to 1080. On the other hand, nanny and juvenile tahr tend to reside in a small range.
3. Bulls and nanny/juvenile tahr are often segregated, with bull tahr tending to occupy higher elevations, and therefore less likely to be exposed to aerial 1080.
4. If aerial 1080 were to reduce the female tahr population substantially, bull tahr may vacate the area in search of nannies, which would be counter to hunters' interests.

Consequently, monitoring collars were deployed on females and juveniles.

Method

Direct monitoring of individual and aggregate tahr survival after exposure to aerial 1080 enabled assessment of survival probabilities. Exposure and mortality was monitored by periodic location of tahr fitted with either Sirtrack 265 or Kiwitrack 360 VHF tracking collars, timed for the days immediately prior to, and post the aerial distribution of bait. Each of these collar types has a mortality mode, when the signal pulse rate doubles, triggered after 12 hours without motion. The target was to fit a minimum of twenty collars to nanny and juvenile tahr to provide sufficient statistical validity of survival rate estimates.

Tahr were captured using a net gun fired from helicopters flown by Fox Franz Heli Services. On capture tahr were hobbled and fitted with blindfolds and horn protectors. Netted tahr were transported to a centrally located site at Elizabeth Stream within the study area, where ground assistants removed the nets, fitted and activated the collars, recorded sex, age, approximate weight and collar frequency for each tahr, and prepared the tahr for transport to release sites within the study area (Figures 1–2). Tahr were transported to release sites in fadges (Figure 1). This work was approved by the Lincoln University Animal Ethics Committee (Approval AEC-2018-14).

In total, 14 adult female, five juvenile male and two juvenile female tahr were captured within (n=10) and outside (n=11) the study area and were fitted with VHF radio collars. One additional female tahr was euthanised after breaking a horn during capture (as per AEC approval conditions). Twelve tahr were fitted with Sirtrack collars and nine were fitted with Kiwitrack collars. All 21 tahr were captured and released on 25 April 2018. At the conclusion of operations, collared tahr will be killed. At time of writing New Zealand is in a state of national emergency. Helicopters are unable to operate because of COVID-19 lockdown. The tahr will be killed as soon as relaxation of emergency lockdown restrictions allow.

Sky Ranger, a system employed by ZIP to monitor kea in the study area that were also fitted with VHF transmitters, monitored tahr locations on periodic flights to fit ZIP's operational research timing. Sky Ranger flew in a 1km grid formation over the wider research area at an altitude of approximately 2400 m, to avoid other aircraft (e.g. tourism helicopters) and maintain safety in the mountainous terrain. Sky Ranger scans for the individual frequencies on each of the collars; with the approximate location of each collar determined by the pattern and strength of the signal received, taking into account the terrain features and the shielding effect of such features (e.g. mountains block signals) – location determinations are likely to have a maximum margin of error of a few hundred metres (P. Bell, pers. comm.).

Sky Ranger flights to detect VHF collar locations took place as soon as practically possible prior to and after each prefeed baiting, and the toxic bait applications to minimise the effects of tahr movement on perceived exposure to 1080. The first post-toxin flights occurred within two days of toxic applications in each case. Individual tahr locations were mapped for each Sky Ranger flight, and were overlaid on toxin application areas to provide information on each individual tahr's potential exposure to 1080 (see Appendix 1 for all individual tahr location maps).

Circumstances and funding permitting, any tahr that died subsequent to 1080 applications would be recovered and one litre samples of rumen contents and 50g samples of liver and leg muscle tissue would be collected and assessed for 1080 content.

Adverse weather and snow conditions prevented the toxic bait applications originally planned for late autumn/winter 2018. Fortunately, the five-year battery life of the VHF monitoring collars meant that plans to postpone operations until 2019 did not compromise the tahr monitoring project. However, there was some concern that the juvenile tahr fitted with collars could grow substantially over that period, presenting a potential animal welfare issue with the collars becoming too tight. The Lincoln University Animal Ethics Committee extended their approval to November 2019 on condition that collar fit on a juvenile tahr was assessed in early 2019. Because of the limited range of the VHF transmitters, this assessment was carried out after a Sky Ranger survey flight which provided an approximate location for the helicopter operator to find a collared juvenile tahr. A radio collared juvenile bull was shot on 2 May 2019 to assess collar tightness and was assessed as having significant room for additional growth (Figure 4). Therefore, all radio collared juvenile tahr remained in the operation.

Baiting operations

In the first operation, the area was prefed (6 g baits at 2 kg/ha) on 19 March and 3 April 2019, followed by toxic baiting (6 g baits, 0.15% 1080, at 4 kg/ha) on 13-14 April 2019. Both prefeed and toxic bait were Wanganui #7 (manufactured by Orillion, Wanganui), lured with double orange (0.3%).

In the second operation, the area was prefed (6 g baits at 1 kg/ha) on 18 June and 25 June 2019, followed by toxic baiting (6 g baits, 0.15% 1080, at 2 kg/ha) on 22-23 July 2019. Both prefeed and toxic bait were RS5 (manufactured by Orillion, Wanganui), lured with double cinnamon (0.3%).

The treatment area in the first five bait applications was 8659 ha; but was reduced to 6153 ha for the toxin application in July (on the basis of no predator detections within the excluded area). All bait in every application (prefeed & toxic) was dyed green, as part of the kea mitigation measures employed to reinforce the learned bait aversion (Nichols and Bell 2019).

Figure 1: Helicopters operating at the Elizabeth Stream site.

Figure 2: Fitting a VHF collar. The tahr on the left already has a collar fitted. Blindfold and horn protectors are visible.

Figure 3: Juvenile male tahr shot to check collar tightness on 2 May 2019.

Statistical analysis method

Define:

- p_1 Probability of surviving first exposure to 1080
- p_2 Probability of surviving second exposure to 1080 (having survived the first exposure)
- p_{Both} Probability of surviving two exposures to 1080
- N_1 Number of tahr exposed to the first treatment
- N_2 Number of tahr exposed to the second treatment (all of which were exposed to the first treatment)
- S_1 Number of exposed tahr surviving their first treatment
- S_2 Number of exposed tahr surviving their second treatment
- S Total number of tahr exposed to 1080 at least once that survive

N_i and S_i are observed. The objective is to estimate P_1 and P_2 using Equations 1 and 2. Equations 3 and 4 follow.

1. $p_1 = S_1/N_1$
2. $p_2 = S_2/N_2$
3. $p_{Both} = p_1p_2$
4. $S = (N_1-N_2)p_1 + N_2p_1p_2$

The standard error for a proportion is $(p(1-p)/N)^{0.5}$, but is not defined when p=0 or p=1.

Because each tahr exposed to 1080 is an independent binomial trial (at least within first and second exposures), it is possible to identify the probability of obtaining the observed outcomes for various p_i. Where $p_1 = p_2 = p$ (previous exposure has no effect), both treatments can be combined. In the presence of learned bait aversion, including from sub-lethal toxicity at first exposure, this assumed scenario underestimates p_2 and overestimates p_1. We have no information on whether tahr learn 1080 bait aversion (although we note that each treatment used different lures and baits), so we urge caution in adopting pooled value estimates. It is instructive to investigate how small p_i can be for the outcomes in the various scenarios to occur.

Probabilities of binomial outcomes are:

$$P(S: N, p) = {}_NC_S.p^S.(1-p)^{(N-S)} = \{N!/[S!(N-S)!]\}.p^S.(1-p)^{(N-S)}$$

Where P(S: N, p) is the probability of S survivors when N tahr are exposed and the probability of survival is p.

When N = S this simplifies to:

$$P(N: N, p) = p^N$$

$$p = P^{(1/N)}$$

In that case the low 95% confidence level is:

$$\pi = (.05)^{(1/N)}$$

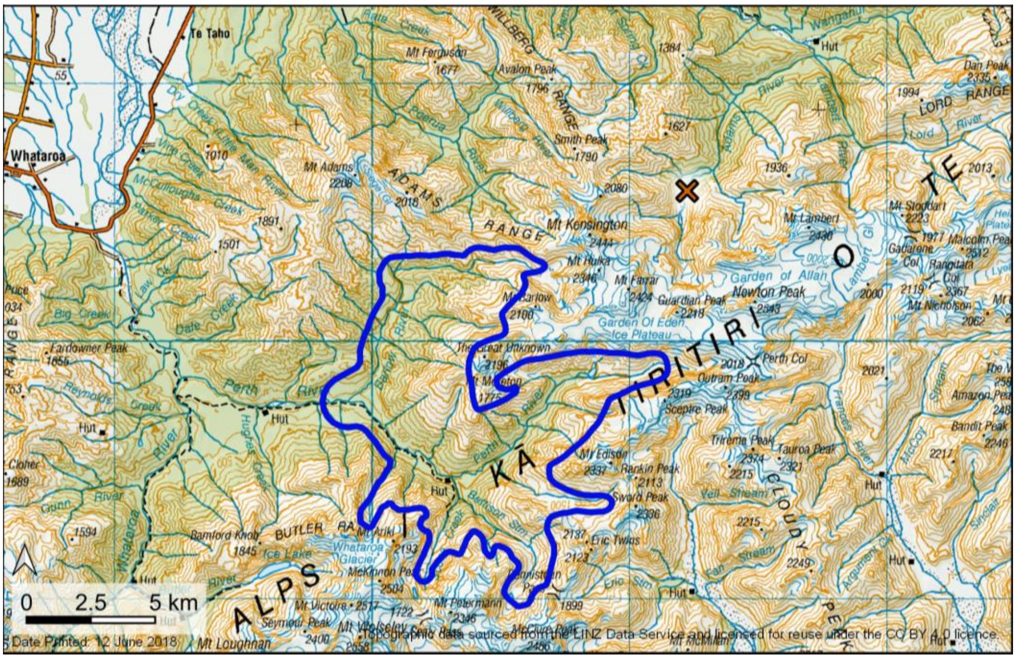
Results

Two prefeed operations and associated Sky Ranger monitoring occurred during 2018 prior to the decision to postpone toxic applications until 2019. A calendar of events (for the full trial period) appears in Appendix Table A1.

Four tahr (three mature females and one immature female) were never detected by Sky Ranger during this period. Non-detection may have occurred for a number of reasons, including collar failure, operator error, human interference, or the tahr being in undetectable positions, including being outside the Sky Ranger monitored area. Previous research has shown tahr can travel large distances (G Ottmann, pers. comm.). There was confirmation of this factor when a hunting party sighted a collared tahr well outside the monitored area near Adams Flat (Figures 4 and 5 in early June 2018).

Figure 4: Photograph of a collared tahr taken by a hunter at Adams Flat, 4 June 2018.

Figure 5: Location of collared tahr sighted near Adams Flat (cross) with area baited April 2019 shown (blue line)



Unlike GPS collars, VHF collars do not provide precise spatial locations, nor do they allow near real-time monitoring. Sky Ranger flights were during the day, at times when previous research indicates nanny and juvenile tahr are likely to have been at the highest points of their daily movements (Douglas, 1967; Tustin & Parkes, 1988). However, anecdotal evidence suggests this pattern may be reversed on the West Coast, with some tahr inhabiting more heavily vegetated lower areas in the middle of the day (Gus Gordon, Pers. Comm.). Since 1080 was applied at the lower elevations within the catchment, tahr present outside the 1080 application area during the Sky Ranger flights may still have been exposed to 1080 during lower-elevation feeding forays.

Unavoidable time lapses (up to 28 days) between Sky Ranger monitoring and 1080 applications provide the opportunity for larger-scale tahr movements. These factors mean that it is not possible to identify definitively individual tahr exposure to 1080 in the window after each treatment when baits remain viable. Subjective exposure judgements, based on temporal interpolation from individual tahr detections, recognise low spatial acuity of the VHF collars and likely daily movement patterns (Tables 1 & 2). Observations of individual tahr behaviour over the three Sky Ranger flights in 2018 and nine flights in 2019, particularly where tahr are loyal to a specific location, assists those judgements. Averaging locations over the three flights adjacent to the second toxin treatment is also helpful. The short time between pre- and post-operation monitoring (10 days before and 2 days after for Treatment 1, and 1 day before and 1-7 days after (3 observations) for Treatment 2) mitigate potential for any tahr thought to be present to actually be absent from the treatment areas.

Some tahr were within the treatment area for one application, some for both applications, and some were outside the treatment area for both applications.

Table 1: Individual tahr exposure to 1080 bait

Tahr number	Radio channel	Sex	Age	Treatment 1	Treatment 2
1	0	Male	Juvenile	Exposed	Exposed
2	3	Female	Adult	Exposed	Exposed
3	6	Male	Juvenile	Exposed	Exposed
5	12	Male	Juvenile	Exposed	Exposed
7	16	Female	Adult	Exposed	Exposed
10	41	Female	Adult	Exposed	Exposed
12	53	Female	Adult	Exposed	Exposed
17	83	Female	Adult	Exposed	Exposed
16	79	Female	Adult	Exposed	Probably exposed
19	87	Female	Adult	Exposed	Probably exposed
8	18	Male	Juvenile	Exposed	Not exposed[1]
6	14	Female	Juvenile	Probably exposed	Probably exposed
15	75	Female	Adult	Probably exposed	Probably not exposed

[1] Shot earlier for animal welfare check

14	73	Female	Adult	Possibly exposed	Probably not exposed
4	8	Female	Adult	Probably not exposed	Probably not exposed

Notes: *An additional four radio collared tahr were not detected during the study, but one was subsequently re-detected outside the operational area after the study concluded. The signals of two more radio collars on tahr were on mortality mode prior to baiting indicating either these tahr had died from unknown causes or the collar had fallen off. Since these tahr could not have died from 1080 poisoning, the collars in mortality mode were not recovered to assess mode of death.*

Table 2: Summary of tahr exposure to 1080 bait

Exposure category	N
Exposed to both treatments	8
Exposed to Treatment 1, probably exposed to Treatment 2	2
Exposed to Treatment 1, not exposed to Treatment 2	1
Probably exposed to Treatment 1, probably exposed to Treatment 2	1
Probably exposed to Treatment 1, probably not exposed to Treatment 2	1
Possibly exposed to Treatment 1, probably not exposed to Treatment 2	1
Probably not exposed to either treatment	1
Definitely not exposed to either treatment	6
Total	**21**

Likelihood of exposure to 1080 was the same, or lower, for each individual tahr in Treatment 2 relative to their likelihood of exposure in Treatment 1. It is highly unlikely that any tahr were exposed to 1080 for the first time in Treatment 2. It is likely that thirteen tahr were exposed to at least one treatment. Six of the 21 collared tahr were not exposed to either treatment, either because they were dead or were undetectable. A range of plausible scenarios is presented in Table 3.

Table 3: Aggregate tahr 1080 exposure scenarios

Scenario	Description	Number of tahr exposed to Treatment 1	Number of tahr exposed to Treatment 2	Number of tahr first exposed at Treatment 2	Total exposures
1	Worst case	11	8	0	19
2	Likely case	13	11	0	24
3	Best case	15	14	0	29

Statistical analysis

All exposed tahr survived both treatments, so $p_1 = p_2 = 1$. This result could have occurred by chance, even if $p_i < 1$. Recall, the probability of N survivors from N exposures, given the underlying survival rate p, is:

$$P(N: N, p) = p^N$$

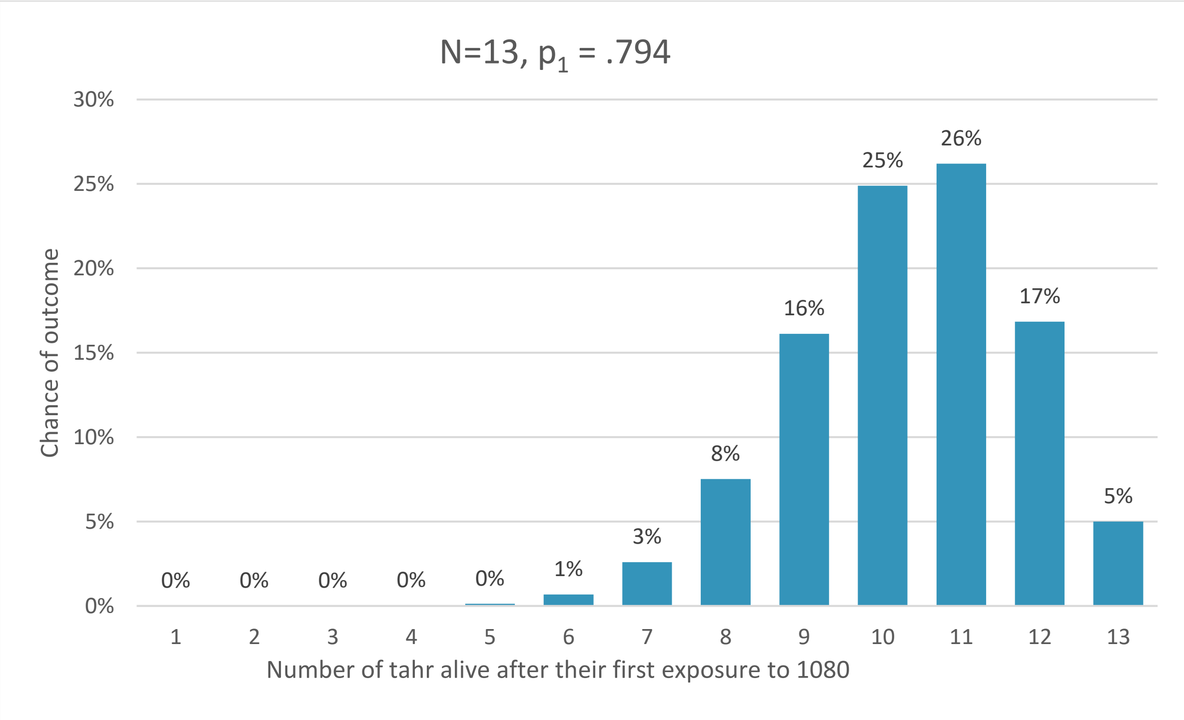
$$p = P^{(1/N)}$$

The 95% confidence level for p_i (π) is:

$$\pi = (.05)^{(1/N)}$$

Figure 6 illustrates statistical results for the *Likely Scenario* (Scenario 2) for survival probability for the first exposure (p_1). In this scenario, thirteen tahr faced an initial exposure to 1080, with all of them surviving. If p_1 were less (more) than .794 the chance of 13 survivors would be less (more) than 5%. In other words, there is a 95% probability that the true survival rate (p_1) is at least .794.

Figure 6: Binomial probability: Scenario 2



Sample size is the sole determinant of the estimates of π, reported in Table 4. Hence, while the estimates of π_2 are smaller than the estimates for π_1, counter to expectations, this outcome is simply an artefact of the necessarily smaller sample sizes for π_2. The smallest estimated lower-bound probability is for the worst-case scenario for π_2 in which only eight tahr were exposed to 1080. This is a highly pessimistic scenario, so provides a very high level of confidence that over two thirds of tahr would survive a second exposure to 1080. Similarly, the worst-case scenario for a single 1080 exposure has over three quarters of tahr surviving. Recalling that all tahr survived both treatments, and that the π estimates in Table 4 are lower bound 95% confidence limits, it is apparent that a very small proportion of tahr are likely to die in 1080 applied in the case study context.

Table 4: π for various scenarios

Treatment	Scenario	N	π
Single treatment	Worst	11	.762
	Probable	13	.794
	Best	15	.819
Second treatment	Worst	8	.688
	Probable	11	.762
	Best	14	.807
Both treatments combined (p1=p2)	Worst	19	.854
	Probable	24	.883
	Best	29	.902

Discussion

Our results are suggestive of extremely high tahr survival during these aerial 1080 operations. This initial study did not detect any 1080-related tahr deaths. The relatively small sample size and some uncertainty about which individual tahr were exposed to 1080 have been limiting factors, however statistical analysis reveals a high level of confidence that nearly all nanny and juvenile tahr exposed to aerial 1080 survived in this operation.

The survival of all tahr exposed to 1080 in this trial, coupled with the high levels of estimated lower bounds on survival probabilities that could have generated these results (π), should mitigate hunters' concerns over significant tahr mortality in areas subject to aerial 1080 operations. Where tahr populations are relatively low, worst-case mortality is likely to be less than the intrinsic population growth rate (Caughley, 1970; Parkes, 1988).

Tahr are not the only ungulates inhabiting kea habitat. In particular, chamois are prominent in some kea habitats, and kea scavenge chamois carcasses. Because significant nanny tahr populations tend to displace chamois (Forsyth, 2000; Forsyth & Hickling, 1998), chamois by-kill may not be an issue where tahr populations are high. During a study on impacts on red deer of aerial 1080 applied on Molesworth Station in spring 2017, Morriss et al. (2019, p.10) observed: "Chamois were counted in much the same numbers and in much the same places in 2019 and in 2018. As 89% of the chamois counted were in the poisoned area, there is no indication that the 2017 operation affected chamois". To our knowledge, there have been no formal studies undertaken on susceptibility of chamois to aerial 1080, and therefore a trial on chamois survival during aerial 1080 operations could be beneficial. We recommend the use of GPS tracking collars for future work of this nature. While they entail a higher capital cost, GPS collars have several advantages over VHF collars. These are:

1. GPS collars can provide near continuous location data, removing the requirement for subjective assessment of exposure to 1080. Monitoring is not restricted to appropriate daylight and weather conditions, and it does not affect animal behaviour.
2. Satellite monitoring avoids the expense of monitoring flights.

3. GPS collars are superior for animal welfare reasons because animals are less likely to be lost during the study. Three tahr remain undetected since their release, despite some additional monitoring outside the study area. It will not be possible to remove the tracking collars from the tahr whose presence remains unknown.

Another consideration for future operations is use of time-release or remotely released collars, which are available for GPS and VHF devices. Remote collar release avoids the difficulties associated with locating animals in real time, which can be exacerbated by weather-imposed delays between aerial mapping of animal locations and recovery, and the relatively small additional expense of shooting or capturing the animals to remove and/or recover the collars relative to recovery of pre-released collars.

In this case, VHF monitoring of kea meant that tahr monitoring by Sky Ranger incurred minimal additional cost. Hence, the operational cost advantages of GPS collars were less than would be expected in other situations.

Acknowledgements

ZIP funded the research, and has worked in partnership with the Game Animal Council throughout this trial. The Department of Conservation provided oversight, and approved and facilitated field operations. The project received helpful advice from a liaison group consisting of the New Zealand chapter of Safari Club International, the New Zealand Deerstalkers' Association, and the New Zealand Professional Hunting Guides Association. Manaaki Whenua Landcare Research staff with expertise in by-kill assessment and in radio-collaring and tracking (Grant Morriss and Graham Nugent) provided valuable methodological guidance. ZIP maintained regular and ongoing communication with Makaawhio (the local iwi). AEC approval (AEC-2018-14) was granted by Lincoln University Animal Ethic Committee, with assistance from Tom Agnew (ZIP), Elaine Murphy (DOC) and James Ross (Lincoln University) in preparing the applications. James Scott and Ken Hutchins were the pilots used during the capture/collaring, and Geoff Kerr and Garry Ottmann did the collaring itself. John Wilks (ZIP) arranged the Sky Ranger monitoring flights, which were flown by Knights Point Air. Nic Braaksma (ZIP) prepared all of the maps in this report.

This report was peer reviewed by Grant Morriss and Ivor Yockney. I am grateful for their extremely helpful suggestions, which greatly improved the report. Remaining errors are not their responsibility.

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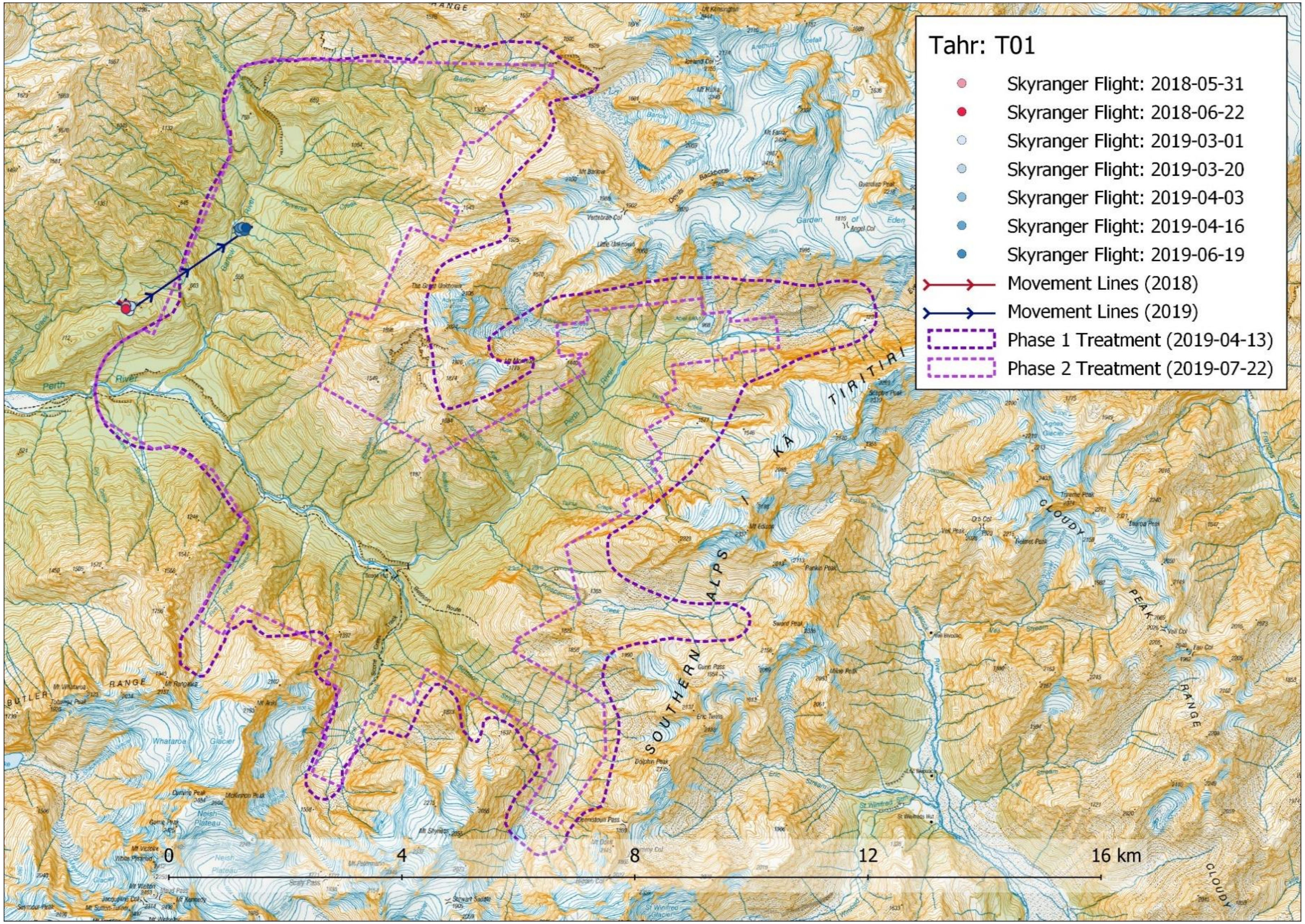
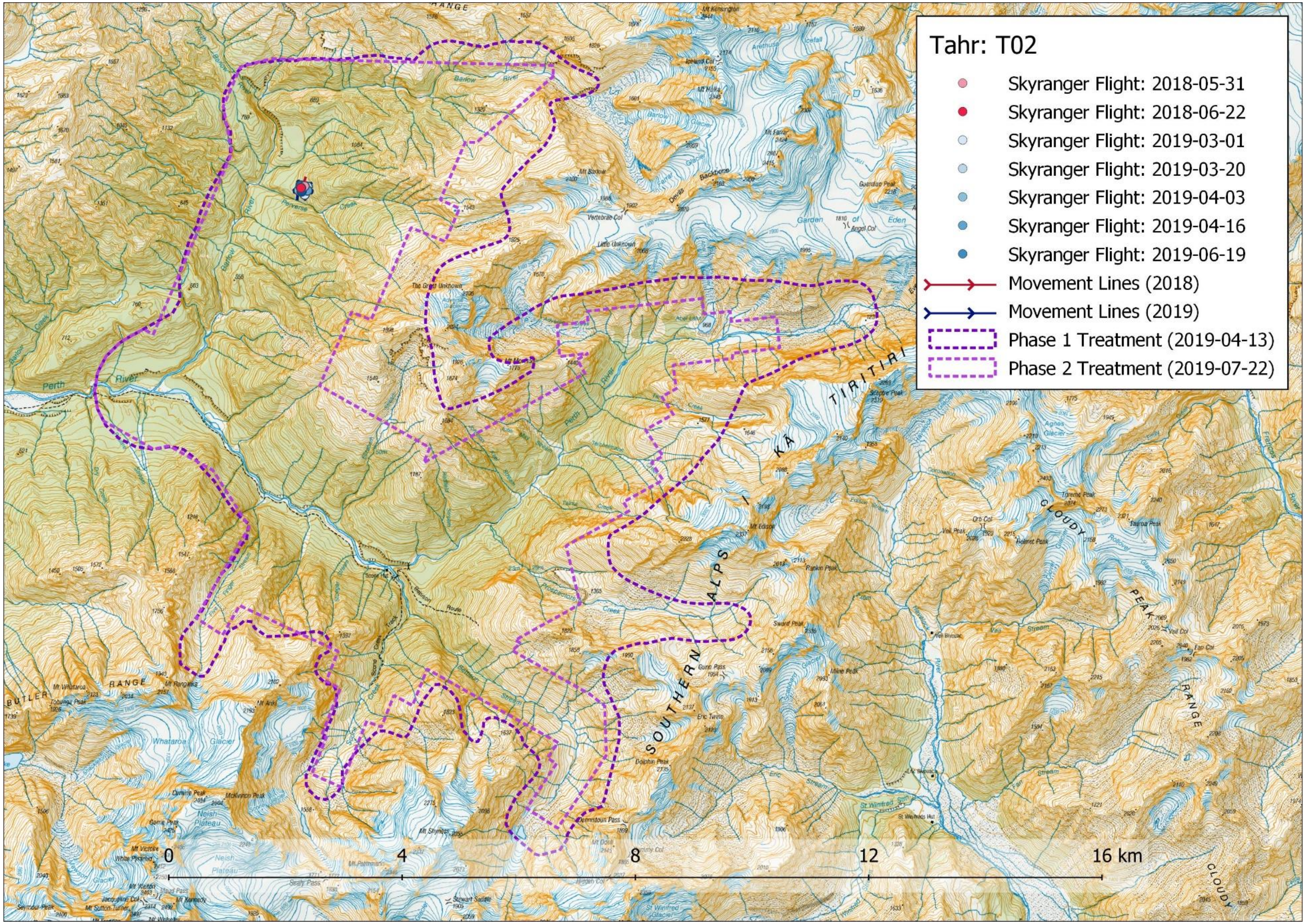
Appendix One: Calendar of events during the tahr monitoring trial 2018–2019

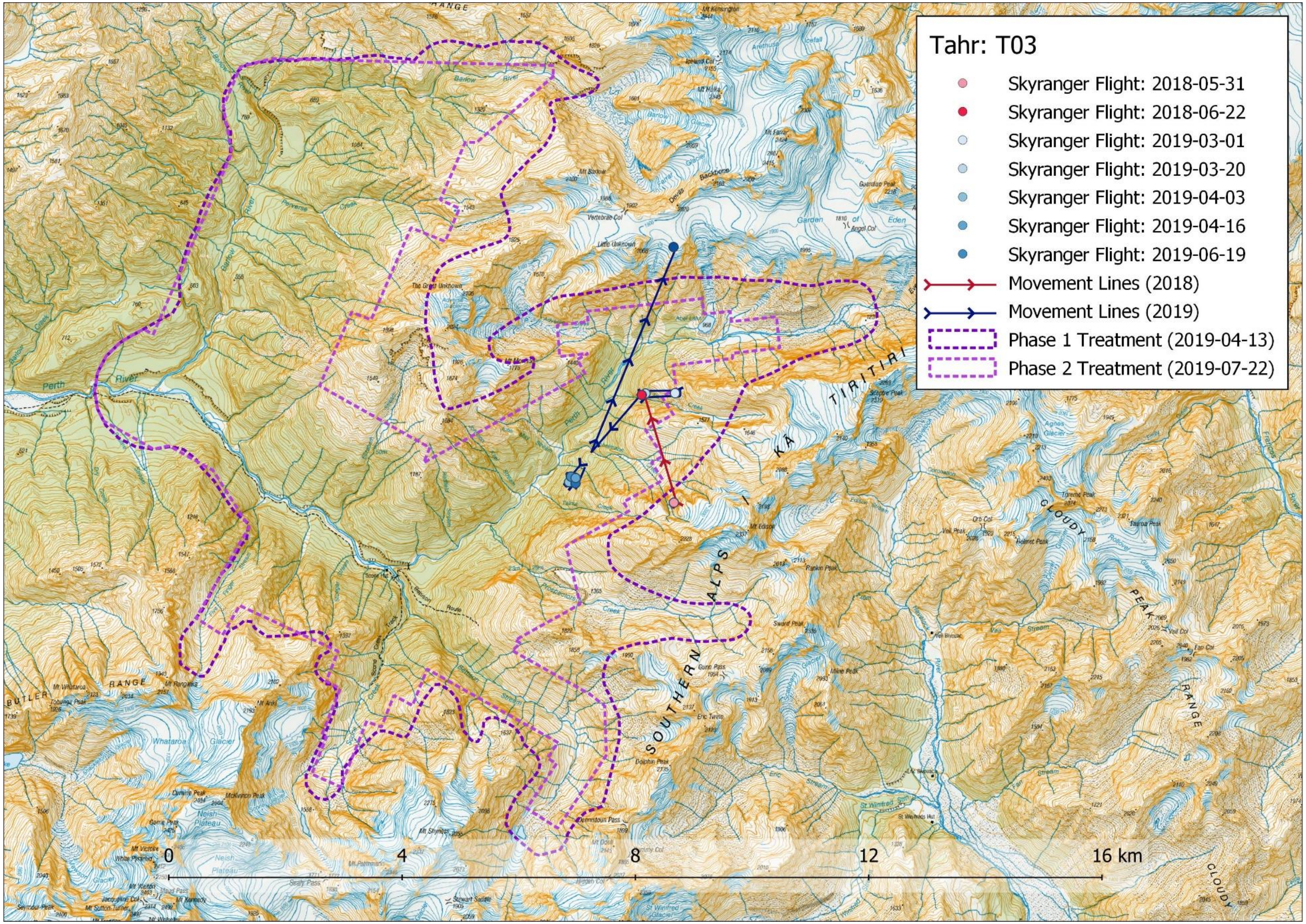
Date	Action	Comments
25 April 2018	21 tahr released	Tahr were captured in and adjacent to the study area, fitted with VHF collars and released in the study area
29 May 2018	Sky Ranger	17 tahr located. Channels 28, 85, 89, 94 missing
30-31 May 2018	Prefeed	
31 May 2018	Sky Ranger	17 tahr located. Channels 28, 85, 89, 94 missing
22 June 2018	Prefeed	
22 June 2018	Sky Ranger	16 tahr located. Channels 28, 75, 85, 89, 94 missing
1 March 2019	Sky Ranger	15 tahr located. Channels 28, 70, 89, 94 missing. None of these missing tahr were detected in later flights. Channels 51 and 85 in mortality mode
19 March 2019	Prefeed	8659 ha, 2kg/ha, 6g Wanganui #7 bait, lured with double orange
20 March 2019	Sky Ranger	15 tahr located
3 April 2019	Prefeed	8659 ha, 2kg/ha, 6g Wanganui #7 bait, lured with double orange
3 April 2019	Sky Ranger	15 tahr located
13-14 April 2019	**Toxic bait**	8659 ha, 4kg/ha, 6g Wanganui #7 bait, lured with double orange
16 April 2019	Sky Ranger	15 tahr located
2 May 2019	Animal welfare check	Channel 18, juvenile male in upper Barlow, shot to check collar tightness.
18 June 2019	Prefeed	8659 ha, 1kg/ha, 6g RS5 cereal bait, lured with double cinnamon
19 June 2019	Sky Ranger	14 tahr located
25 June 2019	Prefeed	8659 ha, 1kg/ha, 6g RS5 cereal bait, lured with double cinnamon
25 June 2019	Sky Ranger	14 tahr located
22 July 2019	Sky Ranger	14 tahr located
22-23 July 2019	**Toxic bait**	6153 ha, 2kg/ha, 6g RS5 cereal bait, lured with double cinnamon
24-30 July 2019	Sky Ranger	14 tahr located Final Sky Ranger locations are averaged from 22/7, 24/7, 30/7

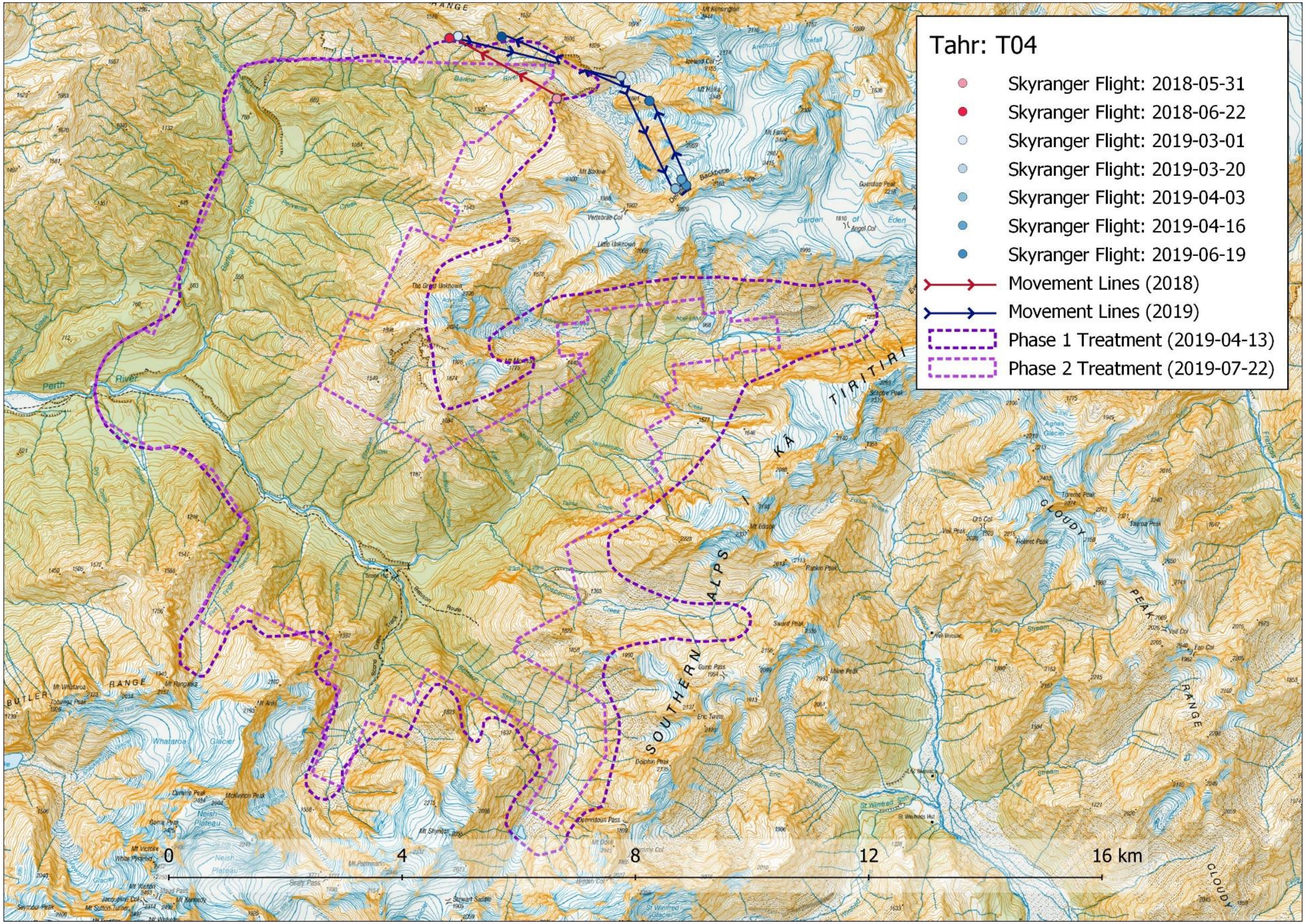
Appendix Two: Individual tahr Sky Ranger locations and movement between flights

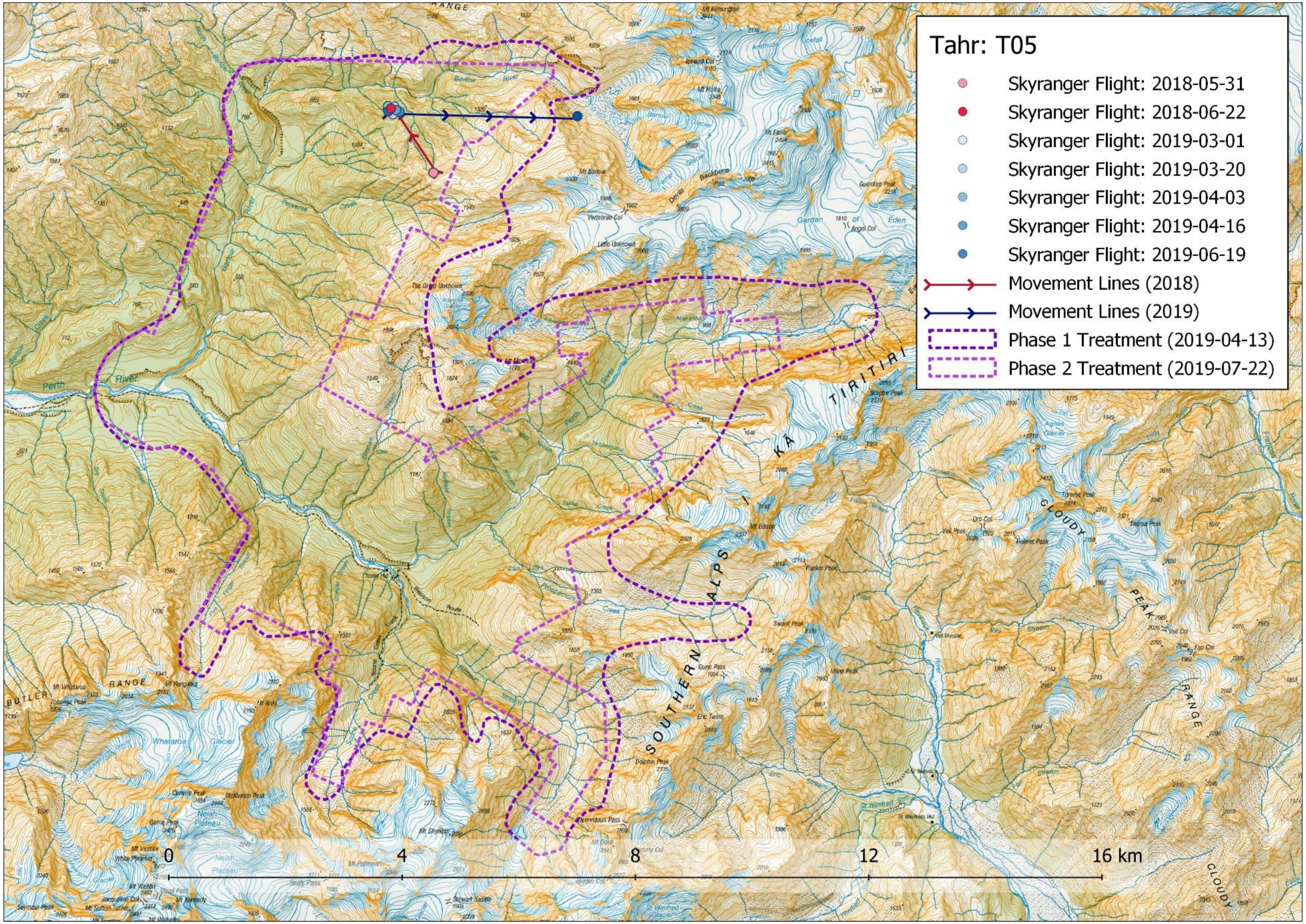


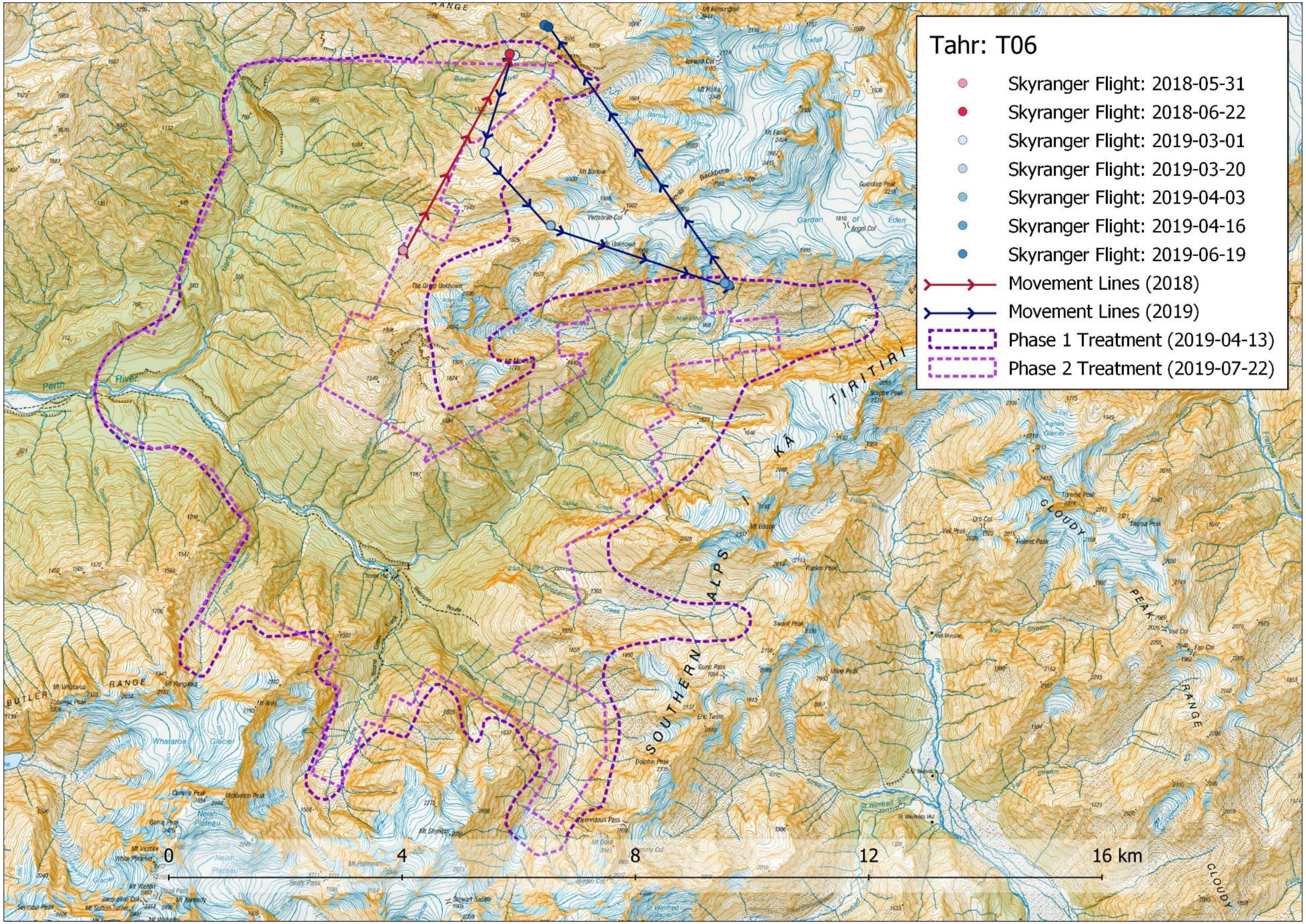


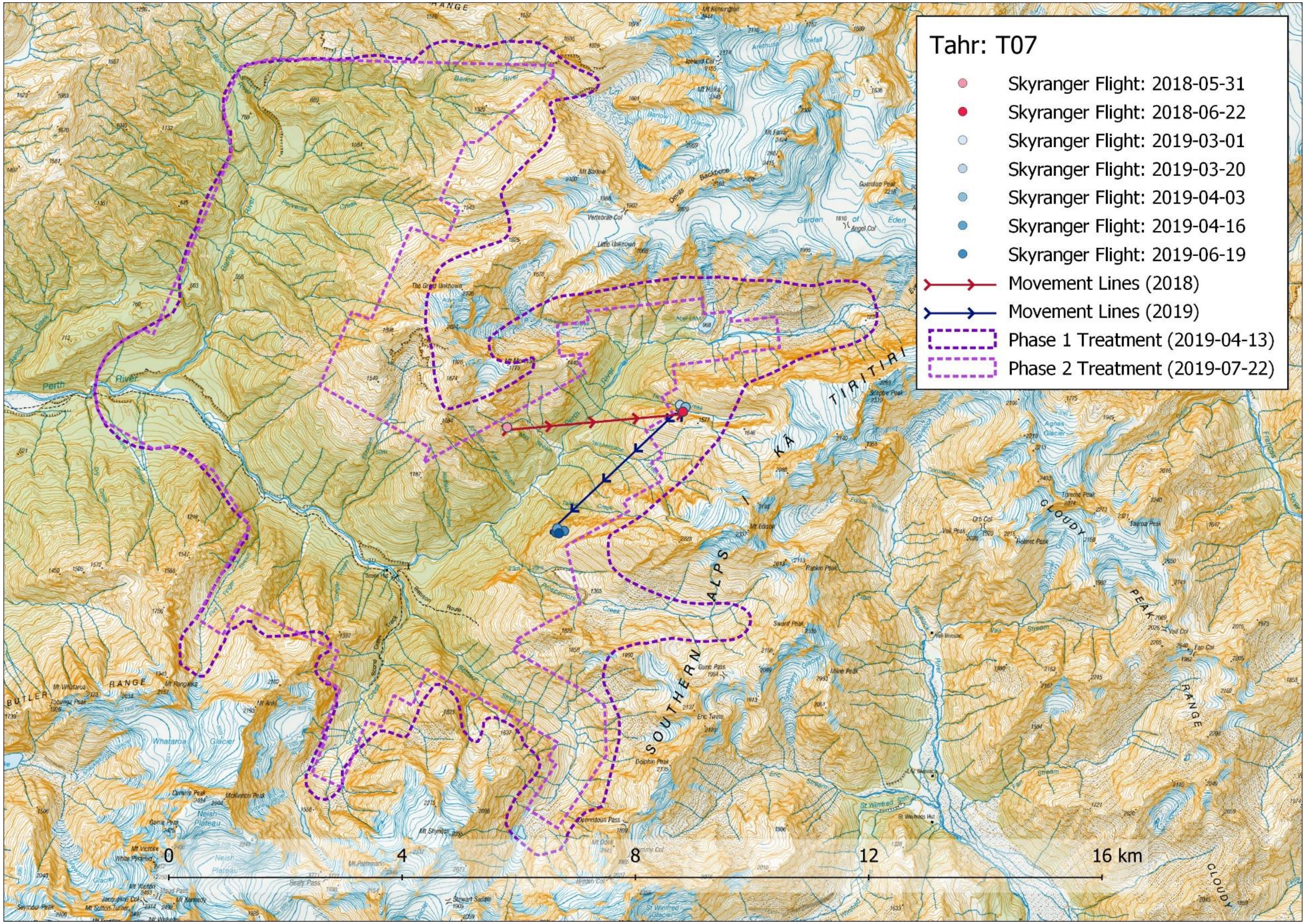
Tahr: T02
Skyranger Flight: 2018-05-31
Skyranger Flight: 2018-06-22
Skyranger Flight: 2019-03-01
Skyranger Flight: 2019-03-20
Skyranger Flight: 2019-04-03
Skyranger Flight: 2019-04-16
Skyranger Flight: 2019-06-19
Movement Lines (2018)
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km

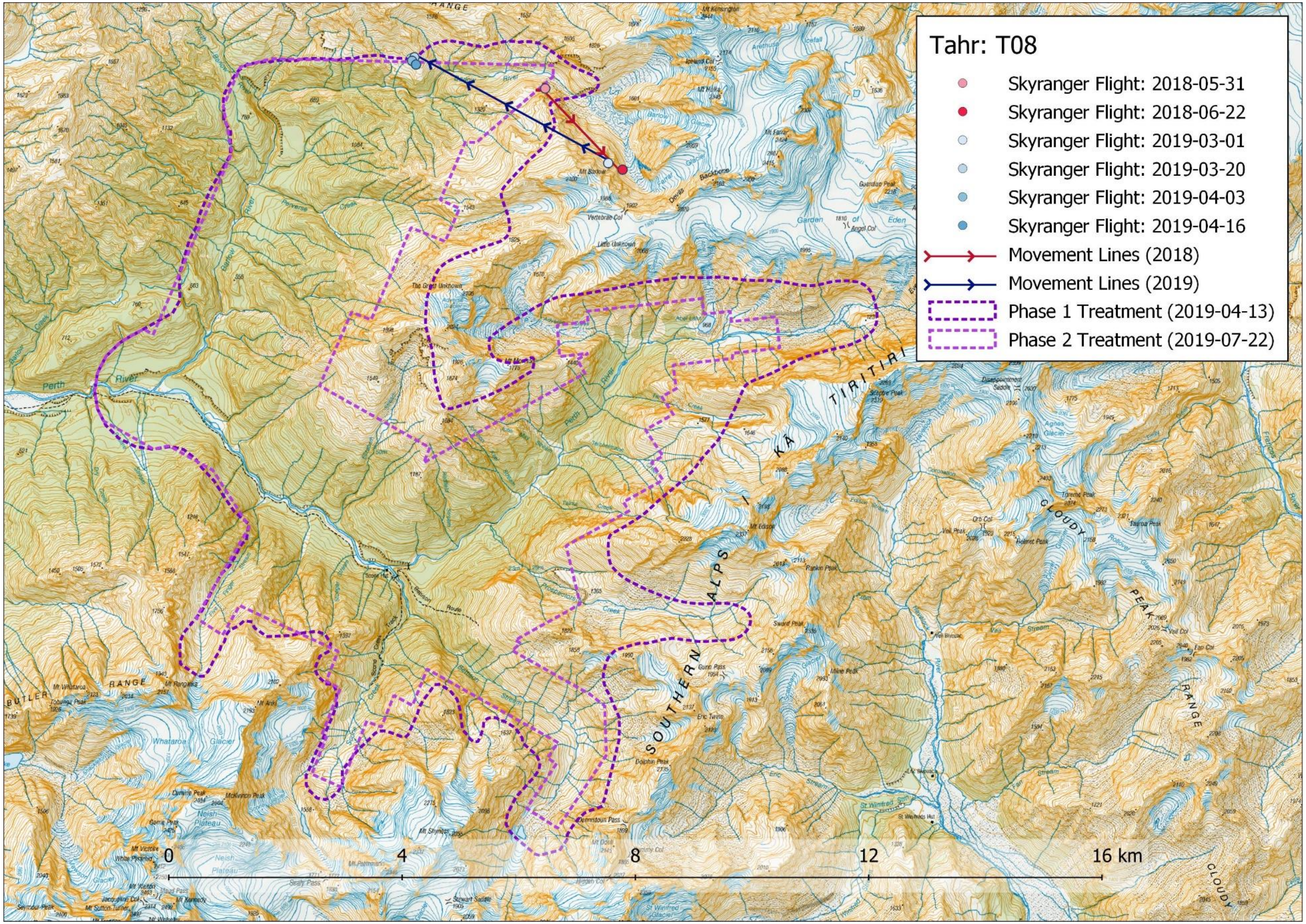

Tahr: T03
Skyranger Flight: 2018-05-31
Skyranger Flight: 2018-06-22
Skyranger Flight: 2019-03-01
Skyranger Flight: 2019-03-20
Skyranger Flight: 2019-04-03
Skyranger Flight: 2019-04-16
Skyranger Flight: 2019-06-19
Movement Lines (2018)
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km
SOUTHERN ALPS / KĀ TIRITIRI
CLOUDY PEAK RANGE
BUTLER RANGE
Perth River

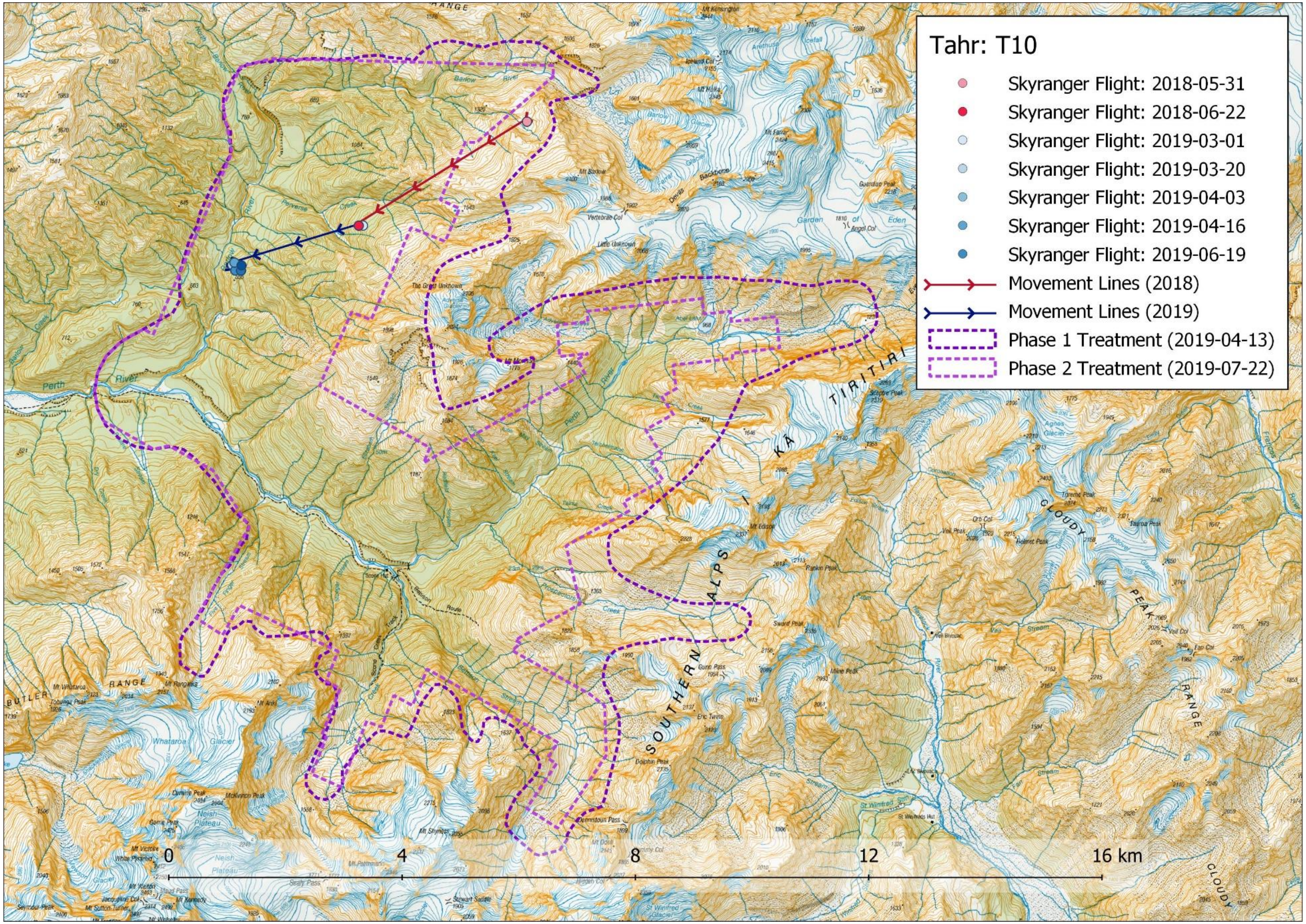

Tahr: T04
Skyranger Flight: 2018-05-31
Skyranger Flight: 2018-06-22
Skyranger Flight: 2019-03-01
Skyranger Flight: 2019-03-20
Skyranger Flight: 2019-04-03
Skyranger Flight: 2019-04-16
Skyranger Flight: 2019-06-19
Movement Lines (2018)
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km
SOUTHERN ALPS / KĀ TIRITIRI
CLOUDY PEAK RANGE
BUTLER RANGE
Perth River
Whataroa Glacier


Tahr: T05
Skyranger Flight: 2018-05-31
Skyranger Flight: 2018-06-22
Skyranger Flight: 2019-03-01
Skyranger Flight: 2019-03-20
Skyranger Flight: 2019-04-03
Skyranger Flight: 2019-04-16
Skyranger Flight: 2019-06-19
Movement Lines (2018)
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km
SOUTHERN ALPS / KĀ TIRITIRI
CLOUDY PEAK RANGE
BUTLER RANGE

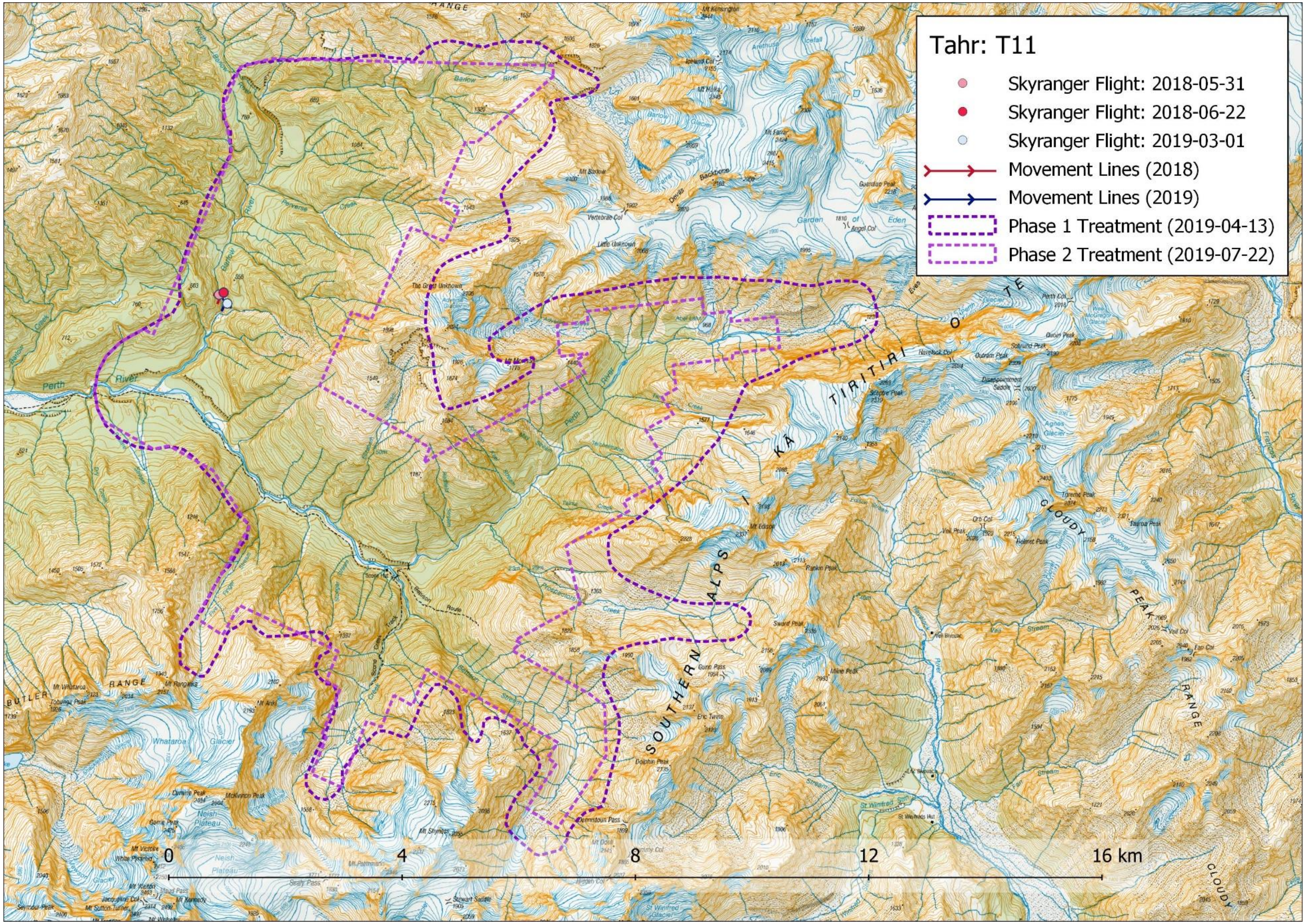

Tahr: T06
Skyranger Flight: 2018-05-31
Skyranger Flight: 2018-06-22
Skyranger Flight: 2019-03-01
Skyranger Flight: 2019-03-20
Skyranger Flight: 2019-04-03
Skyranger Flight: 2019-04-16
Skyranger Flight: 2019-06-19
Movement Lines (2018)
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km
SOUTHERN ALPS / KĀ TIRITIRI
CLOUDY PEAK RANGE
BUTLER RANGE
Perth River


Tahr: T07
Skyranger Flight: 2018-05-31
Skyranger Flight: 2018-06-22
Skyranger Flight: 2019-03-01
Skyranger Flight: 2019-03-20
Skyranger Flight: 2019-04-03
Skyranger Flight: 2019-04-16
Skyranger Flight: 2019-06-19
Movement Lines (2018)
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km
SOUTHERN ALPS / KĀ TIRITIRI
CLOUDY PEAK RANGE
BUTLER RANGE
Perth River

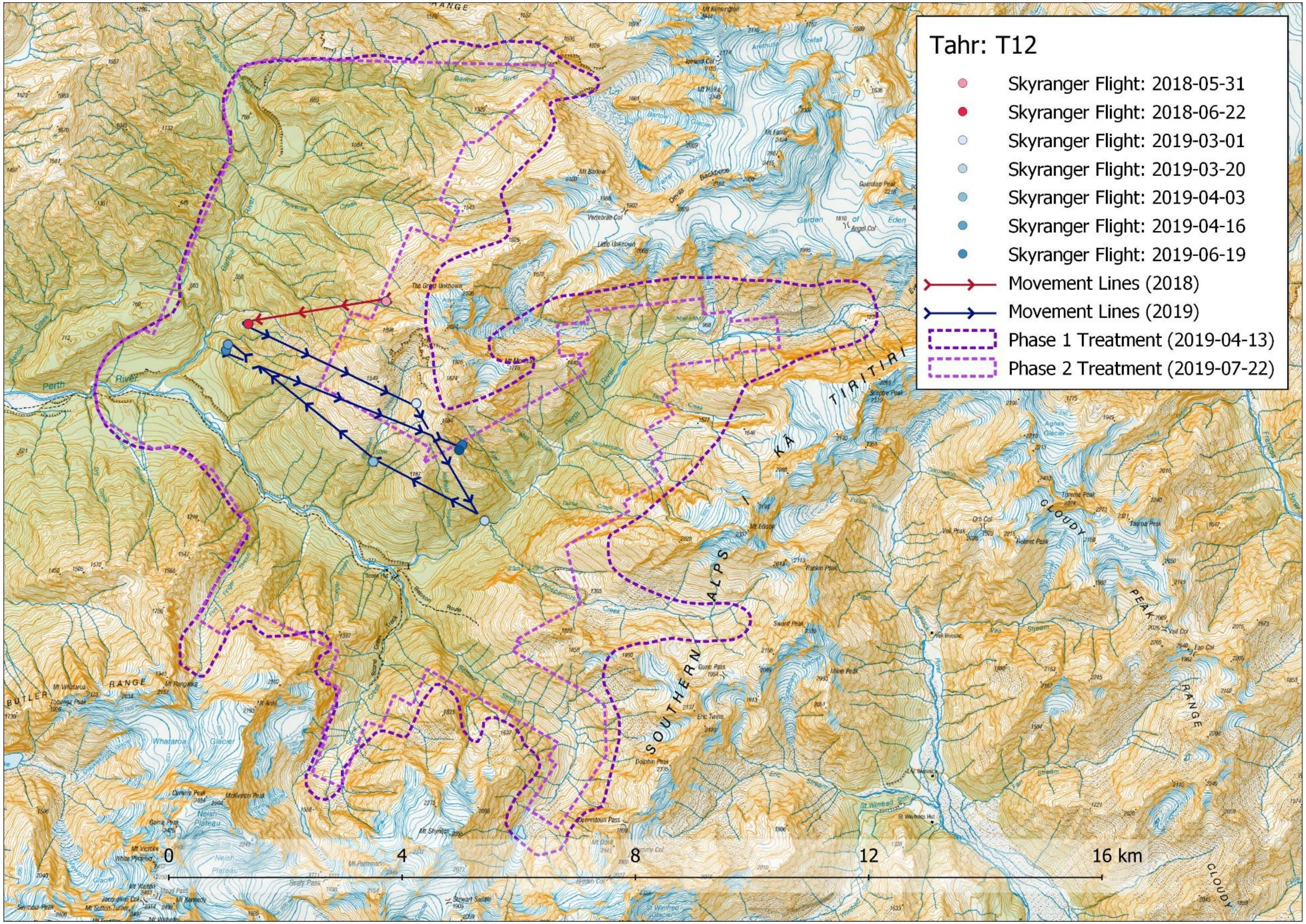

Tahr: T08
Skyranger Flight: 2018-05-31
Skyranger Flight: 2018-06-22
Skyranger Flight: 2019-03-01
Skyranger Flight: 2019-03-20
Skyranger Flight: 2019-04-03
Skyranger Flight: 2019-04-16
Movement Lines (2018)
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km
SOUTHERN ALPS / KĀ TIRITIRI
CLOUDY PEAK RANGE
BUTLER RANGE
Perth River
Whataroa Glacier

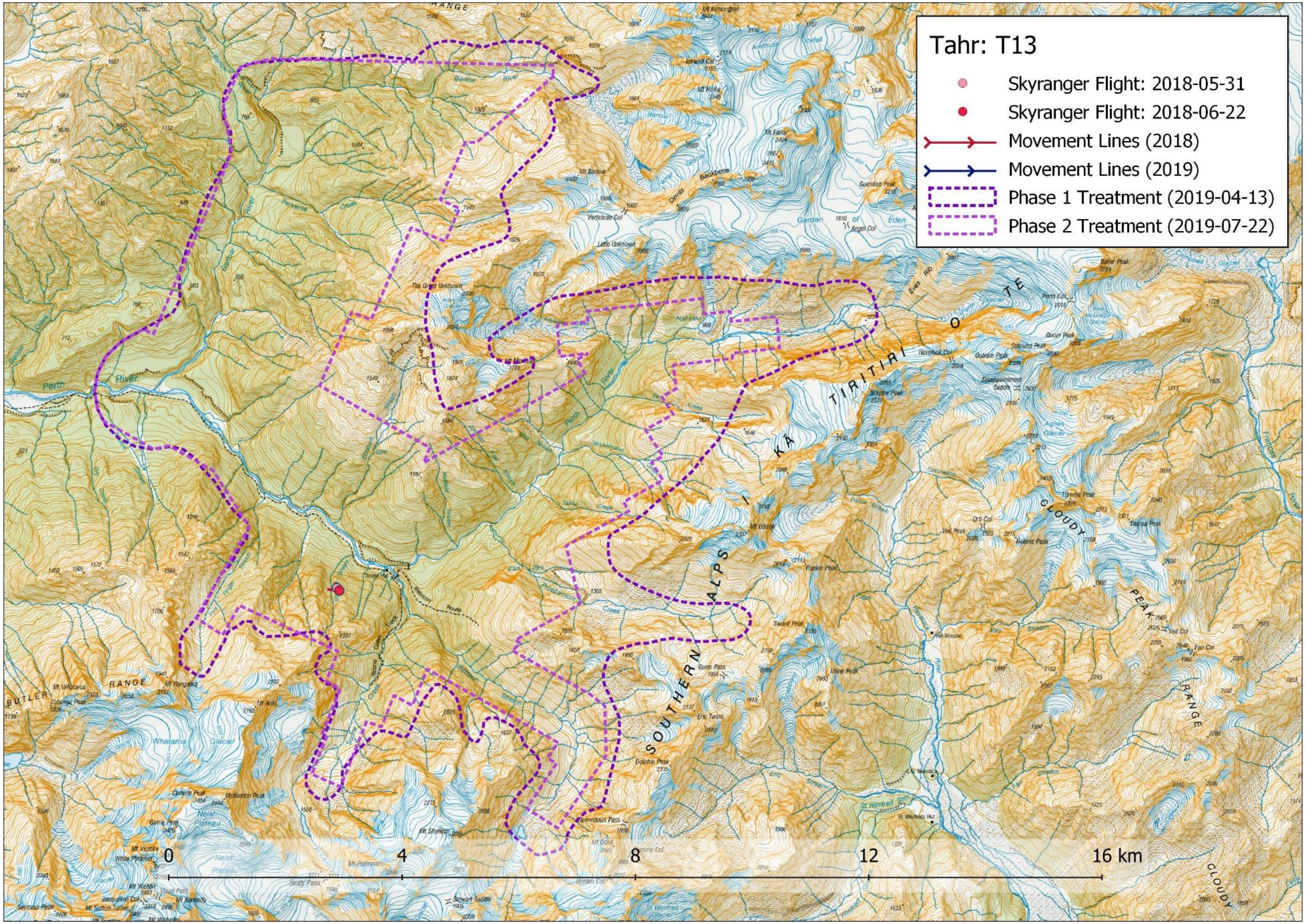


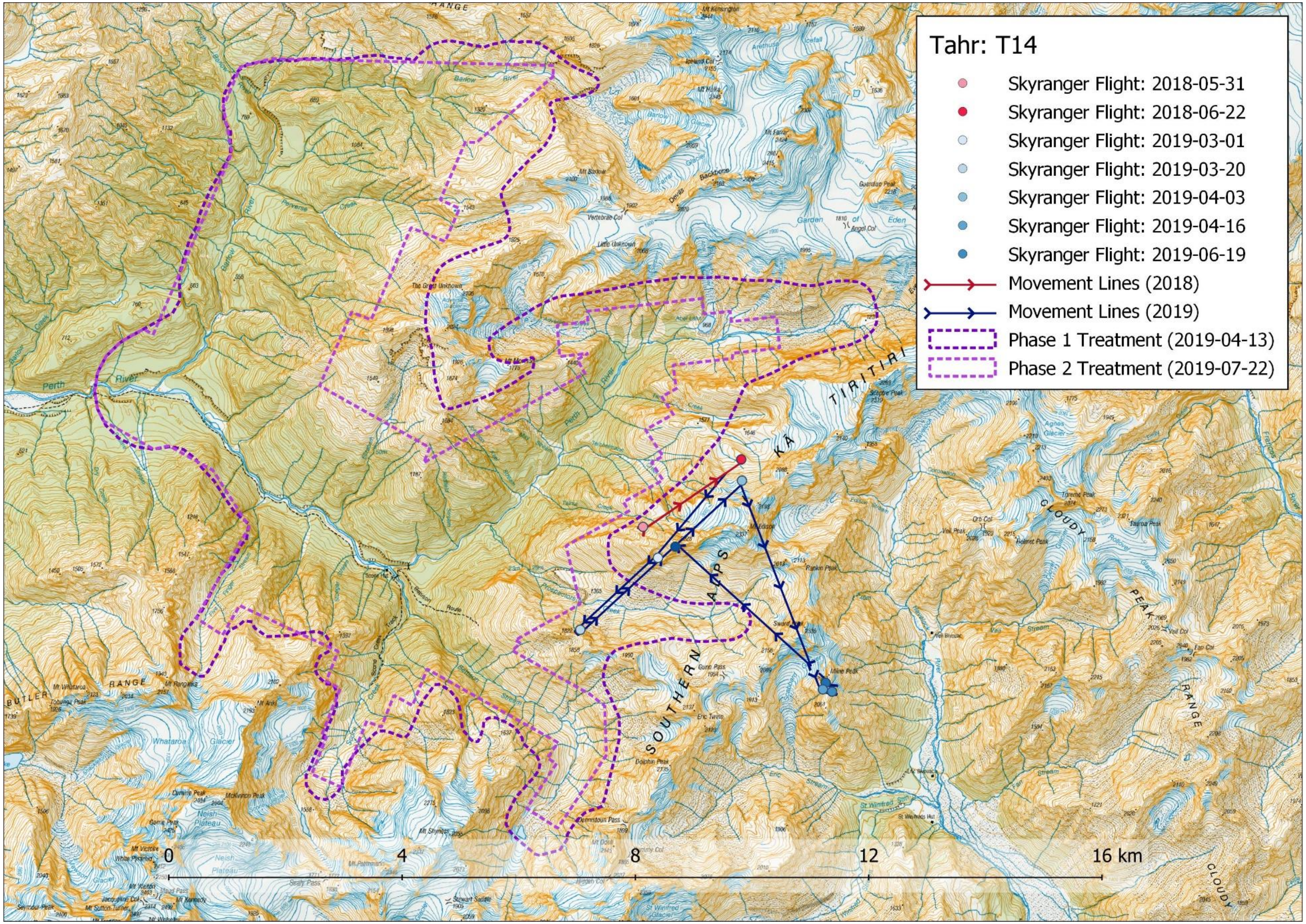
Tahr: T10
Skyranger Flight: 2018-05-31
Skyranger Flight: 2018-06-22
Skyranger Flight: 2019-03-01
Skyranger Flight: 2019-03-20
Skyranger Flight: 2019-04-03
Skyranger Flight: 2019-04-16
Skyranger Flight: 2019-06-19
Movement Lines (2018)
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km



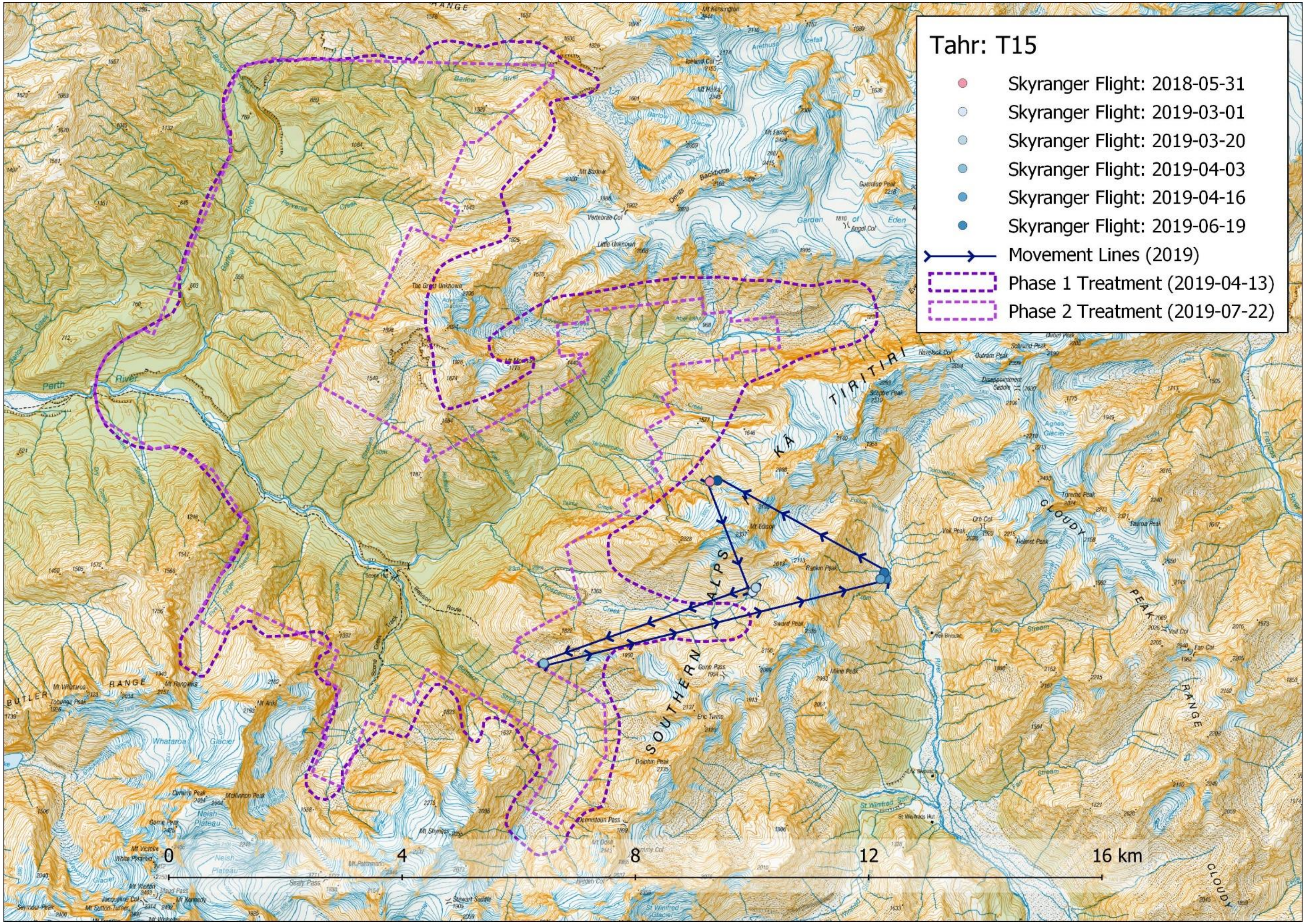
Tahr: T11
Skyranger Flight: 2018-05-31
Skyranger Flight: 2018-06-22
Skyranger Flight: 2019-03-01
Movement Lines (2018)
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km
SOUTHERN ALPS / KĀ TIRITIRI O TE


Tahr: T12
Skyranger Flight: 2018-05-31
Skyranger Flight: 2018-06-22
Skyranger Flight: 2019-03-01
Skyranger Flight: 2019-03-20
Skyranger Flight: 2019-04-03
Skyranger Flight: 2019-04-16
Skyranger Flight: 2019-06-19
Movement Lines (2018)
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km

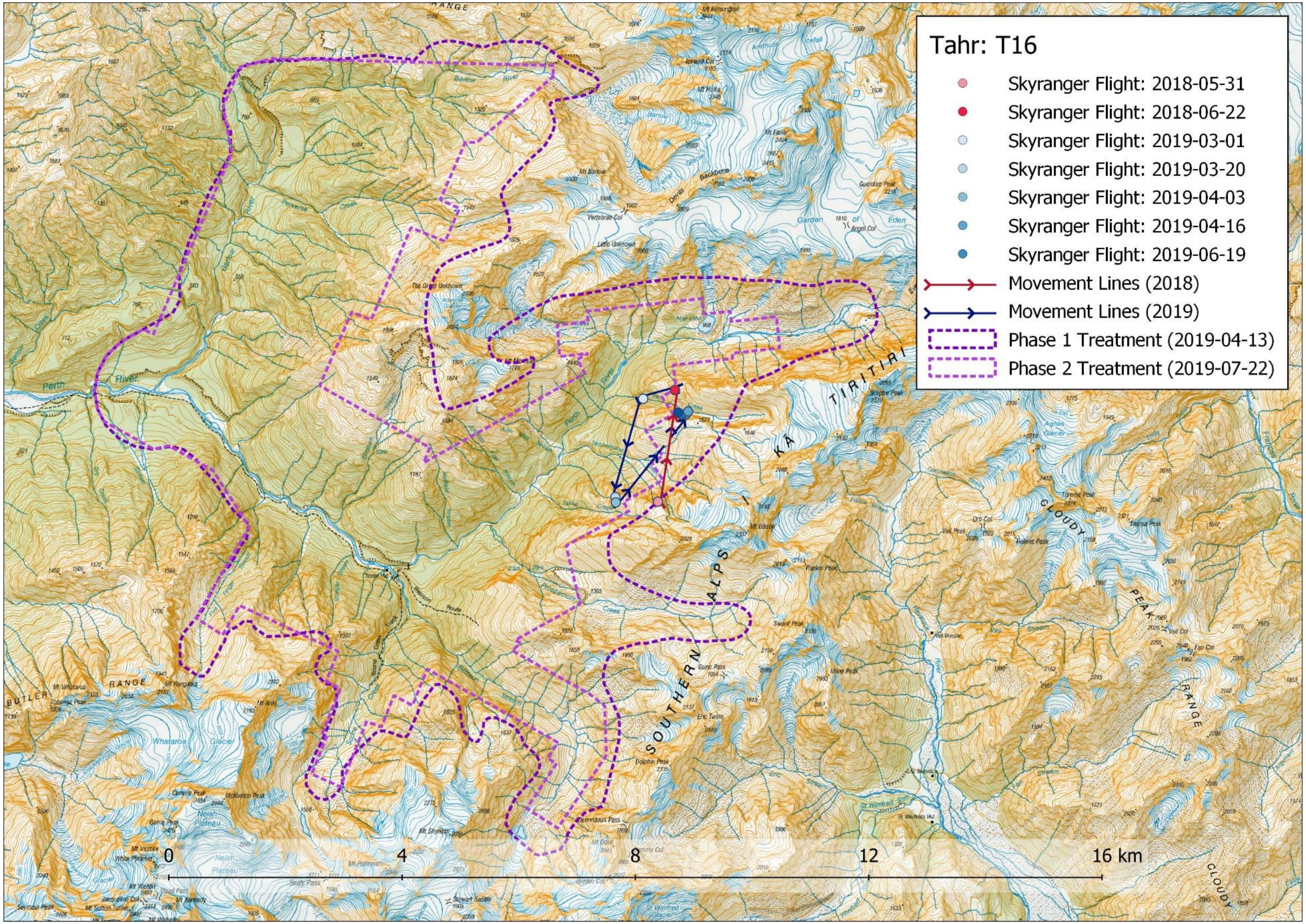

Tahr: T13
Skyranger Flight: 2018-05-31
Skyranger Flight: 2018-06-22
Movement Lines (2018)
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km



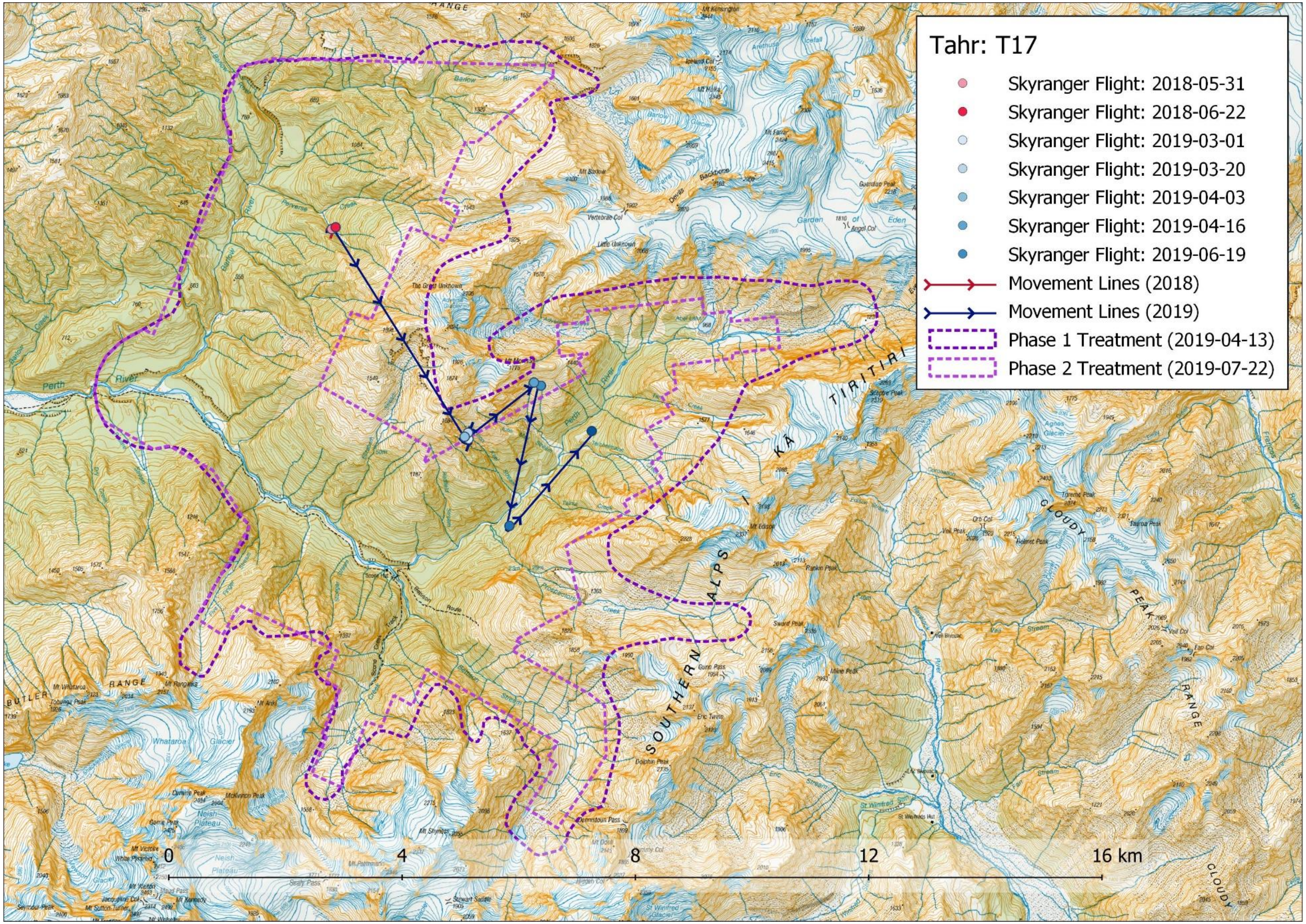
Tahr: T14
Skyranger Flight: 2018-05-31
Skyranger Flight: 2018-06-22
Skyranger Flight: 2019-03-01
Skyranger Flight: 2019-03-20
Skyranger Flight: 2019-04-03
Skyranger Flight: 2019-04-16
Skyranger Flight: 2019-06-19
Movement Lines (2018)
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km



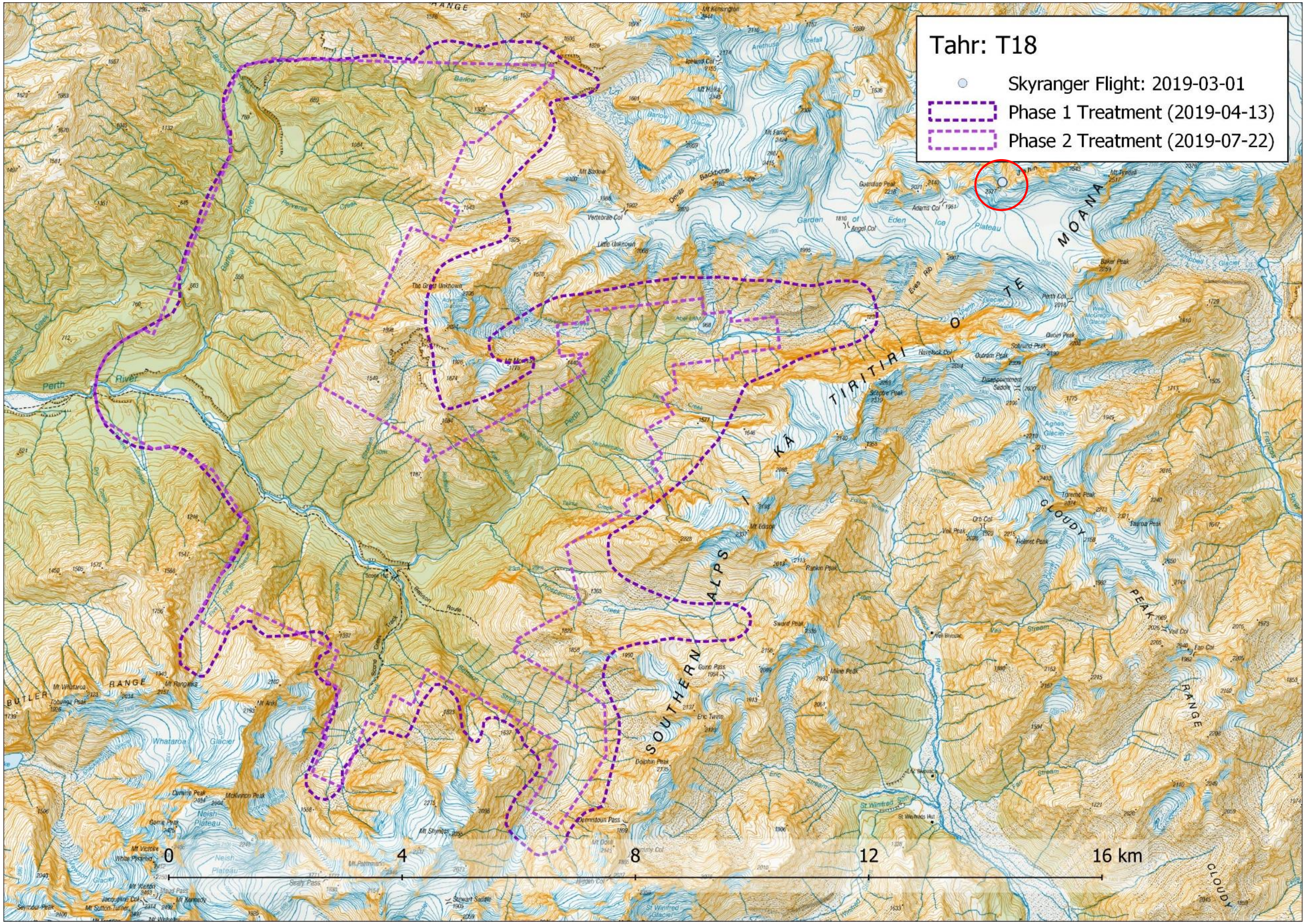
Tahr: T15
Skyranger Flight: 2018-05-31
Skyranger Flight: 2019-03-01
Skyranger Flight: 2019-03-20
Skyranger Flight: 2019-04-03
Skyranger Flight: 2019-04-16
Skyranger Flight: 2019-06-19
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km
SOUTHERN ALPS
KĀ TIRITIRI
CLOUDY PEAK RANGE

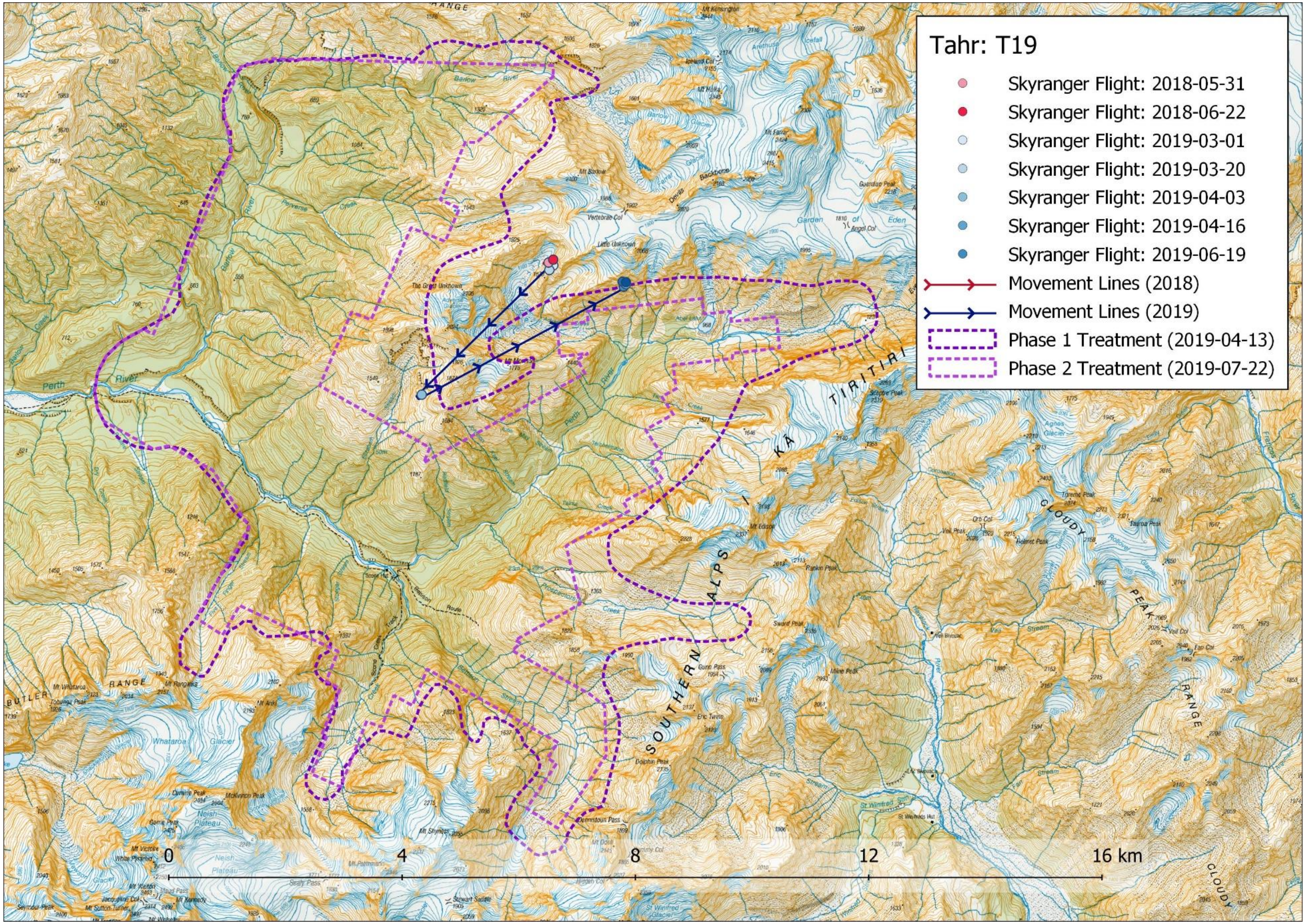


Tahr: T16
Skyranger Flight: 2018-05-31
Skyranger Flight: 2018-06-22
Skyranger Flight: 2019-03-01
Skyranger Flight: 2019-03-20
Skyranger Flight: 2019-04-03
Skyranger Flight: 2019-04-16
Skyranger Flight: 2019-06-19
Movement Lines (2018)
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km



Tahr: T17
Skyranger Flight: 2018-05-31
Skyranger Flight: 2018-06-22
Skyranger Flight: 2019-03-01
Skyranger Flight: 2019-03-20
Skyranger Flight: 2019-04-03
Skyranger Flight: 2019-04-16
Skyranger Flight: 2019-06-19
Movement Lines (2018)
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km
SOUTHERN ALPS / KĀ TIRITIRI


Tahr: T18
Skyranger Flight: 2019-03-01
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km
SOUTHERN ALPS / KĀ TIRITIRI O TE MOANA
CLOUDY PEAK RANGE
BUTLER RANGE
Perth River


Tahr: T19
Skyranger Flight: 2018-05-31
Skyranger Flight: 2018-06-22
Skyranger Flight: 2019-03-01
Skyranger Flight: 2019-03-20
Skyranger Flight: 2019-04-03
Skyranger Flight: 2019-04-16
Skyranger Flight: 2019-06-19
Movement Lines (2018)
Movement Lines (2019)
Phase 1 Treatment (2019-04-13)
Phase 2 Treatment (2019-07-22)
0
4
8
12
16 km
SOUTHERN ALPS / KĀ TIRITIRI
CLOUDY PEAK RANGE
BUTLER RANGE