This turned out to be correct; there was a higher proportion of tree death of all tree species including *Banksia menziesii* compared to the site closer to the water table. *Banksia menziesii* trees rely on soil moisture during the dry summer months and during particularly hot, dry summers this soil moisture may be depleted if it is not replenished by rainfall and this may result in death. However, this did not happen this year.

The year in which the highest number of trees of all species died in the two sites in Kings Park was 2011. Most trees die during autumn, so the relevant rainfall is that of the previous spring and summer prior to death. In 2010 Perth had a record dry, hot year. There were three heat waves in 2010 and six in 2011. This, coupled with the hail storm of March 2010, is likely to have caused the high number of tree deaths, including *Banksia menziesii* observed in the Kings Park bushland in 2011.

Findings from my project revealed that the highest mortality of *Banksia menziesii* trees that was observed seems to have occurred following a particularly hot, dry summer and therefore widespread death may not occur every year.

With predictions of further warming and drying and an increased frequency of heat waves in the future in the south-west of Western Australia (IPCC 2007), we will likely see more *Banksia menziesii* trees dying.

Tree death is a complex process and there may be many contributing factors. There is a lot that we still don't know about this iconic *Banksia* species and therefore more research is needed to understand the process of mortality.

Whether we can do anything about this problem at Kings Park is not clear, but a larger research project is just commencing, involving collaboration of scientists from the Botanic Gardens and Parks Authority and the University of Western Australia may provide more answers.

References

Beard, J.S. (1990) Plant Life of Western Australia. Kangaroo Press.

Crosti R, Dixon K.W., Ladd P.G., Yates C.J. (2007) Changes in the structure and species dominance in vegetation over 60 years in an urban bushland remnant. *Pacific Conservation Biology* 13, 158-170.

IPCC (2007) Climate change 2007: the physical science basis. In 'Contribution of Working Group I to the Fourth Assessment. Report of the Intergovernmental Panel on Climate Change'. (Eds Solomon S., Qin D., Manning M., Chen Z., Marquis M., Averyt K.B., Tignor M., Miller H.L.) pp. 996. (Cambridge University Press: Cambridge, United Kingdom/ New York, USA)

Keighery G (2011) *Banksia* woodlands: A Perth Icon. In: 'Perth *Banksia* woodlands, precious and under threat, proceedings of a symposium on the ecology of these ancient woodlands and their need for protection from neglect and destruction'. (Eds K Sarti) pp. 3-10. (Urban Bushland Council) ■

'Thank you to the Friends of Kings Park for partly funding this project.'

Anthea Challis taking soil moisture measurements in Kings Park. Photo: Alyssa Weinstein

Sexual promiscuity in the shallows

Elizabeth Sinclair
Associate Professor (research)
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Western Australia's vast meadows of *Posidonia australis* seagrass are amazingly productive with massive flowering events annually in the cool winter waters. This is followed in late spring by many millions of seagrass fruit floating across the water and washing up on beaches (Figure 1).

Figure 2: Developing Posidonia australis flower rising above the leaf canopy at Salmon Bay, Rottnest Island, August 2014. Flowering appears to be triggered by cooler water temperatures, which even at the northern extreme of their range in Shark Bay drop as low as 16°C in winter. Photo: courtesy of Angela Rossen, UWA

Figure 1: Posidonia fruit washed up on the beach at Point Peron, December 2011. Photo: courtesy of Angela Rossen, UWA

Because seagrasses are marine flowering plants that complete their life cycle entirely underwater, most people never give a thought to their reproductive systems and are surprised at the fruits that seasonally wash up along the beaches.

The green flowers within the swaying meadows are not easy to pick out from the surrounding leaves, but when the long stemmed *Posidonia australis* flowers are mature, they reach up above the canopy (Figure 2).

Constantly moving water presents challenges for effective underwater pollination (known as hydrophilous pollination) in much the same way a very windy environment would for land plants. Pollen grains can become entangled in the leaves of the seagrass meadow or diluted in the water.

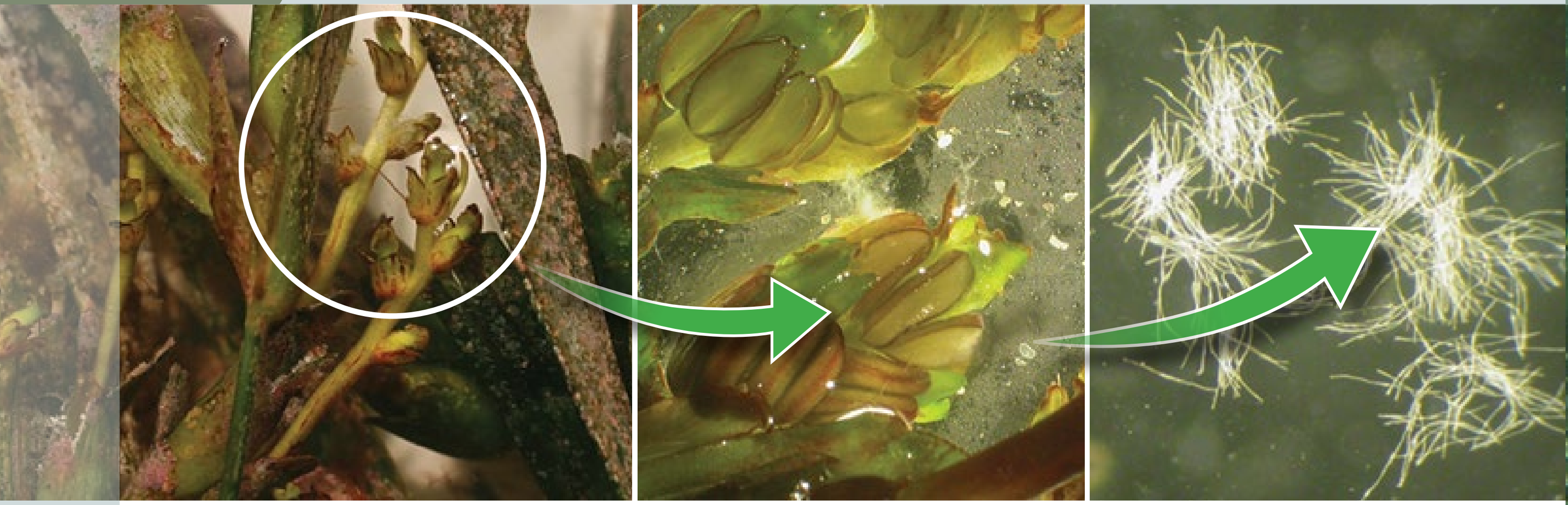

Figure 3: Closeup of flowering Posidonia australis, with mature anthers, and released filiform pollen. Photo: courtesy of Kingsley Dixon, BGPA

Seagrasses have evolved special traits to adapt to these difficulties.

Seagrass pollen has been highly modified for dispersing underwater, with long, narrow (filiform) morphology (Figure 3), absence of a tough outer layer (exine pollen wall), and coated in a sticky, gelatinous fluid (like super-glue).

The pollen grains are also neutrally buoyant, so they remain suspended within the water column and are easily moved by currents. The flowers produce large amounts of pollen that is released as a fine cloud through August and September.

The elongated shape of the pollen grains and complex water flow around the flowers and seagrass canopies slow water movement and increase the chance of trapping pollen.

Successful pollination requires the transfer of pollen from the anther (where it is produced) to a receptive stigma for fertilisation.

Approximately 40% of all seagrass species have male and female flowers present on the same plant. The term for this is monoecious.

Plants vary in size within a seagrass meadow, with some spreading their rhizomes many metres below the seafloor. Shoots extend upwards from the rhizomes and many of these shoots can produce flowers (or inflorescence spikes) in a single year.

Therefore, lots of pollen from the same plant can mix locally and pollinate flowers from the same plant.

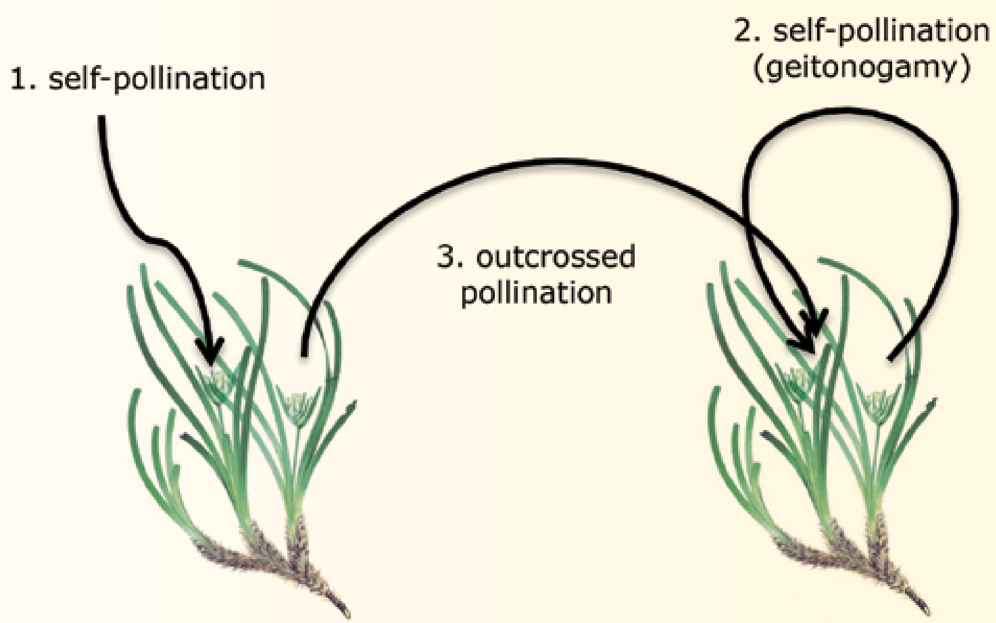

Figure 4 Schematic illustration showing different types of pollination in clonal flowering plants: (1) self-pollination (within a single flower), (2) geitonogamous self-pollination (pollination between flowers on different flowering spikes on the same plant) and (3) outcrossed pollination (between different plants).

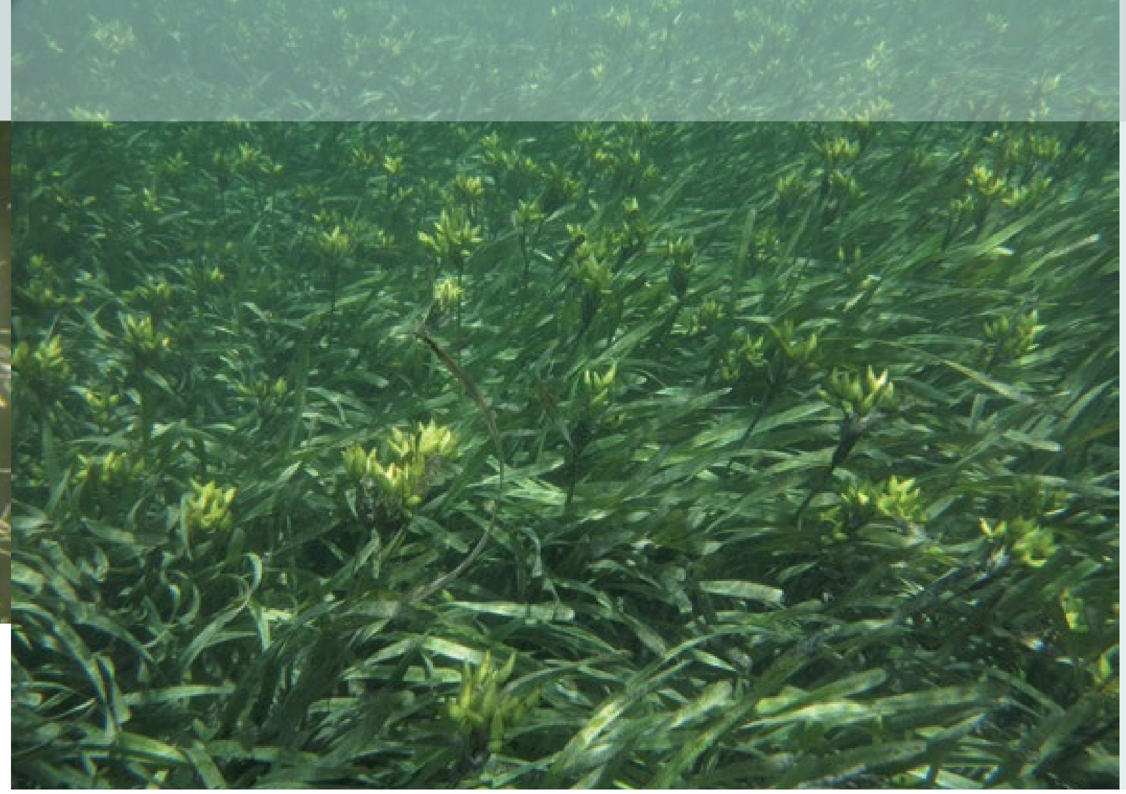

Figure 5: High reproductive output: maturing Posidonia australis fruit at Woodman Point, Cockburn Sound, Western Australia. Multiple pollen donors contribute to successful pollination and seed development on each infructescence spike. Photo: courtesy of Renae Hovey, UWA

Three types of pollination systems are possible in monoecious seagrasses (Figure 4):

(1) Transfer of pollen from anther to stigma within a single flower on the same plant. This type of self-pollination can be prevented by delaying stigma receptivity until after the pollen is released.

(2) Transfer of pollen from a flower on one inflorescence to the stigma of a flower on a different inflorescence on the same plant (also known as geitonogamous pollination, another form of self-pollination).(3) Transfer of pollen from the anther of a flower on one plant to the stigma of a flower on a different plant (outcrossed pollination).

If self pollination is not tolerated, then plants must be able to recognise their own pollen when it lands on a stigma and prevent pollination (pre-zygotic) or seed development (post-zygotic embryo abortion).

When seeds are produced only by outcrossed pollination, then seeds are the result of genetic recombination (new combination of genetic information) and all new plants will be genetically unique.

Measuring the distance individual pollen grains move in the water is important for determining the extent of gene flow among local meadows.

In reality, this is a seemingly impossible task! So rather than attempting to 'track' individual pollen grains in the water column, we used DNA markers to infer pollen movement.

Individual shoots (from a mother plant) and their attached floral spikes containing up to 15 mature fruit (infructescence), were collected as 'families', with the GPS location taken for all samples.

By genetic fingerprinting (genotyping) each mother shoot and all the attached fruit, it is possible to determine the genetic pollen contribution for each fruit.

The genotypes were used to assess overall levels of genetic diversity, size of individual parent plants, the mating system (inbreeding, outcrossing, or a combination), identify pollen donors (single or multiple pollen donors per 'family'), and calculate the distance pollen has travelled between parental plants.

Two local seagrass meadows were chosen; one exposed site at Point Peron and one protected site within Cockburn Sound along the eastern shoreline of Garden Island, to see if the local conditions impacted on pollen dispersal distances and mixing of pollen.

Water movement at the time of pollen release may affect pollen mixing and dispersal distances; for example multidirectional wind and wave action could enhance mixing, while calm conditions with weak currents may reduce mixing across a meadow.

The average plant size was approximately 13m in both meadows, but genetic diversity was higher in the sheltered meadow at Garden Island.

Few plants were identified as pollen donors to specific fruit, likely because of the large and unknown number of plants in meadows and how far pollen can be carried.

For those fruits where a pollen donor was found, the mean distance a pollen grain travelled (calculated from the GPS points) was slightly higher at Point Peron (31 m) than Garden Island (27 m).

The longest distance travelled by a pollen grain was 178m in the Point Peron meadow and less than half that distance in the Garden Island meadow (74 m).

The average dispersal distances for pollen grains in both meadows was larger than the plant sizes and thus contributed to complete outcrossing in both meadows.

Individual flowering spikes at Point Peron also had a higher number of pollen donors contributing to successful pollination of those families. Some plants are also clearly more successful at spreading their pollen (or perhaps they produce more by having a larger number of floral spikes in a year).

One individual plant at Garden Island provided pollen to five different 'families'. This may be explained by the mostly north to south direction of inshore water flow in a largely protected site at Garden Island, relative to the potentially higher amount of water mixing at the more exposed Point Peron meadow.

Seagrasses appear to be very good at reproducing sexually, with high seed production in many of the local meadows (Figure 5).

Pollen is travelling beyond the size of the average plant and thus successful outcrossing is occurring. Seed abortion rates were very low (<8%), unlike a close relative in the Mediterranean (*Posidonia oceanica*), which has in excess of 80% abortion rate in seeds.

Flowers are in high density at both our study sites and are generally positioned above the leaf canopy for better pollen mixing and dispersal. The different localised water conditions at each site (highly exposed conditions versus weak directional current) appear to have little influence on the outcrossed pollination rate, although pollen appears to be mixing better and dispersing further in the more exposed meadow at Point Peron.

Pollen is certainly able to move over hundreds of metres, but it is highly unlikely that pollen moves further than >55 km estimated for fruit (containing seeds; Kendrick et al. 2012; see also Sinclair 2012).

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Other reading:

Kendrick GA et al. (2012) The central role of dispersal in the maintenance and persistence of seagrass populations. *BioScience* 62: 56-65

Sinclair EA (2012) Dispersal on the high seas - the ecological genetics of seagrass seed dispersal. For People & Plants Autumn: 20-22.

Sinclair EA et al. (2014) Against the odds: complete outcrossing in a monoecious clonal seagrass. *Annals of Botany* 113: 1185-1196. ■

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Djilba - Kambarang July – October (Wildflower Season)

	10 am	2 pm
Mon	Water Views + Wilderness	Botanic Garden Walk
Tues	Botanic Garden Walk	Kings Park Past + Present
Wed	Kings Park Past + Present	Wilderness + Wildflowers
Thurs	Wilderness + Wildflowers	Kings Park Past + Present
Fri	Bushland Paths - the Heart of Kings Park	Botanic Garden Walk
Sat	Botanic Garden Walk	Wilderness + Wildflowers
Sun	Kings Park Past + Present	Wilderness + Wildflowers

Walks available in September:

	10 am	12 noon	2 pm
daily	Wilderness + Wildflowers	Botanic Garden Walk	Wilderness + Wildflowers

One extra walk included in October:

	10 am	12 noon	2 pm
daily	same as listed in top panel	Mystery Tour	same as listed in top panel

NOTE Tammy to confirm the hierarchy

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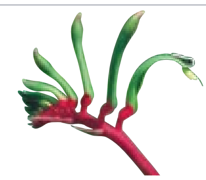

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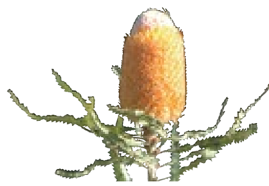

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