SUBMERGED WEED CONTROL BY LAKE LOWERING

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The views expressed by the author are his own and are not necessarily those of his Department, nor any other group with whom he is associated.

Summary

Partial, short-term, drawdown of the Waikato Hydro-electric lakes reduces the quantity of waterweed handled at the generating stations during the subsequent "weed season". Growth control of weed in Aratiatia lake is essential as this station is not serviced by standard weed booms. The use of an annual drawdown of 4 to 5 m, together with a tedder technique, is recommended for this lake. This procedure would maintain a deflected succession where the non-nuisance, *Elodea*-Native association replaces the potential dominant lagarosiphon (*Lagarosiphon major*) for a significant proportion of the year.

INTRODUCTION

This paper considers the efficiency and ecological impact of dewatering as a submerged weed control procedure for Aratiatia lake. The same procedure has been adopted and accepted as an effective weed control method at this and other Waikato Hydro-electric lakes since 1969.

Emersion of the littoral profile in the Waikato Hydro-electric lakes can be effected by manipulating water levels. The principle of the method is that obligate submerged plants dehydrate on emersion and, if this dehydration is sufficiently severe, death ensues.

The relationship between lake lowering and the quantities of weed removed from the generating stations is clear from Table 1. Notwithstanding Waipapa 1973, a diminished harvest of dislodged weed is associated with a lake lowering prior to the weed season. However, it is only an association as there is no control to gauge the consequence of not lowering a particular lake during a particular year.

At stations other than Aratiatia, mechanical harvesting devices such as weed booms successfully deflect floating weed to disposal areas upstream of the stations, thus minimising the quantity actually handled by the screen cleaners. Aratiatia however, is essentially a river station where water-flow-rates discourage the use of weed booms or weed collection barges. Although the maximum quantities of weed which arrive at these stations in any given year is a minor proportion of the resident weed in their lakes (Aratiatia, 0.5%; Ohakuri, 0.01%; Atiamuri, 0.2%; Whakamaru, 0.3%; Waipapa, 0.3% and Arapuni, 0.2% Table 1), screen cleaners cannot be relied on to harvest weed influxes that do occur.

This paper presents a precis of results relating to a 3.7 m drawdown of Aratiatia lake between March 3 and 16, 1974. The objective of the study was to comment on the frequency, duration and level of drawdown required to provide satisfactory growth control of lagarosiphon (*Lagarosiphon major*) in that lake.

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TABLE 1: QUANTITIES OF DISLODGED WATERWEED (cubic metres) REMOVED FROM THE WAIKATO HYDRO-ELECTRIC LAKES BETWEEN 1968 AND 1974
(See Fig. 1 for location of stations)

	Aratiatia	Ohakuri	Atiamuri	Whakamaru	Waipapa	Arapuni	Totals
Lake area (hectares)	58	1280	223	704	156	922	
weed area	31	316	88	234	15	114	
1968	1650	430	1825	2750	50	—	6705
1969	560 (4)*	370	280 (4)*	100 (5)*	50 (7)*	—	1360
1970	650 (4)*	20 (5)*	580 (4)*	70 (5)*	60 (4)*	—	1380
1971	400 (4)*	40	200 (4)*	3500	150	200	4490
1972	280 (5)*	70	320	350 (3)*	50	340	1410
1973	320	115	540	7647	450 (3)*	1650	10722
1974	250 (4)*	340	210 (4)*	700	40	1100	2640
Totals	4110	1375	3955	15117	850	3290	28707

* Lake lowering (m) prior to weed season.

Note; Maraetai and Karapiro lakes are relatively "stable" with regard to dislodgement as dominated by *Egeria densa*.

FIG. 2 MORPHOMETRY OF SELECTED TRANSECTS
ARATIATIA LAKE MARCH 1974 [see FIG. 1]

FIG. 1 ARATIATIA LAKE: outline sketch & position
of resample transects

Topical Issues and Aquatic Weeds

METHODS

Morphometry

Distance from high water level to water level at known drawdown levels (see Fig. 1 for position of resample transects) and line transect analysis by Scuba diving (see Coffey 1974).

Dehydration profiles

Prior to drawdown, four monospecific plots of *Lagarosiphon*, 3.0 m deep were selected for study;

plot a	density 4 - 500 g/m ²	sandy substratum
plot b	density 1 - 200 g/m ²	— — — — —
plot c	density 4 - 500 g/m ²	— — — — —
plot d	density 1 - 200 g/m ²	silty-mud substratum

Ten replicate samples of canopy, sub-canopy, and rootstock tissue were removed from each plot on March 5 (day prior to 3 m drawdown, to give initial dessication state) and at the times shown in Fig. 5. Samples were dried to a constant weight at 110°C in a hot air oven.

Dehydration state was equated to;

$$\frac{\text{initial water content} - \text{water content of sample}}{\text{initial water content}} \times \frac{100}{1}$$

An approximate LD 50 desiccation state was arrived at by placing 5 x 5 cm fragments of replicate samples into an aquarium to detect regrowth from cortical buds.

Temperature profiles

A "12 inch" mercury thermometer was used to measure temperatures 10 cm above the drying weed canopy (air temperature) within the drying weed canopy, within the sub-canopy and at a depth of 1 cm in the substrate under drying weed mats. These measurements were made midway between high-water-level and the existing water level at the times shown in Fig. 6. The thermometer was shielded from direct light during measurement.

Vegetation mapping and biomass estimation (see Coffey 1974).

RESULTS AND DISCUSSION

Morphometry (see Figs. 2, 3 and 4).

The cost of drawdown in a Hydro-electric lake is a function of water-head loss, thus loss of generating efficiency, at less than maximum lake level. In this instance, a 3.66 m level drawdown constituted a 10.9% loss of operating head at the 90MW Aratiatia station (33.5 m for normal operating head) but a 57% decrease of mean lake depth.

The theoretical effect of morphometry on the drawdown level required for weed control is shown diagrammatically in Fig. 3. The most efficient "kill" for a given head loss is achieved with a convex littoral profile (case B) whereas a concave basin (case C) provides an inefficient "kill" for a given head loss. When considering submerged macrophytes it is the area of water surface above the littoral, rather than the surface area of lake-bed, which reflects carrying capacity.

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FIG. 3 EFFECT OF MORPHOLOGY ON
DRAWDOWN - LEVEL EFFICIENCY

FIG. 4.
LAKEBED EMERSION DURING DRAWDOWN SCHEDULE

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Reference to Fig. 2 suggests that generally Aratiatia lake might provide a useful return for drawdown cost, and indeed Fig. 4 evidences the satisfactory case (case A, Fig. 3) where a 57% decrease of mean lake depth decreases lake-surface-area by 58%. Weed area (area of littoral) was calculated for each of the lakes during 1969 (Table 1). This survey (from maps by Wilson and Gibbs, 1968) suggested that only 54% of Aratiatia was occupied by weed; although with 58% surface-area-reduction during this lowering, only 80% of the resident lagarosiphon was included in the growth control zone.

It appears that sedimentation processes are rapidly infilling the lake and extending the area of the littoral (Coffey 1974).

Dehydration and temperature profiles (Figs. 5 and 6).

A subjective assessment of this and other dryout programmes suggested that the drying canopy effectively "seals" plant mounds thus affording dehydration-protection to underlying plants and viable root-stocks. A cover of filamentous algae is particularly effective as a sealant as it dries to the consistency of thick parchment paper. This appraisal was confirmed by the data presented in Figs. 5 and 6. In this case, the canopy layer was essentially dry after 2 to 4 days. Summary results indicated that;

FIG 6 TEMPERATURE PROFILES MIDWAY ALONG RESAMPLE
TRANSECTS, ARATIATIA LAKE LOWERING, 1974

- (a) the canopy dried faster than either sub-canopy or rootstocks
- (b) less dense mounds dried faster than dense mounds
- (c) plants on a free-draining sand dessicated more rapidly than those on a mud substrate
- (d) rootstocks remained viable in each of the undisturbed plots after 9 days of drawdown. Partial dehydration of these structures occurred in free-draining sand plots
- (e) sub-canopy tissue in undisturbed, high density, plots remained viable after 9 days of drawdown. This tissue partially re-hydrated after the canopy was air dried and had "sealed", particularly on a mud substrate
- (f) the desiccation death-point for lagarosiphon is related to both the absolute desiccation state achieved, and the rate of desiccation.

Canopy temperature exceeded air temperature (windless conditions) only after the canopy had effectively sealed (2 to 3 days, Fig. 6) suggesting that evaporative cooling of the canopy was less important, thus net water loss from the sub-canopy and substrate had decreased. Sub-canopy temperatures over a 24 hour period (Fig. 6) were clearly buffered by canopy-temperature fluctuations.

A helicopter "turning trial" (tedding) was attempted to compare desiccation and recovery between tedded and undisturbed plots. Unfortunately this tedding trial was abortive as mats of the dry canopy were swirled into the air and impinged on the machines' rotor blade. A local, non-quantitative tedding trial (with pitchforks) suggested that complete dryout of tedded plant mounds was achieved after three days.

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Submerged vegetation structure and phytobiomass (Figs. 7 and 8).

Stylised vegetation profiles for Aratiatia lake during 1974 are presented in Fig. 7. A list of submerged macrophytes recorded as present during these studies is presented in Table 2. The biomass change of dominant submerged species present in the growth control zone during 1974 is presented in Fig. 8.

Prior to drawdown (January-March) the ecodominant was lagarosiphon ($450 \pm 300 \text{ g/m}^2$) mixed with filamentous algae ($90 \pm 80 \text{ g/m}^2$). The growth control zone (Fig. 7) was the only vegetation zone which was materially affected by the lake lowering. The shallow "low mixed community" (Coffey 1974) which occupied the "inter-tidal zone" between diurnal high and low water, and the deeper zones of lagarosiphon (4 to 6 m) elodea (*Elodea canadensis*) (6.0 to 6.3 m) and nitella (*Nitella* sp.) 6 to 7 m) were faithful community units throughout 1974.

Subsequent to lake lowering (March) nitella dominated a floristically enriched community in the growth-control zone. Lagarosiphon re-established its dominance during October when elodea and the conspicuous, although less substantial (with regard to biomass) colonisers *Myriophyllum* sp. and *Potamogeton* sp. were displaced. The success of lagarosiphon was associated with the displacement of nitella from the understory between October and December. A cursory inspection during January 1975 evidenced an identical lagarosiphon-filamentous algae association to that inspected during January 1974.

Coffey (1974) interpreted this sequence of events as a deflected back to an *Elodea*-Native association which was evident in the lake prior to the establishment of lagarosiphon.

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FIG. 8 PHYTOBIOMASS OF DOMINANT SUBMERGED SPECIES ARATIATIA LAKE

1974 [depth 3.5m: see fig 7, transects 1-5: see fig 1]

TABLE 2: PROVISIONAL SPECIES LIST, SUBMERGED MACROPHYTES, ARATIATIA LAKE, 1974

Algae —	
<i>Nitella hookeri</i> A. Br.	<i>Chara</i> sp.
<i>N. tasmanica</i> F. Mull. ex A. Br.	<i>Spirogyra</i> sp./ <i>Ulothrix</i> sp.
Bryophytes —	
<i>Drepanocladus adnucis</i> (Hew.) Warnst.	
Angiosperms —	
<i>Elodea canadensis</i> Michx.	<i>Ranunculus fluitans</i> Lam
<i>Lagarosiphon major</i> (Ridl.) Moss	<i>Lilaeopsis lacustris</i> Hill
<i>Potamogeton cheesmanii</i> A. Benn.	<i>Limnospira lineata</i> Gluck
<i>P. ochreatus</i> Raoul	<i>Elatine gratioloides</i> A. Cunn.
<i>P. crispus</i> Linn.	<i>Glossostigma elatinoides</i> Benth
<i>Myriophyllum propinquum</i> A. Cunn.	<i>G. submersum</i> Petrie
<i>M. elatinoides</i> Gaud.	<i>Callitriche stagnalis</i> Scop.

CONCLUSIONS

Partial lake-level drawdown is a successful technique for the growth control of lagarosiphon in Aratiatia lake. This control procedure results in a deflected succession from a nuisance to a non-nuisance vegetation type. As the progressive succession from a non-nuisance to a nuisance vegetation type occurs in a period of less than 12 months, lake lowering at not less than annual intervals is required to artificially maintain lagarosiphon as a subdominant plant in the submerged flora.

A drawdown schedule of fourteen days is required for satisfactory control of lagarosiphon if the drying mounds are not tilled. However trials could well recommend a shorter drawdown interval if a satisfactory tilling technique were available. The use of a novel hovercraft design, or a boat-mounted flame thrower may be useful to enhance dryout.

The best return for head-loss cost would have been achieved with a 5.0 m lake lowering during 1974 (95% of the area occupied by lagarosiphon would have been dewatered).

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The demonstrated effect of plant density on desiccation rate, and protection of rootstocks would recommend control during periods of minimum rather than maximum biomass.

For these reasons it might be recommended that the level of Aratiatia lake is drawndown for two, five day intervals (late spring and early autumn) by a level of 5.0 m and that emersed plant mounds are tedded to enhance dryout. Notwithstanding ecological side-effects which require further investigation this practice should provide adequate growth control of lagarosiphon.

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NEW PRODUCTS

CHAIRMAN'S SUMMARY

G. W. IVENS

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Nine new (or relatively new) products were introduced in this session, suggesting that the agricultural chemicals industry is still prepared to invest in new herbicides in spite of rapidly rising development costs.

The first two papers dealt with 'total' herbicides. B. N. MacDiarmid reported trials with VEL 5026, which was not further identified but appeared similar in activity to karbutilate, with greater effectiveness on certain weeds. A. Bowers has evaluated DPX 3674, another persistent, leaf and root-absorbed chemical with a special potential in forestry, *Pinus radiata* being relatively resistant and bracken and toetoe susceptible. Discussion centred on the persistence and mobility of these materials, areas in which further information is clearly required.

The second group of papers related to the grass-killers glyphosate and tetrapion. The former, introduced by L. A. Scherp, is non-residual and has been in experimental use for several years. It appears to be absorbed slowly but translocated rapidly, works most effectively under cool conditions and gives good control of a number of dicotyledonous perennials in addition to such troublesome grasses as couch and paspalum. Tetrapion, discussed by G. R. Rowe is related to 2,2-DPA. Being more persistent and root-absorbed, its main promise is likely to be as a constituent of total herbicide mixtures. It is also effective against Australian sedge. Glyphosate aroused the most interest in the discussion and it was clear that the marketing of this product in New Zealand is eagerly awaited. In reply to questions it was emphasised that uptake is entirely through the leaves and that effective action is dependent on enough leaf surface being present for sufficient absorption to occur.

In the final group of papers R. W. Naish introduced Dowco 290, closely related to picloram but with shorter persistence and greater selectivity towards brassicas. I. C. Logan reported work with the selective, wildoat killer difenzoquat and R. W. Moore gave results of trials with penoxalin, a denitroaniline herbicide promising as a pre-plant incorporated treatment for peas and beans. A new approach to increasing herbicide selectivity was the subject of the final paper, by B. E. Capper, on R-25788, an "antidote" permitting safe use of EPTC in maize at previously damaging doses.

Reference was made in the discussion to another new product Dowco 233 (triclopyr), a pyridyloxy herbicide mentioned in the paper by R. W. Naish in the scrub weeds session and showing considerable promise as a gorse killer. The possibility was also raised of extending the use of antidotes to other herbicides and crops but the protective effects of R-25788 in maize was stated to be rather specific. The paper on penoxalin was criticised for the omission of yield figures and coefficients of variation in the results section, making it difficult to interpret statements about significant effects on yield.